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Evaluation of Predicted and Actual Water Quality Conditions at the Marlin Mine, Guatemala

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Executive Summary

The primary purpose of this study is to evaluate the Environmental and Social Impact Study (EIA&S; Estudio de Evaluación de Impacto Ambiental y Social) and the extent to which predictions made about water quality before mining began comport with actual conditions at the mine.

The Marlin Mine is located in the highlands of western Guatemala in the San Marcos Department and produces gold and silver by open pit and underground mining. The mine is now owned by Montana Explorada de Guatemala, S.A., a 100% subsidiary of Goldcorp. The mine was partially owned by the International Finance Corporation (IFC) of the World Bank until 2006, when the loan was repaid. The Marlin Mine has been in commercial production since December 2005. The mine includes two open pits, an underground mine and associated workings, a vat leach cyanide operation, tailings facility, and two waste rock dumps.

Relationships between the mine and local communities have been tense since the exploration phase began, and a number of complaints have been lodged and protests taken place against the mine. The backdrop of political instability and violence, poverty, and natural disasters in the country and in the immediate Marlin Mine area has heightened tensions between the mine and the local indigenous communities. The 1997 mining law encouraged metal mine development and offered little protection of local land ownership. The Marlin Mine was the first mine to open under the new law and the first to receive IFC funding after their extractive industry review in 2003.

According to the EIA&S, the Marlin project was designed to conform to North American standards and would employ the best environmental management practices to minimize environmental impacts and comply with Guatemalan regulations, international guidelines for environmental management, and company environmental policies. The major shortcomings of the EIA&S are:

- The EIA&S provided limited information on the baseline environmental setting in and around the Marlin Mine. The baseline water quality monitoring period was too short (only 8 to 9 months) to evaluate seasonal and inter-annual changes in water quality before mining began. For groundwater quality, only two springs were sampled; deeper groundwater was not sampled at all during the short EIA&S period. A rapid biological assessment was conducted at a limited number of surface water locations. More monitoring locations and a longer period of baseline analysis should have been conducted for water quality, water quantity and levels, and the abundance and health of aquatic biota.
- There was not enough information on groundwater levels to know the degree of hydrologic connection among aquifers, the extent of hydrologic connection between aquifers and surface water, or the directions of groundwater flow. Without information on groundwater flow directions, it is impossible to know the potential for the migration of contaminants from mine sources to receptors. Groundwater flow directions must be established before a reliable monitoring network can be established for the Marlin Mine.

- Essentially no information on geochemical testing was included in the main body of the EIA&S. The EIA&S predicted that the acid generation and contaminant leaching potential of the rocks would be low, but no supporting tables or figures were provided. More extensive geochemical testing should have been conducted before mining began, and a comprehensive summary of the results should have been included in the main body of EIA&S. This type of information is crucial for developing effective waste rock and tailings management plans.
- A tailings water balance model was conducted for EIA&S. However, infiltration through the impoundment was not considered in the model. The model predicted that direct discharge to the environment would be required by 2007, yet it has not yet been needed at the writing of this report (mid 2010). The causes of the discrepancy between the modeled water balance and actual conditions should be investigated.
- The EIA&S identified a number of moderately or strongly *positive* impacts related to water bodies, most of which were associated with revegetation after operations. None of these positive impacts should have been identified as such, because impacts should be evaluated relative to baseline (pre-mining) conditions rather than conditions resulting from mining operations.

To evaluate the predicted vs. actual environmental conditions, we compared predictions in the EIA&S and early annual monitoring reports with operational water resource information. Following the approach in Kuipers et al. (2006), we distinguished between "potential" impacts – those predicted to occur without mitigation measures – and "predicted" impacts – those predicted to occur after mitigation measures are in place. In the United States, permits are granted on the basis of "predicted" rather than "potential" impacts. However, Kuipers et al. (2006) found that "potential" impact predictions were more accurate and that mitigation measures often fail. For operational water quality information we examined results from Goldcorp/Montana Resources, Asociación de Monitoreo Ambiental Comunitario (AMAC), Comisión Pastoral Paz y Ecología (COPAE), the Ministry of the Environment and Natural Resources (MARN), and the Ministry of Energy and Mines (MEM). Where possible, we compared operational water quality to pre-mining conditions to determine if any observed changes in water quality or quantity resulted from mining operations. Baseline conditions not caused by mining at the Marlin Mine were also taken into account, for example, the effects of sand and gravel operations on downstream water quality.

The EIA&S identified potential and predicted impacts (positive and negative) and mitigation measures. No strongly negative effects were identified in the EIA&S. After mitigation measures are installed, the EIA&S predicted that no moderately negative impacts to water resources or aquatic life would occur. However, our findings suggest that adverse effects to the environment may have already begun as a result of mining operations at the Marlin Mine.

The key findings of the report include:

- *The mine wastes have a moderate to high potential to generate acid and leach contaminants to the environment.* The EIS&A predicted that contaminant leaching and acid generation potential would be low. However, based on waste rock characterization information available in the Goldcorp AMRs, nearly half of the waste rock is potentially acid generating, and an additional 25 to 35% has uncertain acid-generation potential. Wastes with higher acid generation potential will release higher concentrations of metals and pose a greater risk to water resources.

- *Although more information is needed, the existing data suggest that tailings seepage may be migrating to the drainage downstream of the tailings dam.* The EIA&S did not address this issue, but our analysis of limited water quality data from Goldcorp, AMAC, and COPAE suggests that tailings seepage may be leaking into the Quebrada Seca tributary downstream of the tailings dam. A hydrologic and water quality study is needed to fully assess potential leakage from the tailings impoundment.
- *Water in the tailings impoundment does not meet IFC effluent guidelines*. The EIA&S predicted that tailings water would meet IFC guidelines during operation. However, water stored in the tailings impoundment exceeds IFC effluent guidelines for pH, cyanide, copper, and mercury. Maximum concentrations of cyanide, copper, and mercury measured in 2006 were over three, ten, and 20 times IFC guidelines, respectively. Treatment is planned for tailings water discharged to the environment, but treatment will not address leakage of contaminants to groundwater.
- *Groundwater flow directions and seepage pathways from contaminant sources to groundwater and surface water are poorly understood.* The potential for impacts to water resources cannot be adequately evaluated before groundwater flow directions are known. Arsenic and sulfate concentrations in one of the wells have been increasing over time, and because groundwater flow directions are unknown and the monitoring network is so sparse, neither the source nor the potential downgradient receptors are known. A study of water use and transport pathways should be undertaken to evaluate the potential for mine contaminants to reach water resources.

Based on our review, the key technical and policy recommendations include:

- Technical recommendations
  - Monitoring: The groundwater, surface water, and discharge monitoring systems should be expanded. More groundwater wells are needed to establish groundwater flow directions. More surface water monitoring points are needed upstream and more immediately downstream of mine facilities, including upstream of mining activity on Rio Quivichil. All monitoring data should be publicly available in electronic format. Analytical detection limits (the lowest concentration detectable) should be three to five times lower than the most protective water quality standards. Future sampling efforts should incorporate quality control elements to ensure data quality, especially at a site as contentious as the Marlin Mine.
  - Adaptive Management: An adaptive management plan with citizen involvement and annual meetings should be created. Monitoring results from

    the previous year should be reviewed, and changes in mine operations should be recommended and carried out.
  - Studies needed: The potential influence of the mine on groundwater and surface water quality and aquatic life should be evaluated. A hydrogeologic study of groundwater flow directions, transport pathways (including via faults), and the extent of hydrologic connection between mine facilities and water resources and downgradient water resources should be conducted in the near future.
- Policy Recommendations
  - Water quality standards: MARN should develop water quality standards for protection of all possible uses in surface water and groundwater.
  - Bonding requirements: The Ministry of Energy and Mine should develop mechanisms for bonding of hard rock mines in Guatemala. A bond is an amount of money held in reserve to cover unforeseen expenses associated with environmental impacts that occur after closure. Actual costs of reclamation, closure, and post-closure should be incorporated into bonding, which has been as high as $250 million in the United States.
  - Independent monitoring: A well funded, independent, transparent, and scientifically rigorous monitoring system is needed with participation from all stakeholders.

1. Introduction

The Marlin Mine is located in the highlands of western Guatemala in the San Marcos Department (Figure 1) and produces gold and silver by open pit and underground mining. The mine is now owned by Montana Explorada de Guatemala, S.A. (a 100% subsidiary of Goldcorp). The mine was previously owned by Glamis Gold. The International Finance Corporation (IFC) of the World Bank loaned the company $45 million U.S. out of $254 million (CAO, 2005) in June 2004 to help Montana Exploradora de Guatemala S.A. (previously 100% owned by Glamis Gold Ltd) develop the project (IFC World Bank Group, 2004).

The Marlin Mine has been in commercial production since December 2005 (only about four years at time of writing). The minable resource was predicted to be 13 million tons of gold and silver ore (estimated at 5.1 gm/ton gold and 71.7 gm/ton silver), with 11 million tons extracted from the open pit and two million tons removed from the underground mine. According to the Environmental and Social Impact Statement (Montana Exploradora de Guatemala, 2003, hereafter referred to as EIA&S), the minable reserves were projected to last for approximately 10 years of production at a daily rate of 4,000 to 5,000 tons per day. (EIA&S, p. 3-25). At the end of 2007, the proven and probable reserves had grown to 15.6 million tons, and exploration activities in 2008 alone added an additional 1.1 million tones of reserves (AMR, 2008).

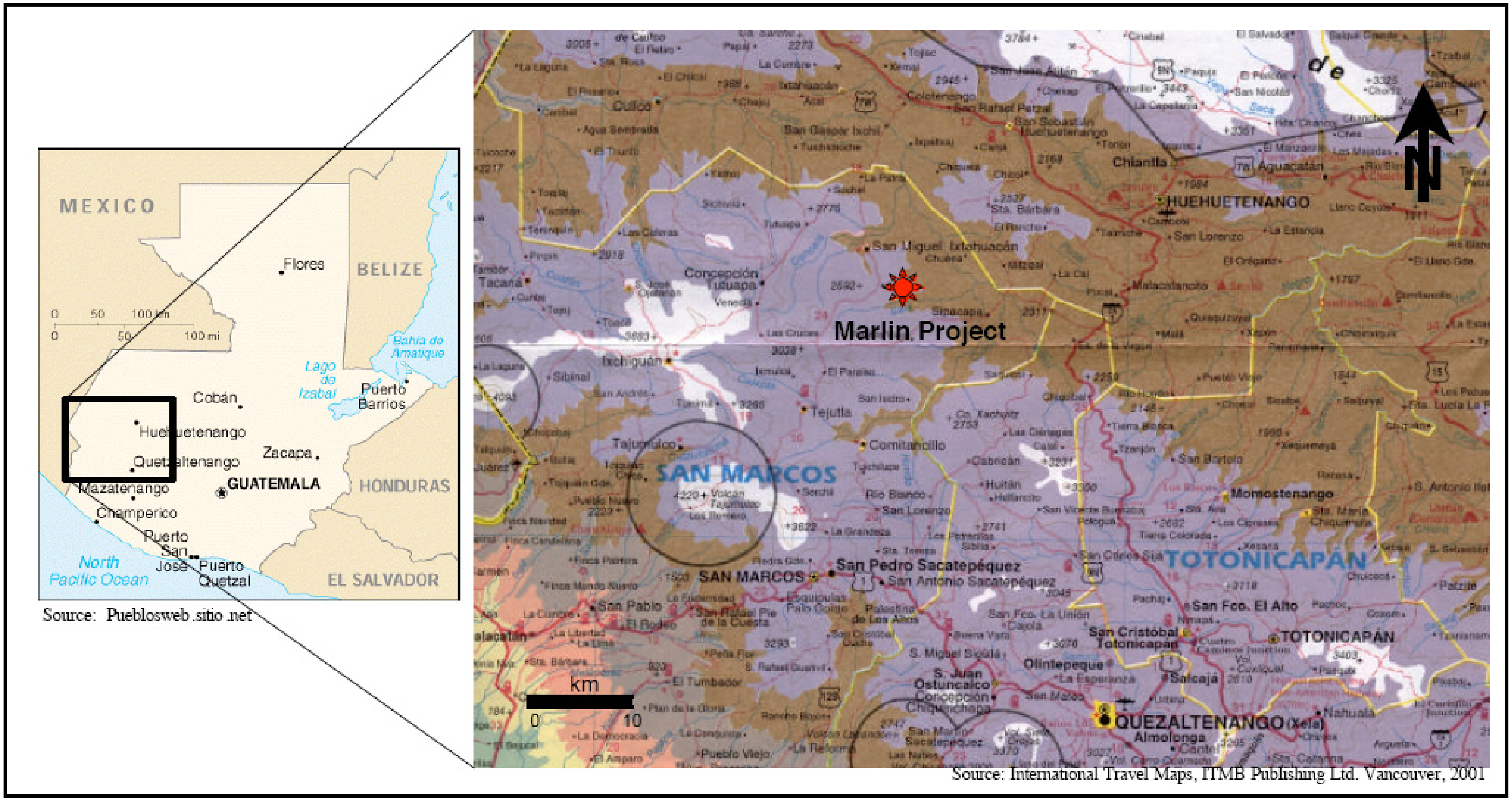
Relationships between the mine and local communities have been tense since the exploration phase began, and a number of complaints have been lodged and protests have taken place against the mine. Although this report addresses technical issues associated with the mine, the reactions of the local communities to the mine and the associated complaints and protests are an important part of the history and development of the mine, and these issues are addressed in Section 2 of the report. Information from community monitoring efforts is discussed and evaluated in Section 6.

1.1 Regional and social setting

Guatemalan History and the Marlin Context

Following decades of indigenous repression and foreign economic and political control and an agrarian economy, Guatemala went through a series of leftist reforms from 1944 to 1954, followed by a U.S. CIA-sponsored coup. Corruption and economic repression led to the military seizing power in 1960 and essentially taking over the country, at times officially, during a civil war with leftist guerrillas that ended with the 1996 peace accords between the Guatemalan government and guerilla factions.

Figure 1. General location of the Marlin Mine in Guatemala.



Source: Pueblosweb.sitio.net

Source: International Travel Maps, ITMB Publishing Ltd. Vancouver, 2001

Source: SRK, 2002.

Hundreds of thousands of largely indigenous Guatemalans died violently during the war. Many lived in the highlands, including the San Martin region where the Marlin Mine is located; sometimes villages were split between those who were massacred and those who were allowed to live in fear. Given this context, one would expect a high degree of distrust and conflict over land rights.

Over 400,000 Guatemalans fled the repression and conflict. Although the country is now at peace, emigration continues at a rapid pace due to lack of economic opportunity. In 2005, an estimated 140,000 more people left the country than returned (Organización Internacional para las Migraciones, 2009.).

Natural disasters have also affected Guatemala. According to the United Nations' World Food Programme, Guatemala has the fourth highest rate of chronic malnutrition in the world and the highest in Latin America and the Caribbean (Espindola et al., 2005). Chronic -malnutrition affects about half of the nation's children under the age of five, and among indigenous children in the highlands, seven of 10 children under age five are malnourished. The World Bank stated that 75% of Guatemalans cannot afford to purchase basic goods and services and live below the poverty line, and 58% cannot purchase a "basic basket of food" and live in severe poverty (CNN.com, 2009).

Just a year after the end of the civil war, in 1997, the government passed a mining law that encouraged investment in the sector and reduced royalties to the government. The current president, Álvaro Colom, who was elected in 2008, has been a theoretical supporter of mining as a source of revenue, but along with a pro-mining investment policy, he has inherited social conflict over the Marlin Mine and other potential mining projects.

Indigenous groups claim the government cannot give their land to Goldcorp as part of a mining concession, while Goldcorp claims they have purchased whatever land is necessary. Indigenous groups and municipalities generally oppose the mine—and often all mining. The indigenous-mine company conflicts have occurred against a backdrop of enormous poverty, malnutrition, and fears that water used for small-scale farming will be depleted by mine dewatering and contaminated by mine discharges.

Since 1989, the International Labor Organization (ILO) Convention 169 has required that signatory countries, including Guatemala, obtain "free, prior and informed consent" by indigenous people for use of their land. Additionally, the Latin American Water Tribunal, an independent inter-American tribunal, accused the Government of Guatemala and Goldcorp of violating ILO 169 and causing environmental damages, based on complaints brought by the Municipality of Sipacapa and community groups (Tribunal Agua Veredicto, September 2008).

On May 20, 2010, based on a complaint by the Guatemalan Pluricultural Center for Democracy, the Inter-American Commission for Human Rights (IACHR)[1] called for

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[1] The IACHR is an autonomous body of the Organization of American States (OAS) that promotes and protects human rights (http://www.cidh.org/what.htm).

suspension of mining operations until Goldcorp and the government could guarantee indigenous community "safety" and clean water. The Vice President of Guatemala announced on June 17, 2010, that the government would have an Organization for American States (OAS) delegation visit the mine and seek more information on environmental and health hazards but would not suspend operations unless the OAS ordered them to do so (Business Week, 2010). The OAS delegation is scheduled to visit the mine in July 2010.

The Marlin Mine was the first mine to open under the May 22, 2001 revised Guatemalan mining law (Decreto 48-97) and the first to receive IFC financing after IFC's extractive industry review in 2003 (an in-depth critical review of IFC loans related to extractive industries such as mining and petroleum extraction).

Fulmer et al. (2008) stated that 873 construction jobs were created for local residents by Goldcorp at the Marlin Mine, but by the time mining began, the number of jobs dropped to 230. Goldcorp's 2008 Annual Report (Goldcorp, 2008) stated that "98% of the 1,500 employees at the Marlin mine are Guatemalan residents, with over 66% of direct employees coming from local communities, most of them indigenous."

The people of San Miguel and Sipacapa are predominantly indigenous Mayans with distinct languages and cultures, although they share the overarching connection to a Mayan worldview and belief system. About 98% of the roughly 30,000 inhabitants of San Miguel are indigenous Mam-Mayans and speak the Mam language, which is one of the largest indigenous language groups in Guatemala. In the municipality of Sipacapa, the vast majority of the roughly 14,000 inhabitants belong to t[illegible]ipacapense-Mayan indigenous group, and approximately 70% speak Sipcapense (Fulmer et al., 2008).

The mine overlaps the municipalities of Sipacapa and San Miguel Ixtahuacan. Primary ore deposits and most of the project's land area are in San Miguel, while the processing facilities are in Sipacapa. The constitution of Guatemala provides for royalty sharing between the national government and the municipality in which a mined ore body is located. Given that all of the Marlin ore body is in San Miguel, there is no constitutionally mandated requirement to share royalties with the municipality of Sipacapa. This has also been a source of tension between Sipacapa and San Miguel, and San Miguel has been more divided into pro- and anti-Marlin camps than Sipacapa, which is largely anti-Marlin.

1.2 Timeline of exploration and production at Marlin

The timeline of mining and related activities for the Marlin Mine is presented in Table 1.

1996 to 2004

Exploration activities began in 1996, and land acquisition activities began in 1998. The environmental studies and EIA&S timeline proceeded rapidly compared to similar studies in the United States. Environmental baseline studies began in July 2002 and generally ended less than one year later in March 2003. An audit of the adequacy of the baseline sampling program was conducted by SRK (SRK, January, 2003). The EIA&S was submitted in June 2003 and approved by the Guatemalan Ministry of Environment and Natural Resources (MARN), six months later in September 2003.

MEM issued a license to Montana Exploradora for development and production of the Marlin Project in November 2003. Shortly after the license was granted, community opposition to the project began, led by the municipality of Sipicapa (AMR, 2004). Construction and development of the mine began in 2004. Development of the underground mine began in January 2004, and construction of the tailings dam began in May 2004. The feasibility study was completed in June 2004.

2005

Construction and development of the mine continued in 2005, and the first ore production began in August. Waste stripping for the open pit mine began in July 2005, and the first tailings were disposed in the tailings facility (TSF) in October 2005. Tests for metals reduction for TSF water and improvements to the INCO cyanide reduction system were conducted in 2005. A third-party environmental audit was conducted in late 2005 by MFG (2005AMR, Attachment C).

Colectivo Madre Selva filed an official complaint against the mine in 2005. The complaint was lodged to the IFC's Compliance Advisor Ombudsman's (CAO) office. The CAO accepts complaints from communities living near projects that the IFC invests in, IFC lent Montana Exploradora money for the development of the Marlin Project. The complaint asserted that the project was developed without adequate and timely consultation of indigenous peoples, and the communities of Sipacapa were concerned that the project would reduce community access to local water supplies, contaminate local waterways, and cause adverse social impacts (CAO, 2009) The CAO investigated the complaint and completed their assessment report in September 2005 (CAO, 2005). One of their primary recommendations was to establish a participatory monitoring program with community involvement. Out of this recommendation, the Asociación de Monitoreo Ambiental Comunitario (AMAC) was formed in late 2005. AMAC membership includes representatives from the communities of San Miguel Ixtahuán and Sipacapa, and technical representatives include a mining engineer from the University of San Carlos and an environmental hydrogeologist). AMAC is funded through FUNSIN (Foundation for the Advancement of Engineering – headquartered in the Guatemala School of Engineering), which received funding from the IFC (until July 2008), Montana Resources, and the Canadian Embassy (starting fourth quarter of 2008). AMAC samples some of the same sites that the mine uses for monitoring. However, AMAC uses a different analytical laboratory for its sample analysis, ALS Laboratory Group in Canada).

Table 1. Timeline of mining, environmental, and other events related to the Marlin Mine.

Date	Event
1996	• Guatemalan Ministry of Energy and Mines (MEM) invites domestic and foreign companies to explore for minerals in Guatemala • Exploration begins by Montana Exploradora de Guatemala, S.A.
1998	• Land acquisition begins • Marlin deposit discovered, December
2002	• Baseline studies begins in July • Glamis Gold acquires Montana Exploradora de Guatemala
2003	• SRK audit of baseline sampling, January • Montana acquires rights to more than 2,200 hectares of land for the project, February • Baseline studies end in March • EIA&S report submitted in June • EIA&S approved by MARN in September • MEM issues license for development and operation of Marlin Project, November • Community opposition to mine voiced, led by Municipality of Sipicapa
2004	• Underground mine development begins, January • Tailings dam construction begins, May • Feasibility Study completed in June
2005	• Colectivo Madre Selva files complaint against mine to IFC's Compliance Advisor Ombudsman's (CAO) Office • Construction of process facilities, offices, and other ancillary buildings • Waste stripping in open pit mine initiated in July • Ore production starts in August • CAO assessment report completed in September • Tailings deposition into TSF begins in October • AMAC (Asociación de Monitoreo Ambiental Comunitario)established in late 2005
2006	• Third party Environmental Audit and Review (Audit) by MFG completed in March • Construction of Phase II of tailings facility continues • IFC loan repaid • Citizen complaints about cracks in houses • AMAC collected water samples in February, May, August, November • CAO complaint closed in May • Four long-term column tests (drum tests) started • Goldcorp Inc. acquired Glamis Gold, Ltd and mine becomes part of Goldcorp in November
2007	• COPAE formed, January • Additional leaching tank added to increase gold and silver recovery;

Date	Event
	new cyanide destruction tank added • Exploration continued with new core holes in Agel and Cancil areas • Bianchini report issued in January; claimed pollution in the Tzalá River • Three new monitoring wells installed • Additional surface water monitoring point added (SW10) • Seepage from Area 5 waste dump first appears in November
2008	• Expansion of TSF continues • Secondary water treatment plant constructed to treat TSF discharge • Exploration on company-owned land and in the Cancil and Agel area continues • MARN and MEM staff visit mine to collect water samples • Community officials from San Miguel Ixtahuacán and Sipacapa visit mine, April and May • Bus carrying mine employees fired on; mine and plant shut down for 30 hrs due to power loss from sabotage, May • Ambassadors from Canada, Holland, and United Nations Development Program visit mine, May • Electrical power to mine cut off (sabotage); no gold production from June 11 – July 26 • Two Marlin Mine workers kidnapped, July • Seven internal spills in 2008 – four in process plant, three petroleum spills • AMAC samples quarterly and conducts surprise visit to mine in September • Goldcorp issues Environmental and Sustainability Policy. • Nine more long-term field column tests (drum tests) added in May and August. • Latin American Water Tribunal accuses the Government of Guatemala and Goldcorp of violating ILO 169 and causing environmental damages, September
2009	• Extraordinary Report on Marlin Mine in November • MEM and Goldcorp sign monitoring cooperation agreement with AMAC in November
2010	• Inter-American Commission on Human Rights of the Organization of American States calls for suspending operations at the Marlin Mine in May • Guatemalan government announces in June an Organization for American States visit of the mine to investigate environmental and health hazard claims

Sources: EIA, 2003; AMR, 2005, 2006, 2007, 2008; CAO, 2009.

2006 and 2007

Construction of the tailings facility continued in 2006, and no discharges of process water were released to the environment. The IFC loan was repaid in 2006, and the CAO complaint was closed in May. The MFG third-party audit was completed in March 2006. Citizens lodged complaints about cracks in their houses in 2006, based on their belief that the cracks resulted from blasting activities at the mine. AMAC conducted environmental sampling four times in 2006 as part of the independent monitoring program; samples were collected at five sampling points and sent to ALS Laboratory in Canada. In November 2006, Goldcorp acquired Glamis Gold, and Montana Exploradora and the Marlin Mine became part of Goldcorp. Comisión Pastoral Paz y Ecología (COPAE) formed in 2007. Its mission is to bring technical assistance to communities in the Department of San Marcos in defense of their lands and natural heritage, as related to multinational corporations and natural resource exploitation.

Exploration continued in 2007, with 57 new drill holes (20,479 m) completed in the Agel and Cancil areas. Three new groundwater monitoring wells were completed (MW8, MW10, and MW11), and an additional surface water monitoring station (SW10) was added in 2007. An additional leaching tank and cyanide destruction tank were added to the production facilities. Seepage from the toes of the Area 5 waste rock dump (sampling point D9) first appeared in November 2007.

2008

In 2008, the expansion of TSF continued, and a water treatment plant for anticipated TSF discharge was constructed. The plant would be activated if and when the mine needs to discharge from the tailings facility to the stream downgradient of the TSF.

Exploration continued on company-owned and other lands, including 73 drill holes on company-owned land (total of 26,360 m of core), 11 holes in the Cancil area (4,435 m of core), and six holes in the Agel area (3,170 m of core).

A number of Guatemalan regulatory agency staff, community members, and international officials visited the Marlin Mine in 2008. MARN staff visited the mine to collect water samples, including a sample of the tailings impoundment surface water, but the mine did not allow sampling (MARN is legally restricted to sampling only discharge points, and they did sample all external monitoring sites). In a follow-up visit, MEM did collect samples from the tailings impoundment (similar restrictions do not apply to MEM). However, the results were not made public because the sampled sites are on the mine property. According to the mine, the results were consistent with their own internal data (AMR, 2008). Community members from San Miguel Ixtahuacán and Sipacapa visited the mine in April and May to learn about the tailings impoundment, mining process, and the use of cyanide on the mine site. Also in May, ambassadors from Canada, Holland, and the United Nations Development Program visited the Marlin Mine.

Several violent incidents involving mine employees and local citizens occurred in 2008. All incidents are as reported in the 2008 AMR. In May, a bus carrying mine employees was fired on. In May and June, the mine was shut down when a local resident caused two different power outages. As a result of the June incident, no gold was produced from June 11 to July 26, 2008. Also in July, the mine and the Sierra Madre Foundation (funded by the mine) was asked by the municipality of Sipacapa to close its communications offices because it had received threats that a Sipacapa water source would be shut off if the offices weren't closed. The mine and Sierra Madre Foundation did close its offices. Finally, two Marlin Mine employees were kidnapped in July.

Seven internal spills occurred in 2008 – four in the processing plant (no information on composition of the spills was provided), and there were three petroleum product spills. All were contained on site and were less than 100 gallons.

AMAC sampled quarterly in 2008 (February, May, August, November), and conducted a surprise visit to the mine on September 5. No irregularities were found in the site visit. Goldcorp issued an Environmental and Sustainability Policy (Attachment B to AMR), and Marlin Mine reviewed its policies and systems to ensure compliance with corporate policy. Nine more long-term field column tests (drum tests) were added in May and August 2008.

The Latin American Water Tribunal accuses the Government of Guatemala and Goldcorp of violating ILO 169 and causing environmental damages.

2009

Monitoring of Marlin was a major focus of the October 23, 2009 Congressional report by the Extraordinary Transparency Commission (2009). The Ministry of Environment and Natural Resources (MARN) is now working as the lead agency in the Presidential Commission to implement a monitoring and enforcement program (Personal Communication, Dr. Eugenia Castro, MARN Director of Environment, 18 December 2009).

Separately from the Presidential Commission, on November 18, 2009, the Ministry of Energy and Mines (MEM) and Goldcorp signed an agreement to cooperate on monitoring with AMAC, the company-funded community monitoring non-profit organization.

2010

In May, the Inter-American Council on Human Rights of the Organization of American States calls for suspending operations at the Marlin Mine, based on a complaint by the Guatemalan Pluricultural Center for Democracy. In June, the Guatemalan vice president announces that the Organization for American States (OAS) will visit the mine and investigate claimed environmental and health hazards.

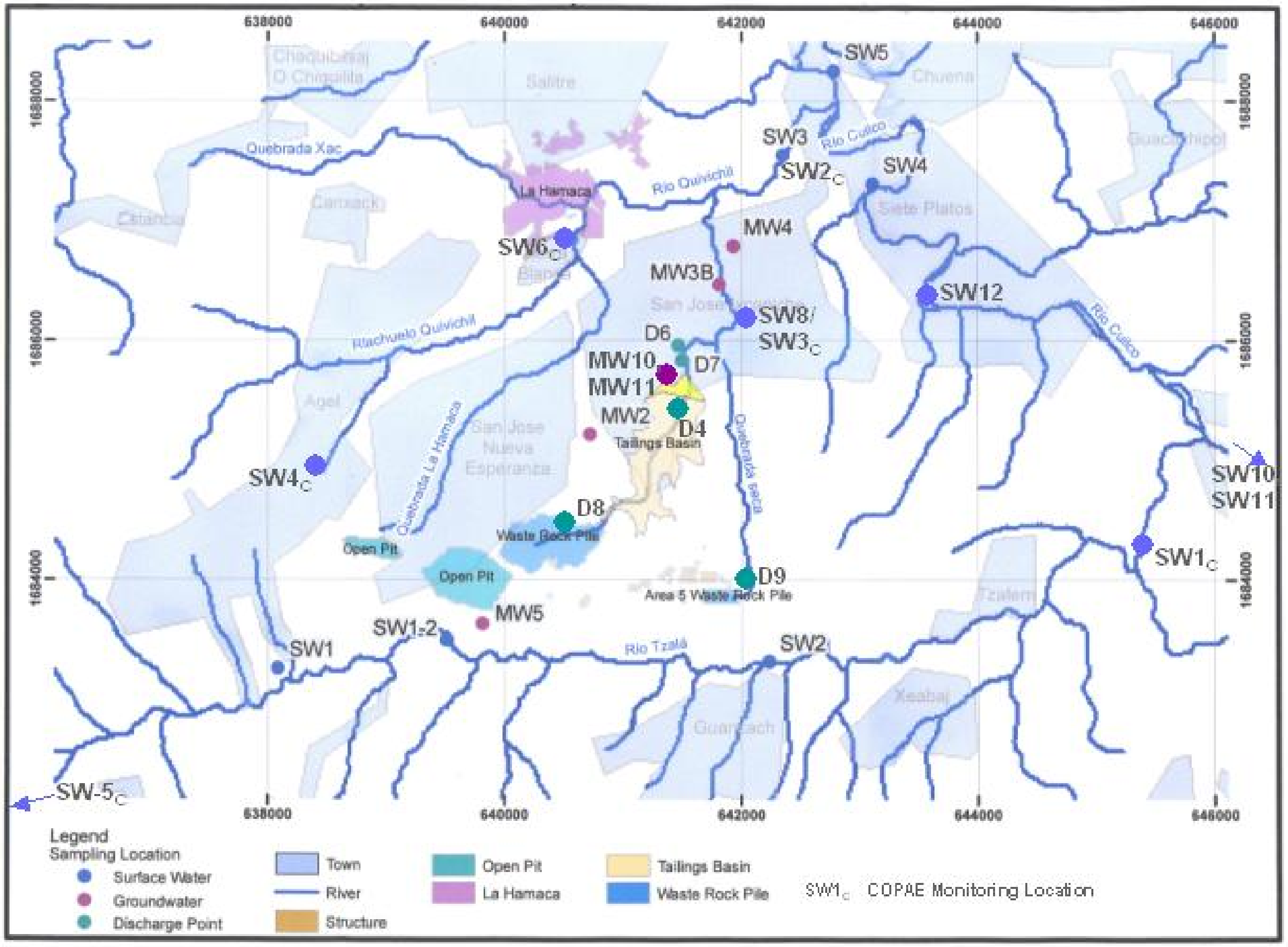
2. Summary of mine operations and waste management

2.1 *Facilities, Processes, and Chemicals Used*

The major mine-related facilities at the Marlin Mine consist of two open pits (the larger Marlin Pit and the Cochis Pit), an underground mine and associated workings, a vat leach cyanide operation, tailings facility, and waste rock dumps. Haul and access roads, an airstrip, borrow areas, and stockpiles are also located in the Quivichil watershed (AMR, 2008). The mining license covers 2,000 hectares of land in total, and the estimated disturbed area at the mine is approximately 300 hectares (Personal Communication, Lisa Wade, Goldcorp, email, April 6, 2010; also in Goldcorp's 2009 Global Reporting Initiative Report). Figure 2 shows the general locations of the major facilities. The vat leach originally consisted of four tanks in series followed by counter-current decantation; however, an additional tank was added in 2007. The tailings impoundment and the downgradient secondary collection pond (for collection of infiltration through the impoundment) are underlain by compacted clay (EIA&S, 2003). No formal pump-back/leak detection system exists for the impoundment. The Merrill Crowe Process (zinc precipitation) is used to remove gold and silver from the cyanide solution.

A sulfur-dioxide INCO process is used to neutralize the tailings and the cyanide solution (EIA&S, 2003). The underground mine and the open pits are above the local water table, but water will pool in the open pits or be encountered in the underground mine at times. Any water from the underground mine is gravity-discharged to the TSF supernatant pond (AMR, 2006, p. 51). There has been no direct discharge from the tailings impoundment to the environment as of January 2010, but surface water discharge is planned for the future. A secondary treatment plant was constructed that includes clarification, filtrations, and carbon adsorption to treat tailings impoundment discharge water if/when discharge does occur (Personal Communication, Lisa Wade, Goldcorp, February 11, 2009).

Figure 2. Location of major mine facilities and environmental monitoring locations.



Sources: Lisa Wade, Goldcorp, 2009; COPAE, 2008 and 2009.

A list of chemical substances and combustibles used at the mine and their toxicity is shown in the EIA&S (2003, pg. 45-46). The substances used or stored onsite in the greatest amounts and with the highest toxicity, flammability, or reactivity (Level I or II, high or medium degree of danger) and their use at the mine include:

- Sodium cyanide (leaching of gold and silver)
- Lime (adjust pH in tailings)
- Sodium hydroxide (pH adjustment in operations)
- Copper sulfate
- Ammonium nitrate (blasting)
- Diesel fuel, gasoline, propane (transportation vehicles).

2.2 Waste Management

The primary mine-related wastes generated on the site are waste rock and tailings. All blastholes in the open pit waste zones are sampled and analyzed for total sulfur and carbon to estimate the acid-generation potential of the rocks. A LECO analyzer is used to determine sulfur and carbon values. Although not stated in the AMRs, we assume that the results are used to determine a net-acid generating number, which is then converted to ANP and AGP ratios. Depending on the results of the tests, each blasthole is categorized non-acid generating, potentially acid generating, or acid-generating according to its derived acid-neutralizing to acid-generating potential ratio (ANP/AGP) and total sulfur content:

- Non-acid generating (NAG): ANP/AGP > 2 and/or S< 0.1%
- Potentially acid generating (PAG): ANP/AGP < 2 and >1 and NP < 20kg/t $CaCO_3$
- Acid Generating (AG): ANP/AGP < 1 and S> 0.1%.

All PAG and AG rock is mapped, flagged, and encapsulated. If there are only small amounts of PAG rock and no geologic evidence of sulfides, it is blended with NAG rock in the waste rock dump. If pyrite and gray or green colored rock is visible in rock identified as NAG, it is sent to the encapsulation area. All waste rock from the underground mine is considered and handled as PAG rock; 80% of the underground waste rock was originally placed in Area 5 of the dump (designed to handle PAG rock), and 20% is used as cemented backfill in the underground mine. Currently, nearly all of the underground mine waste rock is used as cemented backfill in the stopes of the underground mine (AMR, 2006).

Other related wastes are organic wastes (sewage), petroleum-contaminated soil (from vehicle and fuel leaks/spills), chemical contaminated wastes such as empty cyanide bags and boxes), lead-contaminated wastes from the fire assay (for analysis of ore and other rock samples (cupels, crucibles, slag), and used oil and scrap metal (AMR, 2006). A non-hazardous waste landfill is located near the lower platform of the process plant (will be moved to main waste dump). Organic wastes are composted and later used as fertilizer in revegetation areas. Petroleum-contaminated soil is bioremediated on-site. Chemical-contaminated waste is incinerated daily, and the ash is tested and disposed of in the waste rock dump. Lead-contaminated wastes (fire assay) are reintroduced into the process circuit at the mill. Used oil and scrap metal is recycled by outside companies, and used in a cement kiln and at a metal foundry (AMR, 2006, p. 57).

3. Potentially Relevant Standards and Monitoring Locations

3.1 Potentially Relevant Standards

MARN (Ministry of Environment and Natural Resources) approves the EIA&S (Environmental and Social Impact Statement). The Marlin Mine must comply with the recommendations in the EIA&S and the 13 terms of MARN resolution 779-2003/CRMM/EM. The required discharge locations are:

- Pit discharge
- Tailings discharge
- Waste dump
- Area 5 waste dump
- Oil-water separator.

The discharge samples must meet IFC and MARN effluent standards and are monitored quarterly (AMR, 2008). A list of the potentially relevant standards is contained in Table 2.

Guatemala has no water quality standards for natural waters based on beneficial use. According to the EIA&S, surface water and groundwater quality sampling results should be examined for temporal concentration trends, but no water quality limits are applied. Water quality standards for surface water and groundwater should address possible uses, for example, habitat for aquatic biota, drinking water, agricultural use, and livestock watering. U.S. water quality standards for protection of aquatic life (from the Clean Water Act) and drinking water are listed for comparison in Table 2.

3.2 Monitoring Locations

The surface water, groundwater, and discharge monitoring points, their watersheds, and upstream mining facilities are shown in Table 3 (also see Figure 2). Not all locations are monitored by the mine at all times. AMAC monitors the same locations as the mine. Comisión Pastoral Paz y Ecología (COPAE) monitors some of the same sampling points as the mine but has added a location upstream of SW3 and La Hamaca ($SW6_C$) and another more upstream than Goldcorp's SW1 ($SW5_C$). The mine's monitoring results must be submitted to MARN and MEM on a quarterly basis.

Table 2. Potentially relevant water quality standards for discharges and surface and ground waters at the Marlin Mine.

Parameter	**Units**	**Guatemalan MARN[1]**	**Guatemalan COGUANOR (potable water)[2]**	**World Health Organization (WHO)[3]**	**IFC Effluent Guidelines[4]**	**U.S. Safe Drinking Water Act[a, 5]**	**U.S. Clean Water Act[b, 6]**
pH	S.U.	6 - 9	6.5 - 8.5	6.5 - 8.5	6-9	6.5 - 8.5	6.5 - 9
Total Dissolved Solids	mg/L		1,000			500	
Total Suspended Solids	mg/L	100			50		
Nitrate+ Nitrate	mg/L as N	20	10	50[e], 0.2[f]		10	
Ammonia	mg/L as N						0.23
Sulfate	mg/L		250	250[g]		250	
Oil and Grease	mg/L	10			10		
Total Cyanide	mg/L	1.0	0.07	0.07	1		0.0052
WAD Cyanide	mg/L				0.5		
Free Cyanide	mg/L				0.1		
Aluminum	mg/L		0.1	0.5		0.05 - 0.2	0.087
Arsenic	mg/L	0.1	0.01	0.01	0.1	0.01	0.15
Cadmium	mg/L	0.1	0.003	0.003	0.05		0.00025
Chromium	mg/L	0.1[d]	0.050	0.05	0.1[d]		0.011[d]
Copper	mg/L	3.0	1.5	2	0.3	1.3	9.0
Iron	mg/L		1.0	0.1	2.0	0.3	1.0
Lead	mg/L	0.4	0.010	0.010	0.2	0.015	0.0025
Manganese	mg/L		0.5	0.4		0.05	
Mercury	mg/L	0.010	0.001	0.006	0.002	0.002	0.00077
Nickel	mg/L	2.0		0.070	0.5		0.052
Zinc	mg/L	10	70.0	1.5	0.5	5	0.120

a Relevant for groundwater and surface water

b For protection of surface water aquatic life; dissolved chronic concentration; assumes hardness of 100 mg/L as $CaCO_3$ for cadmium, copper, lead, zinc

c total concentration

d Chromium VI

e Nitrate as NO_3^-
f Nitrite as NO_2^-, long-term exposure
g No health-based limit is established, but because of the gastrointestinal effects associated with drinking high-sulfate water, health authorities should be notified of sources that contain sulfate in excess of 500 mg/l (WHO, 2008).
MARN = Guatemalan Ministry of the Environment and Natural Resources
COGUANOR = Guatemalan Standards Commission (maximum permissible limits).
IFC = International Finance Corporation of the World Bank.
1 Goldcorp 2007 AMR, Attachment C.
2 COGUANOR, 2003.
3 WHO, 2008
4 IFC, 2007.
5 U.S. EPA, 2009a.
6 U.S. EPA, 2009b.

Table 3. Water Quality and Water Level Monitoring Locations at the Marlin Mine.

Sample ID	**Monitoring Entity**	**Groundwater/ Surface Water/ Discharge**	**Watershed**	**Upstream/ gradient Mine Facilities**	**Comments**
SW1	Montana/Goldcorp, AMAC, COPAE, MARN	Surface water	Tzalá	None	Upstream of all mine facilities on Rio Tzala; similar to COPAE's $SW5_C$ but more downstream
SW1-2	Montana/Goldcorp, AMAC	Surface water	Tzalá	Marlin Pit and access roads	Added to increase sampling on Tzalá upstream of SW2
SW2	Montana/Goldcorp, AMAC, COPAE, MARN	Surface water	Tzalá	Marlin Pit and access roads	Downstream of mine facilities on Rio Tzalá; similar to COPAE's $SW1_C$
SW3	Montana/Goldcorp, AMAC, COPAE, MARN	Surface water	Riachuelo Quivichil	Tailings impoundment, Marlin and Cochis pits, cyanide facilities, waste rock dumps	Riachuelo Quivichil upstream of confluence with Rio Cuilco; similar to COPAE's $SW2_C$
SW4	Montana/Goldcorp, MARN	Surface water	Cuilco	Far downstream of Marlin Pit and access roads	Non-mining aggregate quarry is upstream of this location
$SW4_C$	COPAE	Surface water	Riachuelo Quivichil	None	Xkus spring, flows to Riachuelo Quivichil
SW5	Montana/Goldcorp, AMAC, MARN	Surface water	Cuilco	All mine facilities	Downstream of all mining facilities in Rio Tzalá and Rio Quivichil watersheds
$SW5_C$	COPAE	Surface water	Riachuelo Quivichil	None	Riachuelo Quivichil upstream of mining influence, also known as "Canshac" or "Q'an shaq"
SW7	Montana/Goldcorp	Surface water	Riachuelo Quivichil	Future La Hamaca facilities	Riochuelo Xac; tributary to Riachuelo Quivichil

Sample ID	Monitoring Entity	Groundwater/ Surface Water/ Discharge	Watershed	Upstream/ gradient Mine Facilities	Comments
SW8	Montana/Goldcorp, COPAE	Surface water	Riachuelo Quivichil	Tailings impoundment	Quebrada Seca upstream of SW3 and downstream of tailings impoundment (downstream of confluence with tailing tributary); not perennial; similar to COPAE's SW3$_C$
SW10	Montana/Goldcorp	Surface water	Cuilco	None	Upstream of Rio Tzalá confluence with Rio Cuilco; no mining influence; aquatic biology station
SW11	Montana/Goldcorp	Surface water	Cuilco	None	Rio Cuilco upstream of confluence with Rio Tzalá
SW12	Montana/Goldcorp	Surface water	Cuilco	Marlin Pit and access roads	Rio Cuilco downstream of confluence with Rio Tzalá, upstream of Riachuelo Quivichil
PW7	Montana/Goldcorp	Groundwater	Riachuelo Quivichil	Waste rock pile, tailings impoundment	Generally for monitoring water levels related to the tailings impoundment seepage
MW2	Montana/Goldcorp, AMAC	Groundwater	Riachuelo Quivichil	None	West of the tailings impoundment; upgradient location
MW3B	Montana/Goldcorp, AMAC, MARN	Groundwater	Riachuelo Quivichil	Waste rock pile, tailings impoundment	North/northeast of the tailings impoundment (downgradient)
MW4	Montana/Goldcorp, AMAC	Groundwater	Riachuelo Quivichil	Tailings impoundment	Downgradient of the tailings impoundment, dry, abandoned in 2006
MW5 / PSA-1 (production well)	Montana/Goldcorp, AMAC, MARN	Groundwater	Tzalá	None	Production well; ~300m deep, avg pumping rate is 10L/s. South of Marlin Pit, near Rio Tzalá.
MW8	Montana/Goldcorp	Groundwater	Riachuelo Quivichil	None	Upgradient of tailing impoundment near Agel; installed in 2007; sabotaged

Sample ID	**Monitoring Entity**	**Groundwater/ Surface Water/ Discharge**	**Watershed**	**Upstream/ gradient Mine Facilities**	**Comments**
MW10	Montana/Goldcorp	Groundwater	Riachuelo Quivichil	Tailings impoundment	Installed in 2007; vandalized soon after created, just now coming back online
MW11	Montana/Goldcorp	Groundwater	Riachuelo Quivichil	Tailings impoundment	Installed in 2007; vandalized soon after created, just now coming back online
D1	Montana/Goldcorp	Discharge	Tzalá	Underground mine	Water collected from underground mine, sent to tailings impoundment
D4	Montana/Goldcorp, MARN	Discharge	Riachuelo Quivichil	Tailings impoundment	Water on tailings impoundment near dam (Note: Goldcorp says D2 and D3 never existed)
D5	Montana/Goldcorp	Discharge		Processing plant	Samples tailings leaving the INCO system; not reported to the public
D6	Montana/Goldcorp, AMAC, MARN	Discharge	Riachuelo Quivichil	Tailings impoundment	Return tailings seepage, located north of the tailings dam; AMAC has sampled
D7	Montana/Goldcorp, AMAC	Discharge	Riachuelo Quivichil	Tailings impoundment	In drainage downstream of tailings dam; discharge of tailings water to the environment (has not yet occurred)
D8	Montana/Goldcorp	Discharge	Riachuelo Quivichil	Main waste rock dump	Now under tailings beach, as designed, so cannot be sampled
D9	Montana/Goldcorp	Discharge	Riachuelo Quivichil	Small waste rock pile	Waste rock seepage; D9 dump is closed and revegetated; mine inspects toe of dump quarterly and collects sample if seepage exists

Sources: 2008 AMR; Personal Communication, Lisa Wade, Goldcorp; email, 2/20/09 and 10/5/09.

Required monitoring (see early AMRs too, and above from 2006 AMR) includes only six surface water points, two downstream of the tailings dam, and four groundwater monitoring points. There are seven required discharge monitoring points, but they are not monitored on a regular basis, and are not consistently publicly reported. The surface water and groundwater monitoring system need improvement to reliably determine if releases from mining are adversely affecting water resources. More groundwater and surface water monitoring points are needed to evaluate potential impacts to drainage downstream and downgradient of the mine and to determine groundwater flow directions.

3.2.1 Surface water monitoring locations

Surface water monitoring locations identified in the EIA&S included SW1, SW1-2, SW2, SW3, SW4, and SW5. Surface water and sediment samples should be collected quarterly and annually, respectively. No standards are applied to surface water sampling results, but upstream locations are compared to downstream locations, and trends in water quality should be observed. Location SW10 (upstream of Rio Tzalá confluence with Rio Cuilco) was added to monitor aquatic biology at a location with no mining influence. Aquatic biological resources are monitored in Quivichil Creek, Cuilco and Tzalá rivers twice annually.

Potable water is also monitored quarterly and compared to values from the Guatemalan Standards Commission (COGUANOR).

3.2.2 Groundwater monitoring locations

Groundwater monitoring locations required in the EIA&S included MW2 (replaced with MW8), MW3 (replaced with MW3B and MW10), and MW4 (replaced with MW11). Again, no standards are applied to groundwater samples, but trends in water quality should be documented. Groundwater wells were replaced due to blockage from a break in the PVC pipe (MW2), and sabotage (MW3). Monitoring wells MW10 and MW11 were completed to monitor groundwater quality and levels downgradient of the TSF.

3.2.3 Discharge monitoring locations

The discharge monitoring locations begin with a "D." Points D2 and D3 have never existed (Personal Communication, Lisa Wade, October 5, 2009). As of December 2009, there has been no official point-source discharge from the tailings facility to the environment, even though the first discharge was expected in 2007, according to the Environmental Impact Assessment. As shown in Table 3, discharge monitoring point D1 is in the underground mine; point D4 is on the tailings impoundment; D6 is tailings seepage from a pond that is pumped back to the tailings impoundment; D7 is in the drainage immediately downstream of the tailings dam; and points D8 and D9 sample (or previously sampled) discharge from waste rock dumps. The AMRs have limited data from locations D1, D4, and D9.

4. Environmental Setting

4.1 Climate

The Marlin Mine is located in the highlands region of Guatemala in an area with many microclimates resulting from high topographic relief. The climate in the Marlin Mine area is temperate with mild and humid winters. The rainy season is between May and October (June and September are most rainy), and the dry season is from February to April. The area gets ~1,000 mm of precipitation per year, with hurricanes occurring in the fall. Approximately 80% of the storms occur in September and October (EIA&S, 2003).

4.2 Geologic setting

The geology of the project area consists of five major units. The oldest unit is the metamorphic basement rocks of Permian and pre-Pennsylvanian age that consists of gneiss, schist, and marble. A Tertiary clastic unit overlies the basement rock and contains sedimentary and volcanic conglomerates and breccias. The next youngest unit is the Tertiary Marlin Formation, a series of andesitic lavas and intrusions (including the Tzalá-Agel River intrusive complex located along these rivers) and andesitic dikes with ~1% pyrite. Rocky areas north and northwest of the intrusions contain abundant chalcopyrite (copper iron sulfide) with disseminated pyrite typically in the 5 to 10 % range. Pyrite is the primary mineral responsible for acid drainage, and weathering of this material can produce low pH values during weathering. Although the EIA&S is not specific, we assume the Marlin Formation is the host rock for the Marlin ore deposit. Younger porphyry dikes, possibly of Quaternary age, cut the Marlin formation and might be related to the compositionally similar Marlin complex. The youngest rocks in the area are Quaternary highly fractured (10 fractures/m^2) pyroclastic deposits (rocks formed by coalescing of exploded volcanic fragments). Monitoring wells MW-3, MW-4, and MW-6 are completed in the pyroclastic deposits (EIA&S, Chapter 4).

4.3 Hydrologic setting

4.3.1 Surface water

The Marlin Mine is located in two sub-watersheds, the Riachuelo Quivichil (918 km^2) and the Río Tzalá (60 km2). Both watersheds drain to the Río Cuilco (450 km2), which ultimately runs into Mexico and eventually discharges into the Gulf of Mexico. The Mexican border is approximately 80 km downriver from the Riachuelo Quivichil - Río Cuilco confluence (2008 AMR and EIA&S, 2003).

The discharge of the Río Tzalá varies widely from the dry to the wet season (0.5 to 7 cubic meters per second, or m^3/s; average flow is 1.31 m^3/s). Riachuelo Quivichil has little flow during the dry months (flow ranges from 0 to 0.7 m^3/s, average flow is 0.13 m^3/s). Peak flows generally occur in September (EIA&S, Table 5.6-12). Water in the Río Tzalá is not used for agriculture or drinking, in part due to the steep slopes on both sides of the river (EIA&S, 2003). Some people do now irrigate crops with water from Riachuelo Quivichil (Personal Communication, Lisa Wade, Goldcorp, , March 2010).

Baseline flow monitoring was collected manually using current meters monthly in 2002 and 2003. For the last two years, Goldcorp has been monitoring flow using pressure transducers between SW1 and SW1-2 (Río Tzalá), at SW4 (Río Cuilco – installed in May 2009), and SW8 (Quebrada Seca) (Personal Communication, Lisa Wade, Goldcorp, email, September 22, 2009).

4.3.2 Groundwater

Groundwater levels under the open pits were at least 200 meters below ground surface (bgs). The EIA&S states that aquifers in the project area function as separate hydrogeologic units with minimal connection, but there is not enough information on groundwater levels to confirm this statement. In addition, there is no information on groundwater flow directions, which is a common component of EISs in the United States. Without information on groundwater flow directions, it is impossible to know which groundwater monitoring wells are upgradient and downgradient of possible contaminant sources. Lack of knowledge about groundwater flow directions also affects knowledge about which surface water locations are up- or down-gradient of mine facilities because movement of groundwater into surface water is not well understood. Therefore, a reliable monitoring network cannot be established for the Marlin Mine before groundwater flow directions have been determined.

Permeabilities of a siltstone in the Tertiary clastic unit were relatively low and ranged from 6.8×10^{-6} to 2.25×10^{-4} centimeters/second (cm/s) (EIA&S, 2003, p. 5-92). A water balance model was constructed for the tailings impoundment (EIA&S, 2003, p. 3-54), but infiltration through the tailings impoundment was not included in the balance. As noted in the EIA&S (2003), discharge from the tailings impoundment to the environment was expected to occur in 2007, most likely based on the tailings impoundment water balance model, yet discharge is still not needed (mid-2010). If infiltration has been occurring, water might not be building up on the surface of the impoundment as much as predicted. More investigation of groundwater downgradient of the tailings impoundment is needed to fully evaluate this issue.

4.4 Baseline water quality

4.4.1 Surface water baseline

Surface water quality samples were collected for the EIA&S from July 2002 through March 2003, a period of only 8 or 9 months (< 1 year), at all surface water monitoring stations (EIA&S, 2003). However, baseline surface water collection continued after the EIS was submitted through May 2004 (Lisa Wade, Goldcorp, personal communication, March 2010). The results of the surface water quality baseline study (through March 2003) are contained in Annex 13.1-A to 13.1-I, and a summary of the concentrations of a few of the constituents is presented in the EIA&S (2003, Figure 5.6-10 and –11). These figures demonstrate that non-mining-related temporal changes in concentrations of chemical oxygen demand (COD), dissolved oxygen (DO), barium (Ba), strontium (Sr), pH, total suspended solids (TSS) have occurred over time and under different flow conditions. Concentrations of suspended sediment, total iron, and total aluminum increase during the rainy season upstream and downstream of the mine area. Sediment metal concentrations were also examined as part of the EIA&S.

4.4.2 Groundwater baseline

Baseline groundwater quality was reviewed using only two springs. No groundwater wells were used; therefore, deeper baseline groundwater quality was not investigated before mining began as part of the EIA&S. The water quality data for the springs are included in the environmental characterization annexes, but no summary of the results were included in the main body of the EIA&S. Some groundwater baseline data is available through May 2004 (Lisa Wade, Goldcorp, personal communication, March 2010).

4.5 Biologic systems

A rapid biological assessment was conducted as part of the ESI&A. Two biologists spent 7 to 9 days in the field during the rainy season (August 2002) and the dry season (February 2003) and evaluated aquatic habitat in downgradient rivers and the abundance of fish and macroinvertebrates at five stations (EIA&S, 2003, p. 5-49). Baseline biologic data is also available through May 2004 (Lisa Wade, Goldcorp, personal communication, March 2010). The assessment also included a characterization of vegetation, the abundance of nematodes, soil quality, and physical/chemical analysis. The EIA&S provides numeric values for biological quality for each station and each component. The rapid biological assessment also examined birds, mammals, and reptiles.

5. Potential and Predicted Environmental Impacts and Proposed Mitigation Measures

According to the EIA&S, the Marlin project was designed to conform to North American standards and will employ the best practices of environmental management to minimize environmental impacts and comply with Guatemalan regulations, international guidelines for environmental management, and the environmental policies of Glamis Gold and Montana (EIA&S, 2003, p. 2-2 to 2-3).

As with U.S. Environmental Impact Statements, positive and negative impacts were identified for conditions with mitigation and without mitigation (see Kuipers et al., 2006). Following the approach in Kuipers et al. (2006), we distinguish between “potential” impacts, which are those predicted to occur without mitigation measures and “predicted” impacts, which are those predicted to occur after mitigation measures are in place. In the United States, permits are granted on the basis of “predicted” rather than “potential” impacts.

The Marlin Mine EIA&S also identified mitigation and contingency measures that would help prevent or minimize negative impacts to the environment. Table 6.1-6 in the EIA&S identified the predicted impacts (positive and negative) associated with geomorphology (landscape alteration), water bodies, atmosphere, soil, flora and fauna (including aquatic life), social-cultural, and visual components. Impacts were defined as a possible change in an environmental parameter in a specific period and a defined area that resulted from the development of the project, compared with the situation that would have occurred without the project (ESI&A, p. 6-2). The definition of impact came from the Interamerican Development Bank (IDB) (Banco Interamericano de Desarrollo, 2001). Impacts can be positive or negative. Environmental impacts were evaluated based on World Bank guidelines (The World Bank, 1998).

The importance of the each predicted impact was identified in the ESI&A as:

- low negative or positive impact
- moderately negative
- highly negative
- moderately positive
- highly positive.

A numeric range is associated with each level, and Chapter 6 in EIA&S discusses how the numbers were derived. Even though the values are numeric, the scoring is general rather than specific.

The only strongly negative impacts were:

- modification of the general landscape from mining and blasting, development of the open pit, and deposition of waste rock and tailings;
- impact on the landscape from deposition of the waste rock dump and tailing deposit
- noise contamination from processing (milling during beneficiation)
- visual impacts to the landscape attributes from mining and blasting (most highly negative impact)
- visual impacts to the “fragility” of the landscape from development of the pit.

No strongly negative impacts were identified for water quality or quantity.

The predicted impacts were rated during different phases of mining, starting with acquisition of lands and continuing through construction, operation, and closure. Table 6.1-6 in the ESI&A identifies the importance of each predicted impact before and after mitigation measures are put in place.

Section 5 of the report identifies the potential impacts (pre-mitigation) to water quality and aquatic life and the mitigation and contingency measures identified in the EIA&S. Section 6 discusses actual water quality and quantity data and information available from parties that are monitoring the mine. Section 7 serves as a summary of Sections 5 and 6 and compares potential, predicted (after mitigation), and actual water quality and proposed mitigation measures.

5.1 Geochemical testing and modeling

According to the EIA&S and subsequent Annual Monitoring Reports, the potential for acid drainage of the overburden is very low, based on initial characterization studies on exploration drill hole materials (EIA&S, p. 3-32). No other information is provided in the main body of the EIA&S on the results of the geochemical characterization studies. Other studies will be conducted during the operation phase, including (EIA&S, p. 3-32) acid-base accounting (ABA) testing, kinetic testing, column tests, and field geochemical tests. Although more geochemical work was conducted after the EIA&S was completed, more extensive geochemical testing should have been conducted on more samples during the exploration phase, or certainly before mining began. This type of information is crucial for developing effective waste rock management plans.

Long-term column testing ("drum tests") is still being conducted to evaluate the longer term acid generation and contaminant leaching potential. There are 13 drum tests currently (3 from September 2006, 7 added in May 2008, and 2 more in August 2008, and one was not identified). The drums contain various rock types. Acid-base accounting is conducted on samples from each drum, and weekly samples of water are collected from the bottom of the drums and analyzed for pH conductivity. A longer list of analytes is determined monthly during the rainy season.

A tailings water balance model was conducted for EIA&S. However, infiltration through the impoundment was not considered in the model. The model predicted that direct discharge to the environment would be required by 2007, yet it has not yet been needed at the writing of this report (early 2010). If infiltration through the impoundment has been occurring, it could explain why the prediction was wrong.

5.2 Water Body Potential Impacts - General

The ESI&A evaluated seven potential general impacts to water bodies:

- changes in surface water and groundwater flow
- changes in surface water and groundwater quality
- impacts to the quality of water in function and actual use
- alteration of runoff or drainage network, and
- impacts to water from acid rock drainage.

As noted above, no strongly negative impacts were identified for water quality, water quantity, or water use. The moderately negative impacts identified for water bodies were:

- Groundwater flow from pit drainage (during operation)
- Water quality and uses from mining and blasting (during operation)
- Alteration of runoff or drainages from mining and blasting and waste rock dumps
- Impacts to water quality from acid rock drainage from pit drainage and waste rock dumps (during operation) and closure of the heap and the tailings impoundment

The EIA&S also identified eight positive impacts associated with water bodies (Table 6.1-6). Seven of the eight impacts should not be considered positive because impacts should be evaluated relative to baseline conditions (before mining began) rather than conditions resulting from mining operations. Five of the seven impacts were associated with revegetation/reforestation practices and positive impacts to water quality and quantity, one was for recovery of construction impacts during operation, one was for treatment of sewage and management of residuals during operation. The last identified positive impact related to water bodies was for drainage from the open pit, because the drainage will add flow to surface waters. This positive effect is especially unwarranted, because the pit takes away much more water supply that it returns to streams, and it ignores the potential adverse impact of pit drainage to surface water quality.

5.3 Potential and Predicted Water Quality Impacts

The potential water quality impacts identified in the EIA&S and the early Annual Monitoring Reports by Montana Resources include:

- Cyanide in the tailings could represent a threat/danger to the environment
- Moderately negative impact to water quality from mining and blasting (during operation)
- Moderately negative impact to water quality from pit drainage and waste rock dumps (during operation) and closure of the heap and the tailings impoundment. The potential for acid drainage and release of metals from the waste rock is low.
- Surface water could see increases in TSS
- It is possible that spills of fuels, chemicals, reagents, or waste water could impact groundwater quality
- Water stored in TSF will meet IFC effluent standards (2006 AMR)

After mitigation (“predicted” impacts) were much reduced and included:

- Cyanide in the tailings will not represent a threat/danger to the environment. Water stored in TSF will meet IFC effluent standards
- No remaining moderately or strongly negative impacts to water quality during or after mining
- “Tolerable” impacts related to TSS in surface water
- No impacts to groundwater because the tails will be neutralized before being put in the impoundment, and the impoundment will be designed and constructed to minimize infiltration of water to groundwater (EIA&S, p. 2-18).

5.4 Water quantity (or quantity/quality) predictions

The potential water quantity (or combined water quality and quantity) or water use impacts identified in the EIA&S and the early Annual Monitoring Reports by Montana Resources included:

- The potential was identified for an increase in the phreatic surface in the TSF abutment which could potentially result in seepage daylighting in the drainage to the east (2006 AMR)
- First discharge from TSF to environment will occur in late 2007 during rainy season, or during 2008 rainy season, depending on precipitation and storm intensity in 2007 and construction schedule for dam (2006 AMR)
- During the dry season, ~85% of the water needed for mining will come from the tailings impoundment; the remainder (0.019 m^3/s) will be pumped from the Río Tzalá. During the wet period, no water will be pumped from the Río Tzalá for the mine (EIA&S, 2003, p. 2-18)
- A well drilled to 240 m depth at the proposed lowest point in the pit found no groundwater, so they assume the pit will be dry and no dewatering will be required (EIA&S, 2003, p. 2-18)
- There will be no impacts to actual or potential surface water or groundwater use.

For water quantity and water use, no strongly or moderately negative impacts were identified, and predicted impacts did not differ markedly from potential impacts.

5.5 Predictions about Aquatic Biological Resources

The potential impacts to aquatic biological resources identified in the EIA&S and the early Annual Monitoring Reports by Montana Resources included:

- Moderately negative impacts from storage and manipulation of combustibles and drainage of the pit during operation and from regrading and closure of the waste rock dump and tailings impoundment
- There could be impacts to aquatic life from increases in suspended sediment during the rainy season.

No remaining moderately or strongly negative impacts to aquatic life were predicted during or after mining after mitigation measures were installed.

5.6 Mitigation and Contingency Measures

Table 8.1-1 identifies mitigation measures for most, but not all, of the identified negative impacts. The mitigation measures were broken down into those for impacts under the direct influence of the mine, indirect influence of the mine, at the national level, and related to traffic effects. Our evaluation focused on mitigation measures related to areas and impacts under the direct influence of the mine because this included all the potential environmental impacts. Each predicted impact identified planned mitigation measures and, for certain components, contingency plans.

The mitigation measures for landscape, water bodies, air, soil, flora and fauna generally included:

- Limiting disturbance, where possible
- Limiting the amount of stored chemicals and combustibles, where possible

- Preserving and storing topsoil for remediation and plant test plots
- Dust suppression and minimization
- Integrating facilities with the landscape by regarding and planting vegetation
- Using best management practices or plans for erosion, surface runoff, storage and use of combustibles and chemicals, disposal of wastes, wildlife, and forests
- Designing containment for process solutions, only discharging treated process solutions
- Simultaneous remediation, where possible
- Controlling introduction of non-native plants during revegetation/remediation
- Reforestation of 300 hectares during construction and operation
- Controlling access for collection of plants and hunting
- Remediation, revegetation, neutralization of cyanide during closure
- Sizing, location, design, maintenance, and monitoring of sanitary and septic systems
- Monitoring of groundwater, potential for acid generation and metal leaching, noise during operations.

The mitigation measures proposed for closure and remediation are not truly mitigation because they do not limit potential impacts during operations.

In addition to mitigation measures, a limited number of contingency plans were identified for:

- Geomorphology/landscape
- Destabilization of slopes/landslides and subsidence
- Water bodies (for water quality and impacts to water from acid rock drainage)
- Air (for noise contamination)
- Soil (for changes in soil quality)
- Flora and fauna (for disruption of aquatic life)
- No contingency plans were identified for the social-cultural component.

Where contingency measures or plans were identified, they mostly addressed problems during closure rather than during operations. The only contingency measures proposed during operations were monitoring of water quality, monitoring of acid generation and metal leaching potential, and mixing of acid-generating with non acid-generating rocks. One of the main mitigation measures for protection of water quality and aquatic life during operation is monitoring, but the water quality monitoring network is inadequate to reliably determine if there are adverse effects to groundwater or surface water resources.

The Environmental Management Plan includes separate plans (some are appended to the EIA&S) that address:

- Forestry
- Wildlife
- Treatment of residual waters (all domestic and project waters will be treated before disposal, if needed)

- Prevention and control of acid rock drainage (minimize the exposure to air and water of PAG rock and monitoring/evaluation)
- Management of waters
- Management of materials and wastes
- Environmental monitoring plan
- Contingency plans
- Environmental audits
- Management of abandoning the area and restoring the affected ecosystems.

An oversight committee is proposed to ensure that the environmental management plan (which includes monitoring) is being implemented. The committee's report should be included in the monitoring reports (EIA&S, 2003, p. 2-23).

6. Available water resources information

6.1 Sources and quality of available water quality data and responsiveness and cooperation of monitoring entities

The primary entities that have collected and analyzed water quality samples from the Marlin Mine are:
- Goldcorp/Montana Resources
- AMAC
- COPAE
- MARN
- MEM.

We formally requested data from all five sources via email and telephone and received reports and monitoring data and information from all except MEM.

6.1.1 Goldcorp

Overview and Accessibility of Information

Available information from Goldcorp included the annual monitoring reports from 2004 through 2008 (Montana Exploradora de Guatemala, S.A. 2005 through 2009) and electronic data and other information received directly from Goldcorp. Our primary contact at Goldcorp was Lisa Wade, the environmental manager of the mine. We had frequent email contact with Ms. Wade, had three phone calls to discuss the data, and met in person in Denver, Colorado, with Ms. Wade and Jim Schenck of Goldcorp in October 2009. Ms. Wade responded to all our requests and provided electronic files (in Excel) of water quality data and streamflow for surface water and groundwater monitoring locations from 2005 through June 2009. However, we did not receive electronic data for any of the discharge monitoring points because no discharge to the environment has yet occurred. She also provided us with electronic versions of maps that were available only in pdf format in the annual monitoring reports. E-Tech feels that we received a high level of cooperation from Goldcorp in providing environmental monitoring information and data.

Data Quality

Goldcorp has used a number of laboratories since 2002, including IAG (2002), XENCO (2002 – late 2004), AGAT (late 2004 – 2005), SGS (Sept 2005 – January 2006), ACZ (early 2006 – late 2007), and SVL (early 2008 – present). Goldcorp/Montana changed laboratories to improve data quality (to address laboratory contamination issues) and to improve turn-around times. SGS had a laboratory at the mine where they analyzed metallurgical samples, and the environmental samples were sent to this laboratory. However, some of the analytical results were anomalously high, likely because the lower-concentration water samples were analyzed on the same instruments as the high-concentration metallurgical samples. Goldcorp then switched to ACZ Laboratories in Steamboat Springs, Colorado, and this laboratory is certified to run low-level environmental samples (2005 AMR). Metal detection limits (the lowest concentration detectable) improved noticeably after work was turned over to ACZ (2006 – 2007). When Goldcorp changed to SVL after 2007, detection limits rose again.

Protocols for sampling, analytical methods and detection limits, and quality control procedures were not available in the AMRs. However, this information was received upon request from Goldcorp.

Goldcorp has a monitoring plan that identifies promises made in the EIS&A related to monitoring and the goals of surface water and groundwater monitoring and contains information on the analytical parameters, methods, and detection limits (Appendix B). (Montana Exploradora de Guatemala S.A., 2008a). More specific standard operating procedures are contained in a separate document (author -unknown, 2006). The monitoring plan mentions blanks and duplicate samples (Appendix A), but the appendices were not included in the version we received from Goldcorp. Goldcorp uses chain of custody forms and has protocols for preservation of samples. The monitoring plan and the standard operating procedures do not state clearly which samples are filtered or unfiltered. However, the water quality data for surface water show that filtered and unfiltered samples are collected for all metals and major cations. Results for groundwater samples show that filtered and unfiltered samples were collected from MW3 and MW5 (total and dissolved metals analyses are available), but only filtered samples were collected from MW8, MW10, MW11, and PW7. Field parameters measured are temperature, pH, specific conductance, and dissolved oxygen (surface water and groundwater samples). Goldcorp measures fewer parameters in surface water and groundwater samples than AMAC does (e.g., oil and grease, total petroleum hydrocarbons, and certain metals are not included in Goldcorp's list). Goldcorp laboratory measurements are: pH, specific conductance, alkalinity, ammonia, chloride, fluoride, nitrate+nitrite as N, sulfate, sulfide, total phosphate as P, total cyanide, WAD cyanide, total dissolved solids, total suspended solids, total solids, chemical oxygen demand, aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, mercury, molybdenum, nickel, phosphorous, potassium, selenium, silica, silver, sodium, tin (groundwater only), thallium, titanium, vanadium, and zinc.

6.1.2 AMAC

Overview and Accessibility of Information

AMAC is a community-based monitoring organization that is currently funded through a foundation known as La Fundación para la Superación de la Ingeniería (FUNSIN), which receives financial support from Montana Resources and the Canadian Embassy. Our main contact at AMAC has been Professor Julio Luna, of the Engineering faculty at the University of San Carlos of Guatemala, and we were put in touch with him by Jim Rader of Avanzar in Vancouver, British Columbia, Canada. Professor Luna is the technical team director for AMAC; the President of AMAC is Herminio Ramirez Valentin.

The idea to establish an independent monitoring program is addressed in generalities in the EIA submitted in June 2003. The EIA proposed a commission that would oversee environmental monitoring and mitigation strategies. The AMAC monitoring program evolved into its current form after the CAO report, although AMAC says that it grew out of the EIA&S rather than the CAO recommendations.

Our understanding is that Goldcorp (then Montana Resources) proposed to form an entity like AMAC that would go one step further than independent monitoring conducted at the Yanacocha Mine in Peru by the CAO. At the Yanacocha Mine, the community members were veedores (witnesses) but did not actually conduct the monitoring themselves. Ms. Wade of Goldcorp, who worked at the Yanacocha Mine during the formation of the independent monitoring program, said that she wanted to make the monitoring of the Marlin Mine more independent than Yanacocha and have the community conduct the water sampling themselves (Lisa Wade, Personal Communication February 2009). AMAC joined MEM in a December 29, 2009 water monitoring evaluation of a December 24, 2009, tailings spill (MEM, 2010b). AMAC's presence demonstrates an important function that an independent monitoring team with access to the mine can serve. In general, E-Tech believes that AMAC has the technical capacity to conduct reliable environmental monitoring of the mine, with the assistance of its technical team director and consultants. The organization says that it is working to improve its technical communications and perceives itself as "apolitical and contributing to non-violence and peacemaking"(Personal communication, Prof. Luna and Mr. Ramirez, email, May 3, 2010). Since Fall 2009, AMAC has been conducting monitoring with Goldcorp and MEM under a joint agreement.

AMAC feels that it is the best model for a community-based independent monitoring team at the Marlin Mine. AMAC officials say that their organizational structure, which separates money and membership in the organization from Goldcorp, as well as its history of responding to local emergencies, should support credence in its independence (Personal Communication, Prof. Luna and Mr. Ramirez, email, May 3, 2010).

AMAC uses a certified laboratory in British Colombia, Canada, ALS, that was selected by Mr. Rader; ALS is not used by the Marlin Mine. A separate, multi-sectoral trust account (fideicomiso) was established as a funding mechanism for AMAC. The FUNSIN foundation was initially funded by combined Goldcorp/Glamis and IFC contributions, and currently includes the Canadian Embassy and Goldcorp funding (FUNSIN website). FUNSIN is headquartered at the Colegio del Ingenieros of Guatemala, a nonprofit professional organization with representation by the Engineering Faculty at the University of San Carlos in Guatemala City. FUNSIN implements other projects in addition to the AMAC monitoring.

Prof. Luna has been accessible when contacted. With the assistance of Mr. Rader, we received laboratory sheets with water quality data from 2006, 2007, and 2008. AMAC also provided us with their protocols for environmental sampling and laboratory analysis. To our knowledge, no written monitoring reports (prepared by AMAC) are available, but AMAC prepares and disseminates a one-page summary of each monitoring event to the public.

AMAC's sampling locations are the same as Goldcorp's. Surface water locations are SW1, SW1-2, SW2, SW3, SW4, and SW5. Groundwater sampling locations are MW2, MW3B, MW4, and MW5. Surface water and groundwater locations are sampled quarterly (February, May, August, and November) on an alternating basis (over the course of a year, each site is sampled once). AMAC also samples two discharge locations, D6 (tailings infiltration pond, every three months on an alternating basis) and D7 (tailings discharge to the environment, which has not yet occurred). Field and laboratory parameters are identical to those for surface water. No monitoring data are available for D6 from Goldcorp, but AMAC has sampled this location a number of times. The first laboratory reports from ALS were sent to Goldcorp rather than AMAC (February 2006), which shows the initial close association of AMAC and Goldcorp. After the first report, reports were sent to Mr. Rader at Avanzar in Canada.

AMAC took its first water quality samples in February 2006 and met with Marlin Mine personnel to compare and discuss results. AMAC's protocols include communicating their results to the participating communities, the Catholic and Evangelical churches, the human rights prosecutor (procurador de derechos humanos), municipalities, Mayan groups, governmental regulatory agencies, embassies, academic institutions, community groups, and other groups in Guatemala City (Personal Communication, Prof. Luna and Mr. Ramirez, email, May 3, 2010).

During 2009-10 AMAC conducted monitoring with a municipal representative from San Miguel Ixtahuacan present. Analytical results from ALS lab are sent to AMAC and are then shared with "local community delegations and representatives who are familiar with the monitoring procedures." The results are disseminated on a quarterly basis through bulletins and meetings with community members where the results are discussed. Since an October 2009 agreement with MEM and Goldcorp, AMAC has coordinated selection of monitoring points and sharing of information with those parties; MARN was invited to join, according to AMAC, and was present at only one sampling event (MEM, 2009b).

Annual reports summarize the results and provide a compendium of activities. AMAC says it has found "no discernible influence" on water quality by the Marlin Mine (Personal Communication, Prof. Luna and Mr. Ramirez, email, May 3, 2010).

Data Quality

AMAC's protocols (AMAC, undated) are a general field sampling and analysis plan. AMAC uses chain of custody forms and has protocols for preservation of samples. Surface water samples are unfiltered, except for dissolved metals (total metals samples are also collected and analyzed); groundwater samples are filtered. Field parameters measured are temperature, pH, specific conductance, and dissolved oxygen (surface water samples). Laboratory measurements are: pH, specific conductance, alkalinity, ammonia, chloride, fluoride, nitrate+nitrite as N, total Kjeldahl nitrogen, sulfate, sulfide, total phosphate as P, total cyanide, WAD cyanide, total dissolved solids, total suspended solids, total solids, total petroleum hydrocarbons, oil and grease, chemical oxygen demand, total metals, and dissolved metals. The metals are aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorous, potassium, selenium, silica, silver, sodium, strontium, thallium, tin, titanium, uranium, vanadium, and zinc. Groundwater field parameters are the same as for surface water, with the addition of depth to groundwater. Groundwater laboratory analyses are the same as for surface water, but oil and grease, chemical oxygen demand and total metals are not determined on groundwater samples.

Detection limits are not specified in the protocols, and there is no mention of field blanks or duplicates or other QC procedures. However, there are analyses for field blanks and travel (trip) blanks in the laboratory sheets from ALS, and laboratory blanks and replicates are conducted by ALS. Because Goldcorp samples the same locations at the same times as AMAC, their samples serve as duplicates of each other when collected on the same sampling days and approximate times. Analytical methods are not listed in the protocols. However, in the ALS laboratory sheets, the methods are included: anions are determined by ion chromatography, except for sulfate (turbidimetric); ammonia, phosphate, sulfide, chemical oxygen demand, and cyanide are determined colorimetrically; metals are determined using atomic absorption spectrophotometry (AAS), ICP-AES, or ICP-MS (no details are provided about which methods are used for which metals). Diesel-range organics (rather than total petroleum hydrocarbons) are determined using gas chromatography with an FID detector.

The first laboratory reports from ALS were sent to Goldcorp rather than AMAC (February 2006), which shows the initial close association of AMAC and Goldcorp. After the first report, all reports were sent to Jim Radar at Avanzar in Canada.

AMAC took its first water quality samples in February 2006 and met with Marlin Mine personnel to compare and discuss results. AMAC's protocols include communicating their results to the participating communities, the Catholic and Evangelical churches, municipalities, Mayan groups, MEM, embassies, and other groups in Guatemala City (2005 AMR).

6.1.3 Comisión Pastoral Paz y Ecología (COPAE)

Overview and Accessibility of Information

Our contacts at COPAE were Marco Vinicio Lopez Maldonado and, initially, Fausto Valiente. We received two monitoring reports from August 2008 and July 2009 (COPAE 2008, 2009). Both of these reports were widely released to the public, and the 2009 report was released at a press conference. We communicated with COPAE by phone and email and asked a number of technical questions.

COPAE samples six locations:

- SW1$_C$: Río Tzalá below the center of operations of Marlin Mine (similar to Goldcorp location SW2)
- SW2$_C$: Riachuelo Quivichil below the mine and upstream of the confluence with Rio Cuilco (similar to Goldcorp location SW3)
- SW3$_C$: the tributary to Quebrada Seca below the tailings dam (similar to Goldcorp SW8)
- SW4$_C$: Xkus spring, which flows to Riachuelo Quivichil (not sampled for 2009 report)
- SW5$_C$: Río Tzalá upstream of the center of the mining operations (similar to Goldcorp location SW1, but more upstream)
- SW6$_C$: Riachuelo Quivichil upstream of mining influence, also known as "Canshac" or "Q'an shaq."

In the 2009 report, SW1$_C$, -2$_C$, -3$_C$, and –5$_C$ were sampled, and a new location on Riachuelo Quivichil (SW6$_C$) upstream of all mining influence was added. Water samples were not filtered.

COPAE analyzes its water samples for copper, iron, aluminum, arsenic, manganese, zinc, nitrate, sulfate, and alkalinity. Temperature, pH, and specific conductance are measured in the field and the lab. Analyses for iron, copper, zinc, nitrate, sulfate, manganese, and aluminum were conducted using a Hach spectrophotometer. Alkalinity was measured using a colorimetric method, and arsenic was measured using rapid test kits (COPAE, 2009). COPAE sent samples to a laboratory in Huehuetenango at the Universidad Rafael Landivar (URL) for analytical comparisons. They do not analyze water samples for any forms of cyanide. They do not filter their samples.

Data Quality

The rapid test kits and colorimetric/spectrophotometric methods used by COPAE generally have high detection limits and are not reliable for measuring low concentrations of metals or arsenic; this caveat does not necessarily apply to nitrate or sulfate, which have higher mg/l values for water quality standards. No information was found on QC procedures or field sampling methods, although they mentioned that the metals samples are preserved with nitric acid (COPAE, 2009).

URL analyzed some samples collected on the same days as COPAE. For the few samples that were collected on the same days, the agreement for copper and zinc values was poor, but the agreement for sulfate concentrations was within typical acceptable control limits (+/- 25%; in most instances values were within 10 to 20%) for duplicate samples[2]. URL does not analyze samples for arsenic, so we could not compare results for arsenic. Table 4 provides a comparison of COPAE's and the external laboratory's (URL's) nitrate results (COPAE, 2009). COPAE's nitrate results were always higher than URL's, ranging from a factor of 1.4 to 13; on average, COPAE's nitrate results were almost four times higher than URL's. The relative percent difference (RPD) ranged from +49 to +178% (average of 110%), which is well outside the acceptable range of +/- 25%. Because of the poor comparison between COPAE's and URL's results, we will not use COPAE's nitrate results further when examining data for the site. However, as also shown in Table 4, sulfate concentrations compared well with those from the external laboratory. Average RPD value for sulfate was 9.1%, which is well within the acceptable analytical range. We received no information on the analytical methods or QC procedures used by the external laboratory.

Table 4. Comparison of COPAE and external laboratory (URL) results for nitrate and sulfate.

Compound	**Date**	**Lab**	**SW1**	**SW2**	**SW3**	**SW5**	**SW6**	**Mean RPD**	**Acceptable RPD Range**
Nitrate (mg/l)	8/27/2008	COPAE	6.4	2.7	5.7	8.6	7.2		
		URL/External Lab	1.1	2	2.4	0.66	1.58		
		COPAE/URL	*5.8*	*1.4*	*2.4*	*13.0*	*4.6*		
		RPD	*141*	*30*	*81*	*171*	*128*	110%	+/- 25%
	12/9/2008	COPAE	6.3	5.9	4.6	5.3	6.5		
		URL/External Lab	3.83	2.42	2.68	2.9	2.6		
		COPAE/URL	*1.6*	*2.4*	*1.7*	*1.8*	*2.5*		
		RPD	*49*	*84*	*53*	*59*	*86*		
Sulfate (mg/l)	10/12/2007	*COPAE*	35	37	12	55	20		
		URL/External Lab	32	30	10	49	23		
		COPAE/URL	*1.1*	*1.2*	*1.2*	*1.1*	*0.9*		
		RPD	*9*	*21*	*18*	*12*	*-14*	9.1%	+/- 25%

*RPD = relative percent difference = ((COPAE - URL)/((COPAE + URL)/2))*100*

6.1.4 MARN

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[2] U.S. Environmental Protection Agency allows +/-20% RPD for laboratory duplicate samples (US EPA, 2005); somewhat higher control limits are expected for inter-laboratory comparisons of split samples.

Overview and Accessibility of Information

MARN data were received in November 2009, after phone and email communication with Secretary Dr. Luis Ferraté, by Environment Director Eugenia Castro through Mario Domingo of the Procuraduria de los Derechos del Arzobispado (Office of the Archbishop's Human Rights Attorney General). Later protocols for sampling events were sent by Dr. Castro directly to E-Tech after our December 2009 phone discussion with MARN. The MARN data included samples from 2007, 2008, and 2009. MARN collected and analyzed surface water samples from SW1, SW2, SW3, SW4, and SW5; groundwater samples at MW5 and MW3B; and discharge samples from D4 (tailings supernatant) and D6 (tailings seepage). A sample was collected from D11B or D118 (copy of laboratory report is very poor), but the location of this point is unknown.

Data Quality

MARN used three different laboratories: LAFYM in 2007; Ecosistemas (a private laboratory) in March 2008; and Laboratorio Nacional de Salud (LNS) in 2008 and 2009. LAFYM used Standard Methods (1998), but no details on specific methods were provided. They analyzed samples for color, hardness, TSS, TDS, ammonia, chloride, nitrate, nitrite, total nitrogen, total phosphorous, sulfate, phosphate, chemical oxygen demand, and biological oxygen demand. Ecosistemas analyzed samples by AAS (metals) and Standard Methods (no other specific information found), and analyzed the surface water samples SW1, SW2, SW3, SW4, and SW5 in March 2008.

Detection limits were too high (higher than many potentially relevant standards) for most constituents, including cyanide (10 μg/l), CrVI (30 μg/l), Al (300 μg/l), Se (200 μg/l), Mo (50 μg/l), nickel and lead (50 μg/l), Cu, Cr, Fe, Mn (30 μg/l), zinc (10 μg/l), arsenic (2 μg/l), and mercury (1 μg/l). LNS analyzed surface water samples at SW1, 2, 3, 4, and 5, and groundwater samples at MW5 and MW3B. Most of their detection limits were also too high (most were higher than Ecosistemas), especially for zinc (350 μg/l), lead, (50 μg/l), mercury (10 μg/l), copper (350 μg/l), and arsenic (5 μg/l). LNS did not analyze samples for sulfate, even though it is clearly a contaminant of concern at the site. Nitrogen, phosphorous, cyanide, and chromium VI were determined by colorimetric analysis. The other analytes were determined using Standard Methods, but no other details are provided.

As far as we can tell, no field or trip blanks or sample duplicates were collected by MARN. We do not know if they used chain of custody for their samples or what kind of field methods and sample handling and preservation techniques were used because no field or laboratory sampling procedures were found.

6.1.5 MEM

Overview and Accessibility of Information

MEM did not respond to our four requests for information to Selwyn Morales and Marley Reyes. However, in the third week of March, 2010, the authors received from the University of Notre Dame four hard-copy reports of joint MEM-AMAC-Goldcorp inspections from September, October, and December 2009 (Ministerio de Energia y Minas, 2009a, 2009b, 2010a) and a January 28, 2010 report (Ministerio de Energia y Minas, 2010b) on monitoring of a tailings spill at Marlin on December 29 and January 15-18. The September 2009 report was online at the MEM website as of early June 2010.

No information was received on data quality. However, from the four reports it is apparent that MEM measured pH, temperature, specific conductance, dissolved oxygen, total dissolved solids, and oxidation-reduction potential in the field. Laboratory results (using results from CANTEST) included: pH, specific conductance, alkalinity (all forms), fluoride, chloride, total suspended solids, nitrate+nitrate as N, sulfate, chemical oxygen demand, oil and grease, total cyanide, and weak acid dissociable cyanide. Metals analyses (both total and dissolved) included: hardness, aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cesium, cadmium, calcium, chromium, cobalt, copper, lanthanum, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, phosphorus, potassium, rhenium, rubidium, selenium, silicon, silver, sodium, strontium, sulfur, tellurium, thallium, thorium, tin, titanium, tungsten, uranium, vanadium, zinc, zirconium, and mercury. A cation-anion balance was calculated from the results and most results were acceptable in the +/- 20% range.

Due to the late receipt, these reports were not integrated into the evaluation of AMAC, MARN, and Goldcorp monitoring data. A brief summary of the four reports follows.

1. Technical report of the first Dirección General de Mineria – Unidad de Gestion Socio Ambiental (DGM-UGSA) monitoring of the Marlin Mine, October 2009 (MEM, 2009a).

The joint AMAC-MEM sampling discussed in this report occurred on September 8, 2009. The laboratory used for the analyses was CANTEST, from Burnaby, British Columbia. This laboratory was not used by Goldcorp or AMAC. Sampling (see Figure 2 for locations) was limited to three surface water points located in the Río Cuilco basin at points where there has been monitoring for several years by the Marlin Mine and AMAC (SW3, SW4, SW5), one groundwater location northeast of the mine, MW3B, and the tailings filtration collection pond, D6. Results are also shown for SW13, but the results are not discussed in the report. The surface water and groundwater samples had low concentrations of most constituents, and no cyanide was present. According to the report, all parameters except pH were within the established baseline water quality values. The discharge location D6 did have elevated concentrations of nitrate, sulfate, and manganese, reflecting the tailings water composition.

2. Technical Report: Extraordinary Monitoring Report of DGM-UGSA, December 2009 (MEM, 2009b).

Water samples were collected by AMAC, MARN, and Montana (Goldcorp) from the areas surrounding the Marlin Mine during the second week of October 2009. The locations included three groundwater (MW3B, MW5, WV (underground mine water)), six surface water (SW1, SW2, SW3, SW4, SW5, SW11), six discharge samples (five related to the tailings: D6, D4, D5, Dcentro (center of the tailings impoundment), D11; and one from the treatment plants, D7B). Field duplicate samples were also collected. MARN was the lead sampling entity. According to the report, surface water samples showed no mine impacts. Of the groundwater samples, the supply well (MW5), located south of the mine and just north of the Rio Tzala, showed values "outside of the baseline that suggest intensive usage": pH (6.87), conductivity (2,017 µS/cm) sulfate (262 mg/L), and dissolved arsenic (0.022 mg/L). The meaning of "intensive usage" was not explained in the report. The tailings impoundment samples had elevated concentrations of nitrate, sulfate, and cyanide (up to 6.7 mg/L total cyanide in sample D5). The underground mine sample had elevated sulfate and arsenic concentrations, but concentrations of nitrate and cyanide were below detection. According to the report, no established norms or standards were exceeded in the discharge sampling locations (tailings and underground mine). Also according to the report, the field duplicate samples did not meet the quality control limits required for Marlin by MARN for hardness, aluminum, calcium, copper, iron, lead, lithium, magnesium, manganese, potassium, silica, sulfur, titanium and vanadium.

3. Technical Report: Monitoring Corresponding to October to December 2009 by DGM-UGSA, March 2010. (MEM, 2010a)

Sampling locations included three surface water sites (SW1, SW2, SW3), two groundwater sites (MW3B and MW5), and one industrial/discharge location (D6). CANTEST was used as the laboratory. According to the report, there was no evidence of problems in surface waters. The supply well to the south (MW5) again had concentrations outside of baseline values, "suggesting an intensive usage." Concentrations of sulfate, hardness, arsenic, boron, calcium, iron, and nickel were notably higher in MW5 than MW3B. According to the report, the tailings infiltration pond (D6) had acceptable values for parameters analyzed, and concentrations were within the standards established under the Cyanide Code. The report concluded that supply well MW5 should be monitored in the future to observe tendencies. With exception of boron, field duplicate results were within acceptable quality control limits.

4.Tailings spill monitoring report by DGM-UGSA, January 2010 (MEM, 2010b).

The tailings spill took place on December 24, 2009, and the monitoring discussed in the report took place on December 29, 2009. On December 24, 2009, Montana reported a 15-minute spill (83 cubic meters) of neutralized tailings from a pipe at the mine site that discharged to the east of the tailings impoundment. According to the report, 75% flowed in rain drainage canals into Quebrada Seca, and 25% went to the tailings impoundment; 75% of the spill was described as inert solids and 25% as fluids. Three emergency containment dams were constructed on Quebrada Seca on mine property. In subsequent days material was bulldozed out of Quebrada Seca and deposited in the tailings impoundment.

Samples were collected at SW8 in Quebrada Seca, north of the tailings impoundment, and at three groundwater locations: MW11 (northeast of the tailings impoundment), PSA2 (production well northeast of the tailings impoundment and downgradient of MW11), MW3B (monitoring well north of the tailings impoundment), and GW3 (north of the tailings impoundment). Samples were also collected by MEM at SWTA (in Quebrada Seca, northeast of the tailings impoundment and downstream of the spill) and SWTB (downstream of SWTA in Quebrada Seca) to monitor the remediation. Water quality samples were sent to ALS (the laboratory used by AMAC). Two additional MEM samples were also analyzed by ALS. Samples of tailings "muds" were analyzed at a MEM laboratory. Concentrations measured in the tailings were 83 mg/kg lead, 4.0 mg/kg of chromium, 68 mg/kg copper, and 125 mg/kg zinc; cadmium values were below detection. PSA2 had elevated concentrations of arsenic (0.237 mg/L), total dissolved solids (979 mg/L), and sulfate (361 mg/L), indicating potential tailings infiltration. The report concluded that measured concentrations did not pose a risk to human health or aquatic life and that the cleanup by the mine was adequate to avoid surface water and groundwater contamination.

6.1.6 Additional Studies

In addition to the five sources of monitoring data described above, limited information was available from Bianchini (2006), Robinson (2007), and the CAO (2005). The Bianchini (2006) report, which was conducted in coordination with community members in Sipacapa, included analyses from two samples, one collected upstream and one downstream of the mine in Río Tzalá. The location upstream of the mine may be similar to the Goldcorp location SW1, and the downstream location appears to be more downstream on Río Tzalá than the Goldcorp location SW2, but upstream of the confluence with Río Cuilco (see Figure 2). Bianchini (2006) provided no additional information on sample location (e.g., coordinates). The only information about analytical methods is a statement that a UV/VIS spectrophotometer was used. We assume that he used colorimetric analysis for the metals, but this could not have been the analytical method for sulfate or some of the other analytes. The report found that concentrations of copper, manganese, and zinc were measurably higher downstream of the mine in Río Tzalá than upstream of the mine. For example, copper concentrations were higher downstream of the mine (39.9 vs. 1.3 mg/l), but both concentrations were orders of magnitude higher than either the Goldcorp or COPAE data at the same or similar locations. No original laboratory sheets, field collection or laboratory protocols, or quality assurance program information were provided in the report.

Robinson (2007) conducted training of local citizens through the Unitarian Universalist Service Committee and also did some field analyses of basic water quality parameters (pH, specific conductance, hardness, arsenic, copper, temperature). As noted in Section 2, the CAO (2005) investigated the citizen complaint filed by the community of Sipacapa and concluded that the community would not experience water pollution or decreased water quantity as a result of the mine (CAO, 2009). No original analyses were conducted as part of the CAO investigation.

6.1.7 General Findings about Data Quality

All of the entities conducting water quality sampling at the Marlin Mine had some shortcomings in their field or analytical approaches. We received or found the most information on field and analytical methods from AMAC. The laboratory methods used by AMAC are reliable and similar to those commonly used in the United States and Canada. Based on detection limits alone, it appears that the analytical methods used by Goldcorp are also reliable. Limited information was received from all entities on sample handling (although COPAE stated that they acidify their metals samples) and field or laboratory quality control methods.

Detection limits for a number of constituents were too high (as noted in the sections above) relative to water quality standards, especially those for the protection of aquatic life. Goldcorp changed laboratories a number of times, in part to improve detection limits and decrease laboratory contamination. However, their most recent change from ACZ to SVL resulted in increased detection limits. Ideally, detection limits should be 3 to 5 times lower than the lowest relevant standard (see Table 2) so the comparison of water quality results to standards is meaningful. Recent detection limits shown for Goldcorp and AMAC are generally acceptable, with some exceptions noted in Sections 6.1.1 and 6.1.2, while detection limits shown for COPAE and MARN are generally too high, especially for metals and arsenic. COPAE's sulfate concentrations appear to be reliable, based on the good comparison results with the outside laboratory. Sulfate is an important water quality indicator at most hardrock mine sites because increasing concentrations can reflect the weathering of sulfide ore bodies and the onset of acid drainage.

The following elements, some specific and some general, are needed to ensure the reliability of water quality data and decrease errors in the field:

- Field sampling and analysis plans created before sampling occurs
- Training of all sampling personnel on methods outlined in the sampling plan
- Use of field sampling sheets or notebooks for recording of field measurements, sample location information, field conditions, etc.; ideally, site-specific field sheets would be made in advance of sampling
- Sample preservation such as acidification with nitric acid to pH<2 for dissolved and total metals samples; keeping samples on ice if required, etc.
- Use of chain of custody forms and seals
- Collection and analysis of field replicates (usually collected at rate of at least 1 duplicate for every 20 sample locations)
- Collection and analysis of trip and equipment blanks (usually collected at rate of at least 1 of each type of blank for every 20 sample locations)
- Photographing or videoing collection of water quality samples.
- Use of analytical methods that achieve required detection limits
- Adhering to sample hold times
- Use of standard reference water samples (e.g., from the U.S. Geological Survey); these samples contain known concentration ranges of certain constituents and can serve as a external check against analytical measurements
- Use of laboratory quality control/quality assurance methods, including matrix spikes, laboratory duplicates, continuing calibration blanks, etc.
- Calculation of cation-anion balance.

Many of these elements were missing from the sampling efforts at the Marlin Mine, although Goldcorp meets the majority of these elements, with the possible exception of field replicates and blanks (they may collect them, but no information was provided), the use of standard reference water samples, and calculation of cation-anion balance. Future sampling efforts should incorporate these and other elements to ensure data quality, especially at a site as contentious as the Marlin Mine.

6.2 Summary of Environmental Conditions in Sources and Receiving Water Bodies

6.2.1 Analyses of sources of contamination and contaminants of concern

Potential sources of contamination related to the Marlin Mine include the open pits, the underground mine, the tailings impoundment, the waste rock dumps, and the vat leach processing facilities. Goldcorp points D1 and D4 monitor water in the underground mine and the tailings supernatant pond, respectively. Goldcorp points D6 and D7 sample tailings seepage and tailings water discharge (when discharge to the environment occurs). Goldcorp points D8 and D9 sampled the large and small waste rock dump, respectively (see Table 3). Water quality data are available for D1 and D4 from the 2005 and 2006 AMRs.

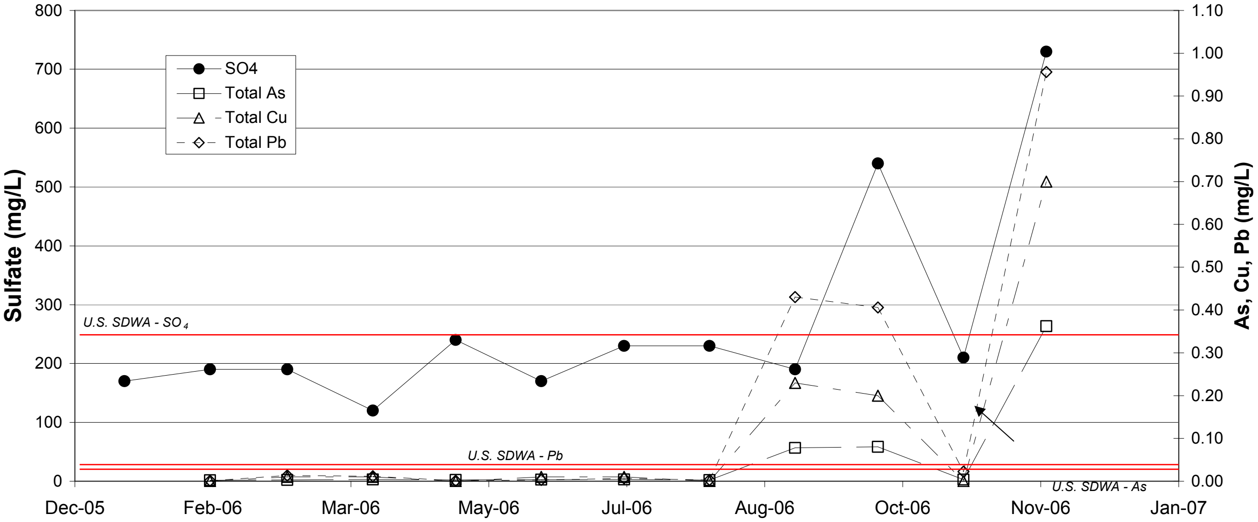
Underground Mine

Dewatering of the underground mine occurs through a sump in the mine, and the underground mine water is sent to the tailings facility. Underground mine water is a combination of water infiltrating through the workings and fresh water pumped to the mine for operation of mine equipment. Only two years of data were available: 2005 and 2006. In 2005, the underground mine water had elevated concentrations of ammonia (up to 22.4 mg/l) and total Kjeldahl nitrogen (up to 19.8 mg/l), and detectable total cyanide (up to 0.036 mg/l). Nitrogen compounds derive from blasting agents, and cyanide could derive from the gold processing facility. Although there are no known cyanide facilities that appear to be upgradient of the underground mine, the groundwater flow directions are poorly understood at the site. Water quality data were also made available electronically by Goldcorp from the 2006 AMR and similarly showed elevated concentrations of nitrate+nitrite, arsenic, sulfate, total suspended solids (TSS), total dissolved solids (TDS), aluminum, beryllium, cobalt, copper, chromium, iron, manganese, mercury, molybdenum, nickel, silver, lead, selenium, vanadium, and zinc. Only total metals concentrations were elevated; dissolved metal concentrations were generally below detection. Total suspended solids increased markedly at the end of the year (from 116 mg/l in June to 50,600 mg/l in December 2006), and large increases were also seen in total dissolved solids, sulfate, alkalinity, and chemical oxygen demand.

The following metals had elevated concentrations in Fall/Winter 2005 and 2006: aluminum (up to 827 mg/l total aluminum), arsenic (up to 0.362 mg/l total arsenic), barium (up to 12.2 mg/l), beryllium (up to 0.060 mg/l total beryllium), copper (up to 0.7

mg/l), chromium (up to 0.6 mg/l), iron (up to 737 mg/l total iron), manganese (up to 36.7 mg/l total manganese), nickel (up to 0.4 mg/l), silver (up to 0.263 mg/l), lead (up to 0.956 mg/l), vanadium (up to 1.32 mg/l), and zinc (up to 3.6 mg/l). Most of these concentrations exceed relevant drinking water or potable water standards by many times (see Table 2 for water quality standards). These standards are relevant because the groundwater in the underground mine could move to surface water or springs and be used for drinking water. A number of the contaminants of concern had markedly increasing concentrations at the middle and end of 2006, as shown in Figure 3 for sulfate, total arsenic, total copper, and total lead. Concentrations of sulfide were also elevated at the end of 2006 (increasing from below detection (<0.020 mg/l) in June to 31.8 mg/l in December. The presence of particulate metals and sulfide in the mine water suggests that solid metal sulfides from the ore may account for the observed increases. The pH of the mine water was above neutral in 2006, but changes in pH (higher or especially lower) could solubilize metals from the particulates and add to the more mobile dissolved metal load in groundwater or the tailings impoundment.

Figure 3. Concentrations of selected contaminants of concern in underground mine water (D1) in 2006.



Data source: 2006 AMR.

Based on the water quality data for the underground mine water, the contaminants of concern include:

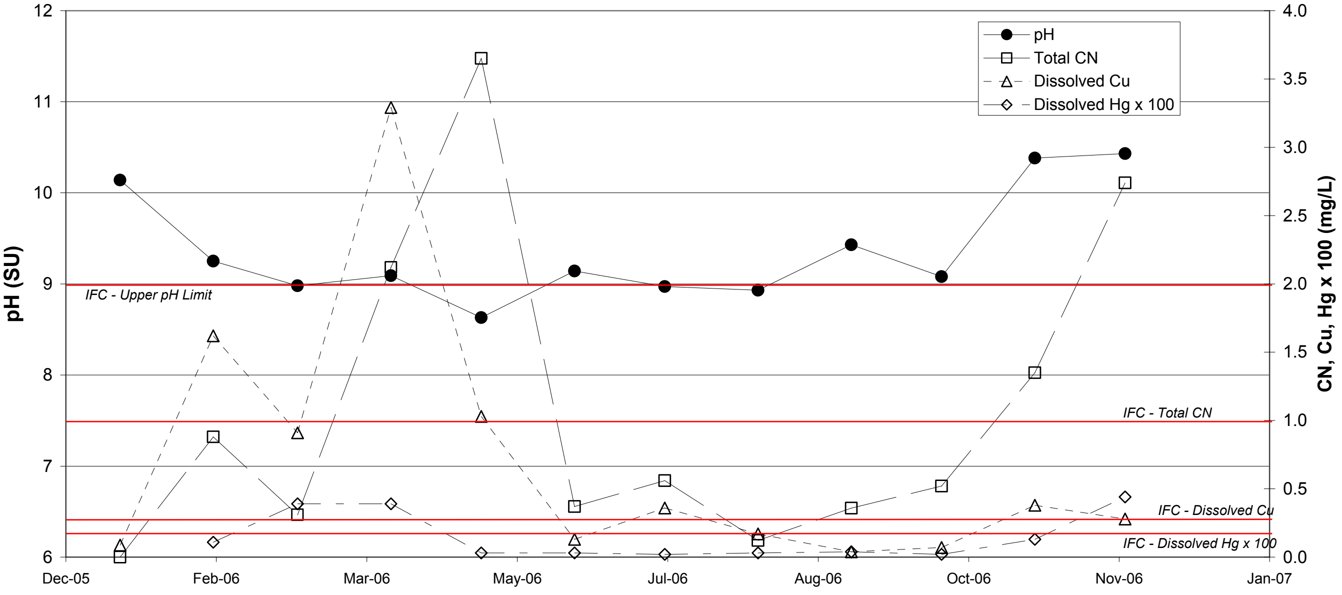
- Nitrogen compounds
- Cyanide (possible COC)
- Sulfate and sulfide
- TSS
- TDS
- Aluminum
- Arsenic
- Beryllium
- Cobalt
- Copper
- Chromium
- Iron
- Manganese
- Mercury
- Molybdenum
- Nickel
- Silver
- Lead
- Selenium
- Vanadium
- Zinc.

Tailings Impoundment

The tailings water generally had fewer contaminants of concern and lower contaminant concentrations than the water in the underground mine. The tailings supernatant water (D4) had elevated concentrations of the following constituents in November and December 2005: field pH (9.53 and 9.92 – too high), ammonia (2.64 mg/l), total Kjeldahl nitrogen (19.8 mg/l), sulfate (up to 600 mg/l), arsenic (up to 0.014 mg/l), antimony (0.846 mg/l – this is an SGS analysis, so it may be unreliable), copper (up to 1.65 mg/L), mercury (up to 0.0046 mg/l), and silver (up to 0.022 mg/l).

In 2006, sample D4 also had elevated concentrations of the same constituents and total dissolved solids (up to 2,960 mg/l), total cyanide (up to 3.65 mg/l), total aluminum (up to 2.87 mg/l), total iron (up to 1.6 mg/l), and mercury (up to 0.011 mg/l). Antimony concentrations were not elevated after Goldcorp switched to ACZ Laboratories from the onsite SGS laboratory. Sulfate concentrations were as high as 1,830 mg/l. Figure 4 shows the concentrations of selected COCs in tailings supernatant during 2006. Concentrations of total cyanide, dissolved copper, dissolved mercury, and pH values exceeded IFC discharge standards at different points in 2006. Maximum concentrations of cyanide, copper, and mercury were over three, ten, and 20 times higher than IFC standards.

Figure 4. Concentrations of cyanide (CN), dissolved copper (Cu), dissolved mercury (Hg), and pH in tailings supernatant water (D4), 2006.



Data source: 2006 AMR.

Based on the water quality results for the tailings water, the contaminants of concern include:

- pH (high)
- Nitrogen compounds
- Cyanide
- Sulfate
- TDS
- Aluminum
- Arsenic
- Copper
- Chromium
- Iron
- Mercury
- Silver

Waste Rock

Waste rock seepage from the small waste rock pile in Quebrada Seca (see Figure 2) was sampled in 2007 (2007 AMR, Appendix C). The pH was somewhat depressed (6.53), but no other parameters or constituents had elevated concentrations or appeared to be contaminants of concern for waste rock, based on the one sampling in 2007.

Another way to evaluate contaminants of concern for waste rock is to examine the geochemical testing results in the AMRs. The 2008 AMR, Appendix F shows that 10 or 11 out of 13 long-term field column samples are either PAG or uncertain. Two of the samples were incorrectly identified as uncertain in the 2008 AMR (Appendix F), when they should have been PAG; therefore, the total number of PAG samples, based on the NP:AP ratio from the static tests, was five rather than three. Another sample had an NP:AP ratio of 1.02, which is very close to the value that would identify a sample as PAG (NP:AP ratio <1). Therefore, nearly half of the samples were potentially acid generating. These results do not match with predictions from the EIA&S, which predicted that the minority of the waste rock would be acid-generating and the majority would be acid-neutralizing (2008 AMR).

The following constituent were elevated in one or more of the drum test leachate sample and are considered contaminants of concern for waste rock:

- Low pH
- Sulfate
- TDS
- Nitrogen compounds
- Cadmium
- Iron
- Selenium
- Manganese
- Nickel
- Zinc.

6.2.2 Groundwater and Surface Water Resources

Groundwater Resources

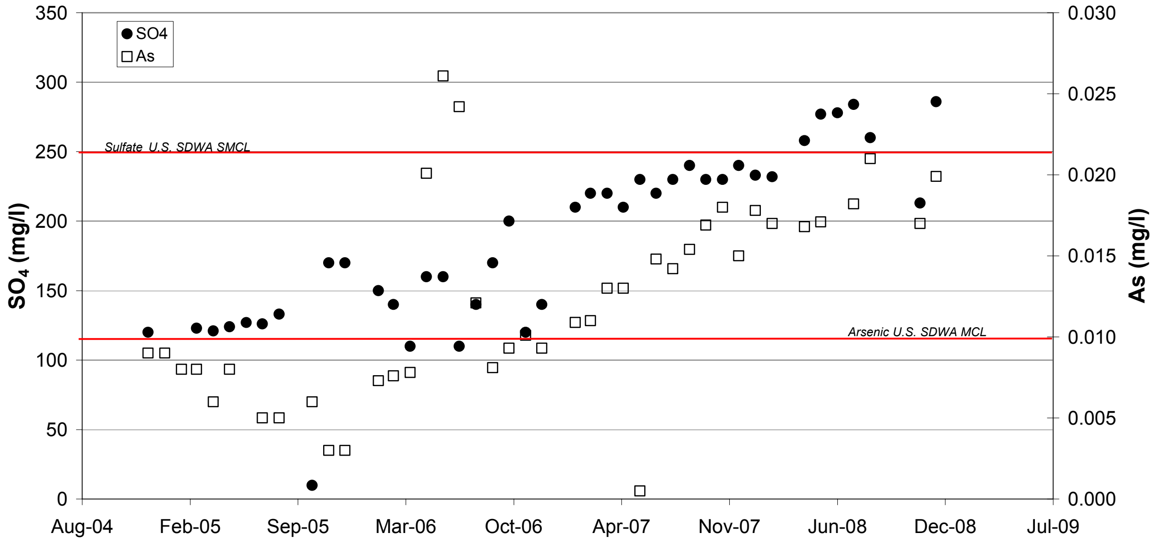
As noted in Section 4.3, there is not enough groundwater elevation data (and too few wells) to reliably determine which monitoring wells are up- and downgradient of mine facilities. However, the available groundwater quality data were reviewed to evaluate if there were changes over time that could indicate influence of mining activity. Based on information received from Lisa Wade of Goldcorp (email, February 20, 2009), PW7, MW10, MW11, and MW3B are downgradient from the waste rock pile and tailings impoundment and wells MW5 and MW8 are upgradient. Goldcorp samples all available groundwater sampling locations (see Table 3, although we received electronic data only for MW3B, MW5, MW8, MW10, MW11, and PW7), AMAC samples MW3B and MW5 (we received no electronic data from AMAC), and MARN sampled groundwater locations MW5 and MW3B (we received no electronic data from MARN). COPAE does not sample any groundwater wells, but they did sample a spring (SW4 COPAE) briefly in 2007. The spring dried up during the first year of monitoring, and COPAE chose a spring in the headwaters of Río Quivichil that is not directly influenced by the mine (COPAE, 2009).

MW3/3B. Goldcorp data show no elevated COC concentrations; highest sulfate concentrations were only 30 mg/l. All cyanide values were below detection, with the exception of one spurious result from SGS Laboratories before the mine changed to ACZ Laboratories. There was one exceedence of the U.S. Safe Drinking Water Act standard for arsenic in February 2004 (14 μg/l), but all other values were below detection, and this value is not considered representative of actual groundwater conditions.

MW5. Goldcorp data show that concentrations of sulfate and dissolved arsenic have been increasing over time, as shown in Figure 5. Originally, both dissolved and total arsenic concentrations were measured, but after August2005, only dissolved arsenic was measured. Concentrations now exceed U.S. drinking water standards of 0.010 mg/l (see Table 2). Results from AMAC were very similar. Results from the combined AMAC-Goldcorp-MEM monitoring were also similar (MEM, 2010a). Groundwater from this well is used for makeup water for process plant, and is not considered potable water. According to Goldcorp (Personal Communication, Lisa Wade, email Feb 20, 2009), the well is ~300 meters deep and the changes in water quality over time may be due to a deep, geothermal source that they are likely drawing water from over time. However, the temperature from this well is no higher than that from other wells, and the silica concentrations, which can often be elevated in geothermal sources, are not higher than those from other monitoring wells on the site. An analysis of oxygen isotopes may help resolve the issue. Goldcorp stated that the well is not in the same basin as any of the processing, waste rock, or tailings impoundment facilities (Lisa Wade, Feb 20 2009 email), but it may be in the same basin as the Marlin open pit and the underground mine. The extent of hydrologic connection between the well and Río Tzalá is also unknown. The increased concentrations of sulfate and arsenic, which are COCs for the underground-mine, may be related to increased leaching of wall and fractured rock from blasting in the underground mine and pit.

MW8, MW10, MW11. Monitoring well MW8 does not show elevated concentrations or increasing trends of any COCs. Monitoring wells MW10 and MW11, which were installed recently to upgrade groundwater monitoring downgradient of the tailings impoundment (Lisa Wade, Pers. Comm., email, Feb. 20, 2009) have elevated concentrations of arsenic. Concentrations of arsenic in MW10 range up to 261 µg/l, and in MW11 were as high as 46 µg/l. However, arsenic concentrations in well PW7, which is shallow and downgradient of the tailings impoundment, were not elevated (high of 6 µg/l). Arsenic concentration in the tailings supernatant water (D4) in 2006 were only as high as 38 µg/l, but pore water values in the tailings themselves have not been reported and could be higher or lower. Therefore, the source of the elevated arsenic concentrations in MW10 and MW11 is uncertain at this time. Sulfate concentrations are elevated in MW10 (up to 450 mg/l) and are lower in MW11 (high of 70 mg/l). Sulfate concentrations are high in tailings impoundment water (up to 1,830 mg/l; 2006 AMR).

Figure 5. Sulfate and dissolved arsenic concentrations in monitoring well MW5 over time.



Data source: Goldcorp, 2009.

Surface Water Resources

Tzalá Drainage

The most upstream location on Río Tzalá**, SW1,** has generally good water quality. This location is upstream of any mining activity. According to the 2005 AMR, sulfate concentrations ranged from 25 to 63 mg/l. There were two detections of total cyanide (10 and 100 mg/l), but these analyses were conducted by SGS, which had analytical problems with cyanide and metals. All other total cyanide values in 2005 were below detection. Total aluminum and iron, which are known to be naturally elevated (see Section 4.3) ranged up to 5.3 and 3 mg/l, respectively; copper concentrations were below aquatic life standards (mostly below 0.002 or 0.003 and up to 0.008 mg/l). Most mercury, lead, and zinc concentrations were below detection, although there were one or two detections of lead (up to 0.005 mg/l) and zinc (up to 0.038 mg/l). Generally, water quality met all potentially relevant standards (see Table 2) through 2008, using the electronic data received from Goldcorp. Results for **SW1-2** were very similar to those for SW1.

Using the electronic data received from Goldcorp for **SW2** from 2002 through 2008, water quality at this location was similar to that at SW1 and SW1-2. Total aluminum and iron concentrations appeared to increase after mining began at SW2, but the increases were also seen at the upstream location, SW1. However, in recent samplings, concentrations of TSS, iron, and aluminum were higher at SW2 that at the more upstream locations, even though concentrations increased at the same time at all locations. There were occasional detections of selenium and lead and a peak in specific conductance in late 2003/ early 2004, but no other clear trends of increasing concentrations of COCs were apparent.

As shown in Table 5, results from MARN's samples collected in Río Tzalá (SW1 and SW2) during 2009 showed detectable concentrations of total cyanide: 0.025 mg/l at SW1 in July and up to 0.123 mg/l at SW2 in February (the aquatic life criterion value is 0.0052 mg/l). However, results from Goldcorp taken during the same time periods showed no detectable cyanide in Río Tzalá. Because MARN detected cyanide at the sampling location upstream of all mining activity, their cyanide data are considered unreliable. MARN also had detection limits for zinc that were substantially higher than water quality standards for the protection aquatic life (i.e. the U.S. Clean Water Act aquatic life criterion value for zinc at a hardness of 100 mg/l is 0.120 mg/l, but the MARN detection limit was 0.350 mg/l). Goldcorp's zinc concentrations in Río Tzalá were generally below detection at 0.010 mg/l. COPAE's results for zinc were notably higher (see Table 5), but their detection limits were also higher.

Riachuelo Quivichil Drainage

The Riachuelo Quivichil is a tributary of Río Cuilco that includes the mainstem and three tributaries that drain the mine site: Quebrada Seca, which drains the small waste rock pile; the unnamed tributary of Quebrada Seca, in which the tailings impoundment and large waste rock pile are located; and Quebrada La Hamaca, which drains the Cochis open pit (see Figure 2). Processing facilities (cyanide vat leach operations) are also located in this drainage. The Goldcorp and AMAC surface water monitoring locations in this drainage are: SW8 and $SW3_C$, located downstream of the tailings impoundment and the waste rock pile on Quebrada Seca; and SW3 and $SW2_C$, in Riachuelo Quivichil downstream of the confluence with Quebrada Seca. The mine also samples a location similar to COPAE's $SW6_C$ (see Figure 2) as a La Hamaca baseline station (Lisa Wade, personal communication, March 2010), but the data are not reported in the AMRs;

AMAC has no upstream monitoring locations in the Riachuelo Quivichil watershed. COPAE samples a station called SW6$_C$ on Riachuelo Quivichil that is located upstream of mining influence (also known as Canshac or Q'an shaq). COPAE also samples locations near Goldcorp's D6 (SW3$_C$) and SW3 (SW2$_C$) (see Figure 2 and Table 3).

Some of Goldcorp's and COPAE's monitoring results were similar, while results for other parameters were quite different. Goldcorp's and COPAE's results for sulfate and specific conductance at SW3/SW2$_C$ (same location) are compared in Figure 6 and are very similar. The values fluctuate seasonally and appear to return to baseline levels between the concentration peaks, suggesting that mine releases of sulfate have not adversely affected water quality at SW3. Goldcorp's sulfate values were often slightly higher than COPAE's, but specific conductance values were more similar. However, COPAE's results for the upstream Quivichil station, SW6$_C$, showed noticeably lower sulfate concentrations (than values downstream of the mine) during the recent dry season (February, March, April 2009 – see Figure 6), suggesting that weathering of sulfide minerals in wastes (waste rock and tailings) may have begun to adversely affect the Riachuelo Quivichil mainstem. Additional monitoring is needed to evaluate this possibility. There were occasional detections of arsenic, mercury, lead, and zinc, but

Table 5. Comparison of MARN, Goldcorp, and COPAE's 2009 water quality sampling results for the Marlin Mine: Total cyanide and zinc.

Sample ID	**Drainage Basin**	**Month 2009**	**Cyanide Total (mg/L)**		**Zn (mg/l)**		
			MARN	**Goldcorp**	**MARN**	**Goldcorp**	**COPAE**
SW1 (SW5$_C$)	Tzalá	February	<0.010	<0.010^{a}	<0.35	0.012^{d}	0.08
		July	**0.025**	NA	<0.35	NA	0.03e
SW2 (SW1$_C$)	Tzalá	February	**0.123**	<0.010^{a}	**0.60**	<0.010^{a}	**0.12**
		July	**0.019**	NA	<0.35	NA	0.01e
SW3 (SW2$_C$)	Riachuelo Quivichil	February	**0.256**	<0.010	**1.12**	<0.010	0.06
		April	NA	<0.010^{b}	NA	<0.010^{b}	0.03
		July	**0.047**	<0.010^{c}	**<0.35**	<0.010^{c}	**0.22**
SW4	Cuilco	February	**0.102**	<0.010^{a}	**0.44**	<0.010^{a}	--
		July	**0.066**	<0.010^{b}	<0.35	0.027^{b}	--
SW5	Cuilco	February	**0.161**	<0.010	**0.60**	<0.010	--
		July	**0.069**	<0.010^{b}	<0.35	0.021^{b}	--
MW3B	Riachuelo Quivichil	February	<0.010	<0.010^{a}	**5.58**, <0.35	<0.010^{a}	--
		July	<0.010	NA	<0.35	NA	--
MW5	Tzalá	February	<0.010	<0.010^{a}	**0.64**	**0.146^{d}**	--
Quebrada Seca	Riachuelo Quivichil	July	**0.020**	NA	<0.35	NA	--

Values in bold exceed one or more relevant standard (see Table 2). Note that some detection limits are higher than potentially relevant standards.

a 2009 data not available, <0.010 for all of 2008
b January 2009 data
c December 2008 and April 2009 data
d Average for 2008; maximum=0.448 (MW5) and 0.013 (SW1)
e April 2009 data.
NA Data not available
Note: COPAE does not analyze samples for cyanide.

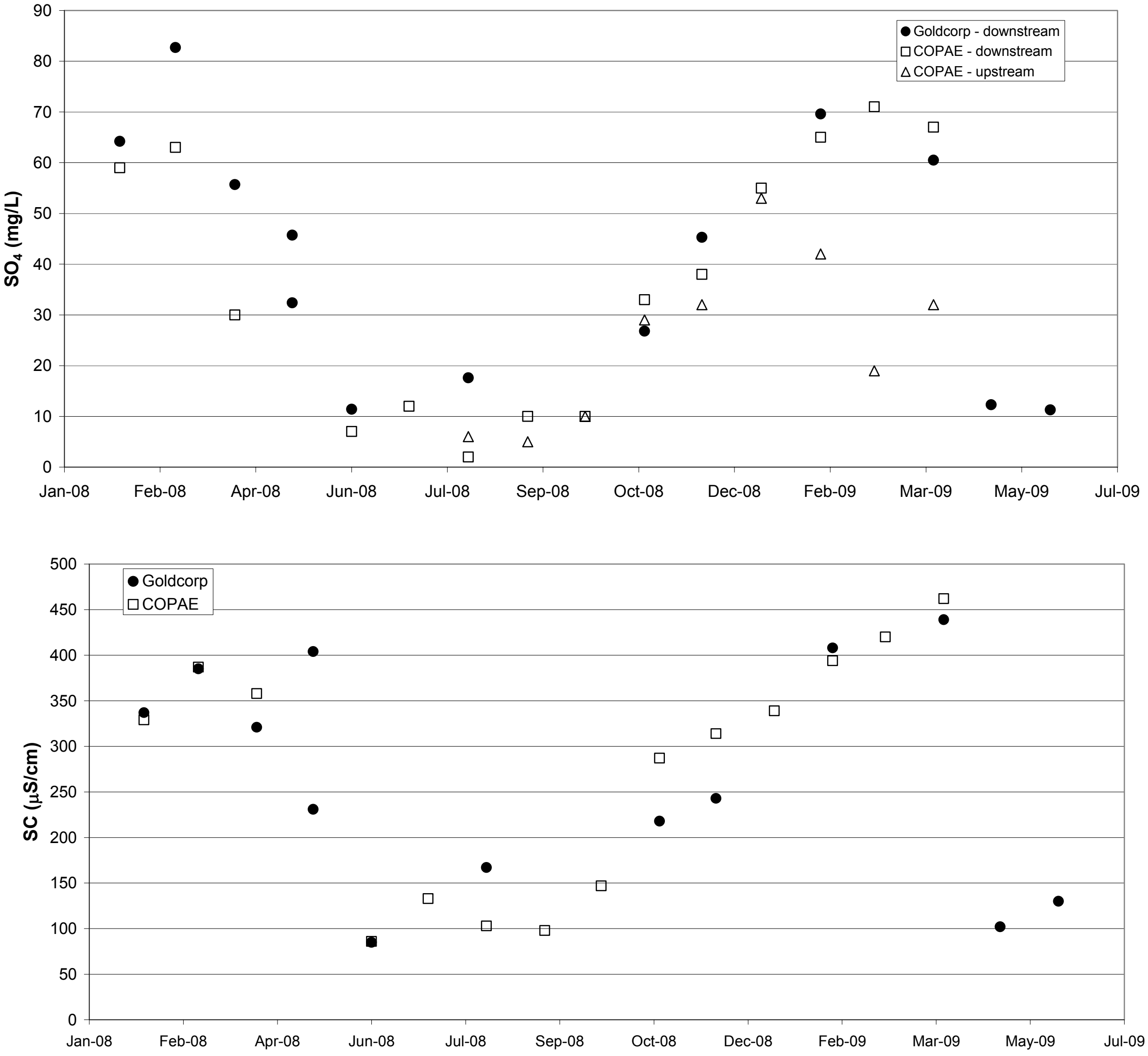
these appear to be one-time or anomalous excursions. Baseline manganese concentrations are elevated here and in all other drainages and were as high as 0.524 mg/l at SW3.

A tributary of Riachuelo Quivichil that drains the mine (Quebrada Seca, and its tributary below the tailings dam) was sampled by Goldcorp (SW8) and COPAE ($SW3_C$) (same location, see Figure 2). This location is downstream of both the waste rock dump and the tailings impoundment (see Figure 2); no sampling sites that would be unaffected by mining activities exist on the tailings impoundment tributary upstream of Quebrada Seca or on Quebrada Seca upstream of the tailings impoundment tributary (because the mine wastes are located at the very upstream end of the drainages) that would allow monitoring of possible separate effects from the two mining-related sources.

No results were available for D6, seepage from the tailings impoundment, from Goldcorp, but AMAC has sampled this location a number of times. The sampling point is in a secondary tailings water collection pond located outside of the drainage channel, and the water is pumped back to the tailings facility (Lisa Wade, Personal Communication, March, 2010). The pond is lined with compacted clay rather than a synthetic liner, and there is no leachate collection system downgradient of the pond. Seepage into the pond was estimated at 100 liters/second (L/sec) in 2009 (MWH, 2009), including an estimated 37 L/min from tailings impoundment infiltration (MWH, 2009). Although water in the pond is continually pumped back to the tailings impoundment, it is unlikely that the pond captures all the seepage from the impoundment. Additional infiltration from the impoundment and the secondary pond could be leaking to groundwater, and possibly to downgradient surface water locations. As far as we are aware, no estimates of the total amount of seepage from the tailings impoundment and the pond have been conducted. AMAC's results for sulfate and TDS at D6 are shown in Figure 7. Sulfate concentrations reached 705 mg/l in November 2008. Although sulfate standards are for aesthetics (taste), concentrations in the range of 1,000 to 1,200 mg/l can induce a laxative effect, and the World Health Organization recommends notifying health authorities of sources with concentrations higher than 500 mg/l (WHO, 2008).

AMAC's total cyanide values for D6 in 2007 and 2008 are shown in Figure 8. The highest measured concentrations exceeded U.S. Clean Water Act aquatic life criterion values by over 12 times, and infiltration to groundwater from this source could adversely affect downgradient surface water. AMAC's results for D6 indicate that tailings seepage has elevated concentrations of sulfate, TDS, and cyanide. More information on the engineering of the tailings seepage pond and possible transport to the tailings tributary and Quebrada Seca should be investigated.

Figure 6. Comparison of Goldcorp and COPAE results for (a) sulfate concentrations in Riachuelo Quivichil upstream ($SW6_C$) and downstream (SW3 and $SW2_C$) of Quebrada Seca, and (b) specific conductance downstream of Quebrada Seca (SW3 and $SW2_C$).



Data source: Goldcorp, 2009; COPAE, 2009.

Goldcorp and COPAE sampled surface water station $SW8/SW3_C$, a non-perennial location in Quebrada Seca located downstream of the tailings dam and large waste rock pile (see Figure 2). Goldcorp's data showed occasional detections of total and WAD cyanide in October 2005 (0.40 mg/l), but concentrations were below detection (at 0.002 and 0.02 mg/l) in September and November of that year. No samples were collected during the dry season in 2006 (January through April), and cyanide was detected again in

November 2006 (0.008 mg/l) and December (0.005 mg/l) at values at or above the U.S. Clean Water Act aquatic life criteria. However, the detection limits were too high to know for certain if the measured values were reliable.

A comparison of Goldcorp's and COPAE's data in Quebrada Seca (SW8 and $SW3_C$) is shown in Figure 9. Where they overlap in time, specific conductance and sulfate values for Goldcorp and COPAE are similar, and the values were elevated in 2004/05 (using Goldcorp's data) and again in 2009 (using COPAE's data). Sulfate concentrations hit the U.S. drinking water secondary standard only once in 2007. COPAE's arsenic and nitrate concentrations show increasing concentrations over time (Figure 9c and 9d). One of Goldcorp's samples exceeded drinking water standards for arsenic in 2007.

Based on sulfate and specific conductance results from Goldcorp and COPAE, Quebrada Seca should be evaluated more thoroughly for possible infiltration and migration from the tailings impoundment and seepage pond and the waste rock pile. If seepage is affecting the drainage, adaptive management measures should be taken to decrease concentrations at the sources or limit the downgradient migration of mine-related contaminants.

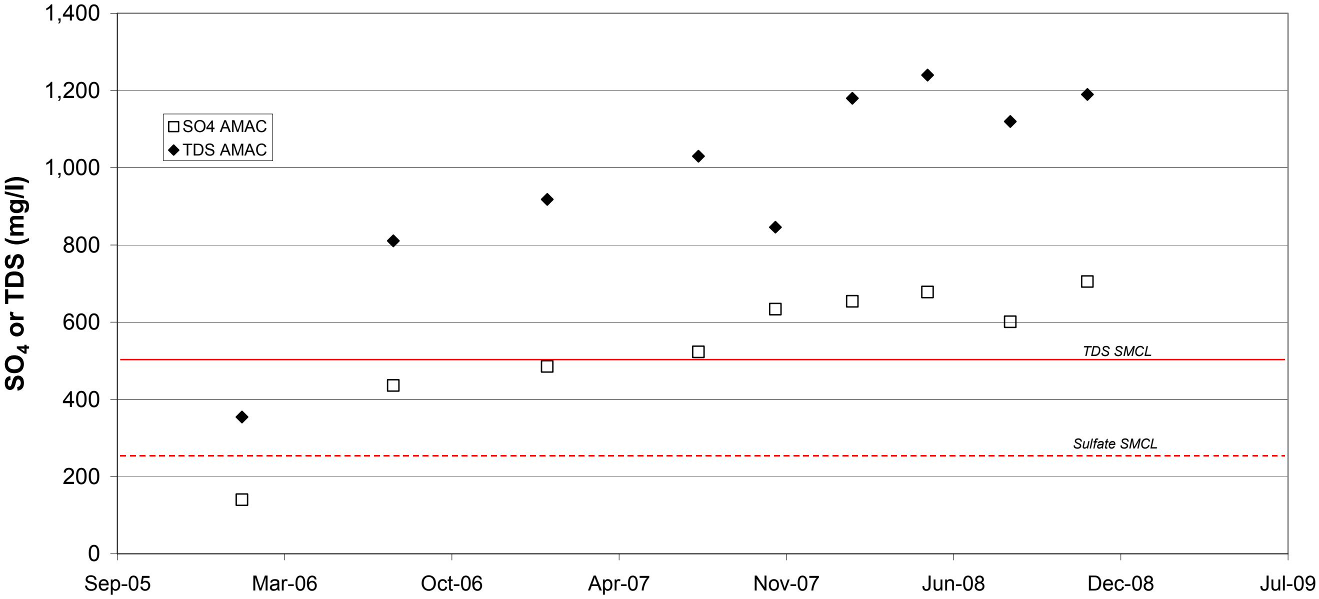
Río Cuilco Drainage

Goldcorp, AMAC, and MARN collected and analyzed samples from locations SW4 (Ro Cuilco upstream of Río Quivichil) and SW5 (Río Cuilco downstream of Río Quivichil). Both locations are downstream of mining activity (see Figure 3), but they are a distance from the mine. Locations SW11 and SW12 are also located in the Cuilco drainage upstream of Río Tzalá and all mining activity (SW11) and downstream of Río Tzalá (SW12).

Goldcorp provided electronic data for SW4 and SW5 from July 2002 to June 2009. Their data showed that water quality at both locations (SW4 and SW5) is good, with low concentrations of sulfate, no detectable cyanide (at a detection limit of 0.010 mg/l), and mostly below-detection metal concentrations. TDS values and sulfate concentrations are generally lower in Río Cuilco than they are in Riachuelo Quivichil (see Figure 2), which drains the mine site. TDS values in Río Cuilco are often one-half as high as those in Riachuelo Quivichil (with values in Riachuelo Quivichil ranging from ~200 to 350 mg/L). Sulfate concentrations in Río Cuilco are less than 20 mg/L with little seasonal fluctuation, while values in Riachuelo Quivichil reached almost 100 mg/L and have a large seasonal variability. Concentrations downstream of Riachuelo Quivichil in Río Cuilco (SW5) are rarely higher than those upstream of Quivichil (SW4), suggesting that influence from the Quivichil drainage is rapidly diluted in Río Cuilco. MARN's samples at SW4 and SW5 had elevated cyanide concentrations (up to 0.102 mg/l at SW4 and 0.161 mg/l at SW5), as shown in Table 5, but MARN's results also showed elevated cyanide in the Ro Tzalá location upstream of the mine, and are therefore considered unreliable.

The data available for the Río Cuilco drainage suggest that mining impacts are not currently important at the sampled locations.

Figure 7. Sulfate and TDS values in tailings seepage pond below the dam (D6), AMAC data.



Data source: AMAC, 2006, 2007, 2008.

Figure 8. Total cyanide concentrations in tailings seepage pond below the dam (D6), AMAC data.

Data source: AMAC, 2006, 2007, 2008.

Figure 9. Specific conductance (a), sulfate (b), arsenic (c), and nitrate (d) values in Quebrada Seca at SW8 and SW3$_C$.

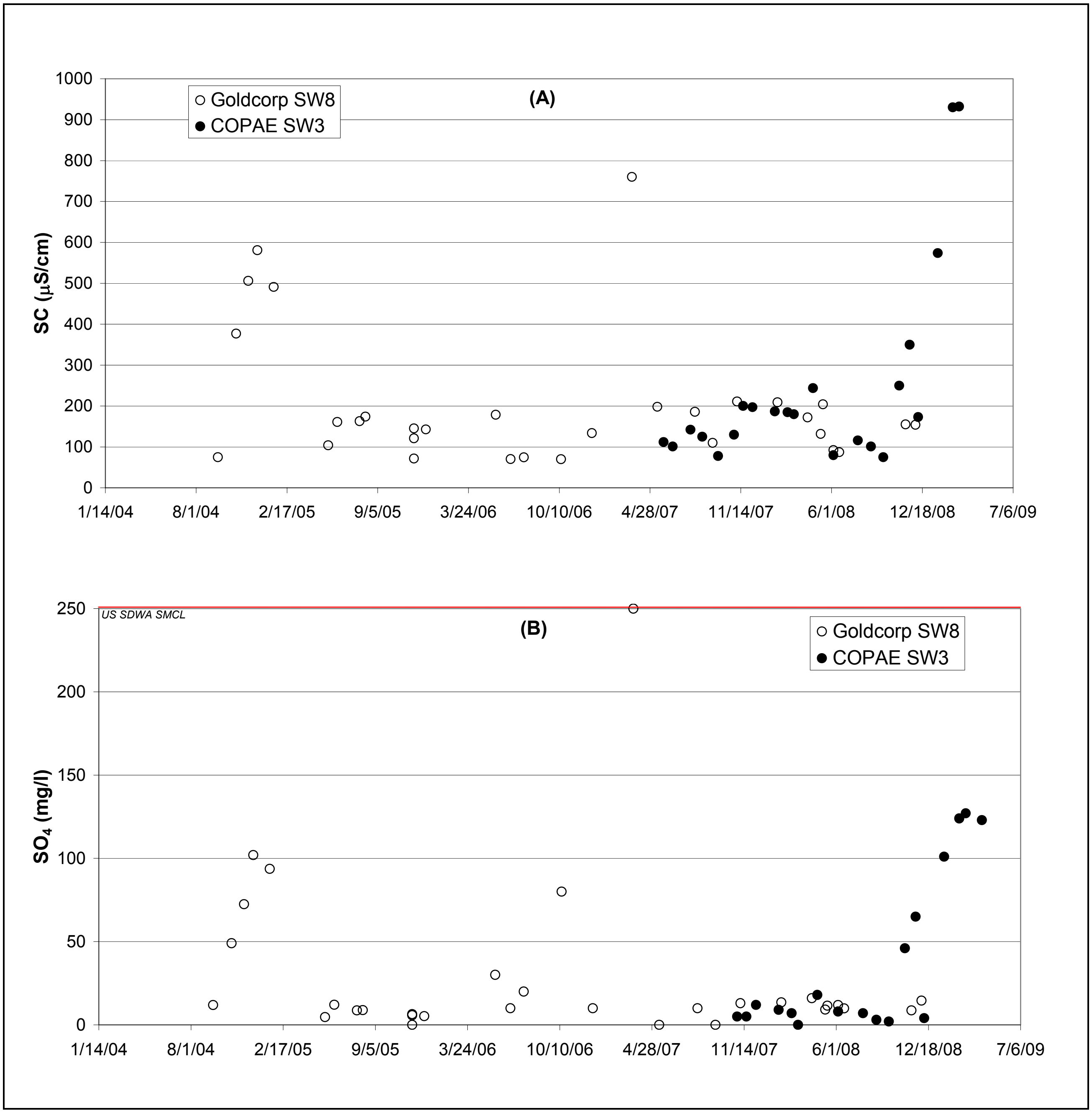
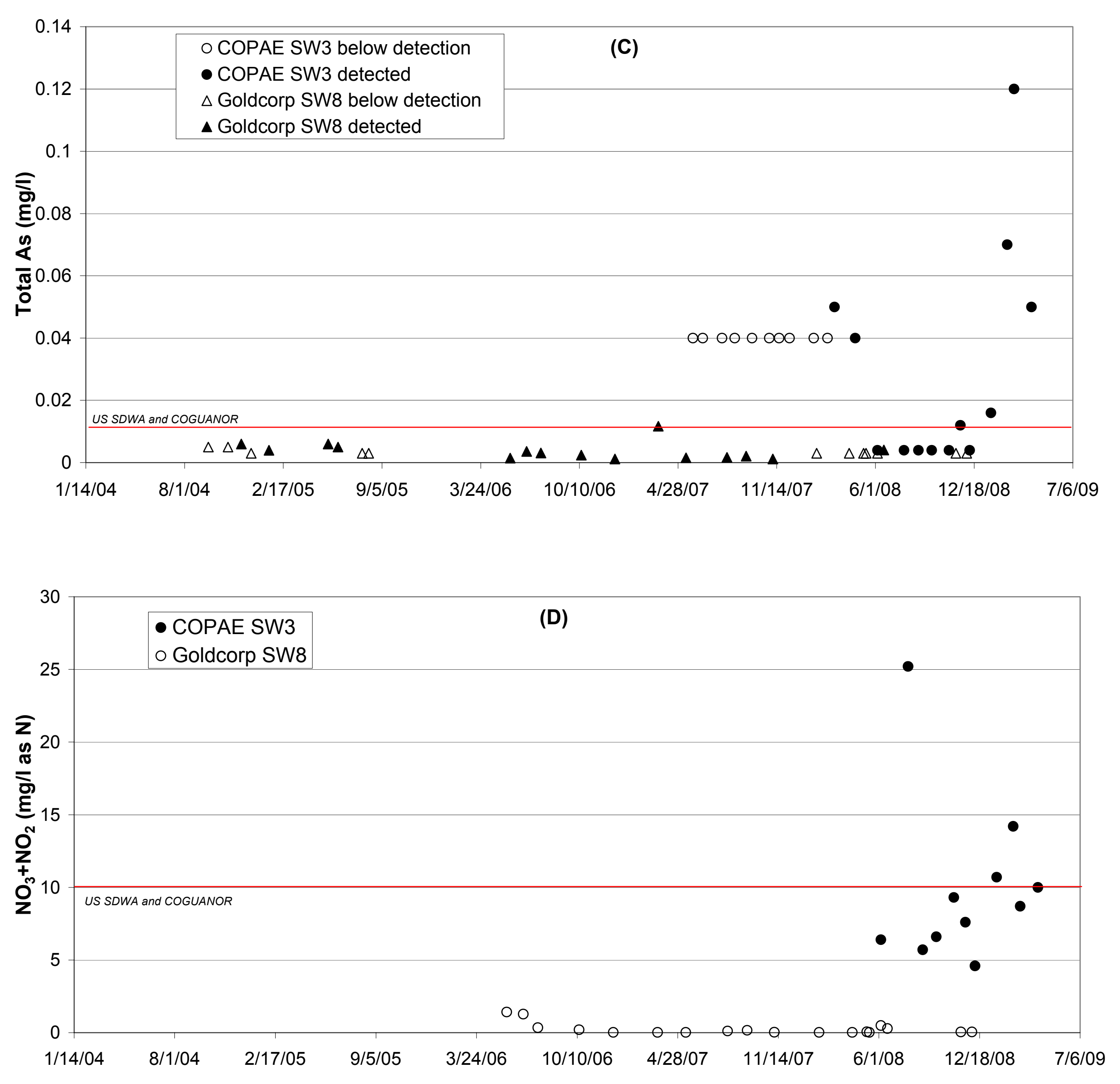


Figure 9 (cont.). Specific conductance (a), sulfate (b), arsenic (c), and nitrate (d) values in Quebrada Seca.



Data source: COPAE, 2008, 2009; Goldcorp, 2009.

6.2.3 Aquatic Life

Monitoring of aquatic life was conducted by Goldcorp at surface water stations SW1, SW2, SW3, SW4, and SW5 starting in the rainy season of 2002 (July) (2006 AMR). An additional aquatic life monitoring location was added in March 2006 upstream of mining influences at SW10. Monitoring is conducted twice a year: during the rainy season and during the dry season. Fish, macroinvertebrates, habitat, and the Index of Biotic Integrity (IBI) are monitored and reported, as required by the EIA&S. IBIs are measured for fish, macroinvertebrates, and habitat, and an overall IBI (average of all three) was also included in the EIA&S (Annex 13.1-J). IBI values range from zero (completely deteriorated) to 100 (ideal conditions), and values measured during operational conditions can be compared to values measured before potential impacts began. The IBIs for fish were reported for each monitoring station in the 2006 and 2007 AMRs (and included values for preceding years) but were not included in the 2008 AMR. Separate detailed reports on aquatic life monitoring were prepared but were not available on the Goldcorp website.

Two fish species were reported: *Profundulus spp*. and *Rhamdia laticauda*. Decreasing fish numbers (*Profundulus)* were observed in Riachuelo Quivichil below the tailings facility (SW3), starting in the September 2004 rainy season, and in Río Cuilco upstream and downstream of Riachuelo Quivichil (SW4, SW5) in 2006 (2006 AMR). The large drop in fish populations in SW4 and SW5 in September 2006 was ascribed to an aggregate extraction project in the Cuilco drainage upstream of the confluence with Riachuelo Quivichil. The continuing decrease in population numbers in Riachuelo Quivichil (SW3) was ascribed to mine construction in the tailings area. According to the 2006 AMR, improvements to construction practices were made in 2006, and no further decrease in fish populations was seen between 2005 and 2006. Further improvements and reclamation of some disturbance areas in 2007 were expected to result in gradual increases in fish populations (2006 AMR, p. 53). In the 2008 AMR, after five seasons of monitoring, Goldcorp stated that no adverse effects on fish populations have been observed, with the exception of location SW3, located in Riachuelo Quivichil downstream of the tailings impoundment (2008 AMR). However, fish populations at SW4 and SW5 have not returned to 2004/2005 levels.

The IBIs for fish during the rainy and the dry seasons for SW3 (Riachuelo Quivichil) and SW4 (Río Cuilco upstream of Riachuelo Quivichil) are plotted in Figure 10. The IBIs show a large amount of variability between dry season and rainy season and from year to year. Before active mining began, the IBIs for fish at SW3 were higher than that at SW4 during both the dry and the rainy season. The IBIs for SW4, located upstream of the tailings impoundment in Río Cuilco, have not dropped below the lowest pre-mining values. However, IBI's for SW3 dropped to zero in 2007 during both the dry and the rainy season. The drop in fish population numbers at SW3 was attributed to ongoing construction of the tailings impoundment (2008 AMR). The decrease in IBIs is not discussed in Goldcorp's annual monitoring reports. The influence of possible deteriorating water quality in Quebrada Seca on aquatic life in Riachuelo Quivichil (SW3) should be evaluated in future studies.

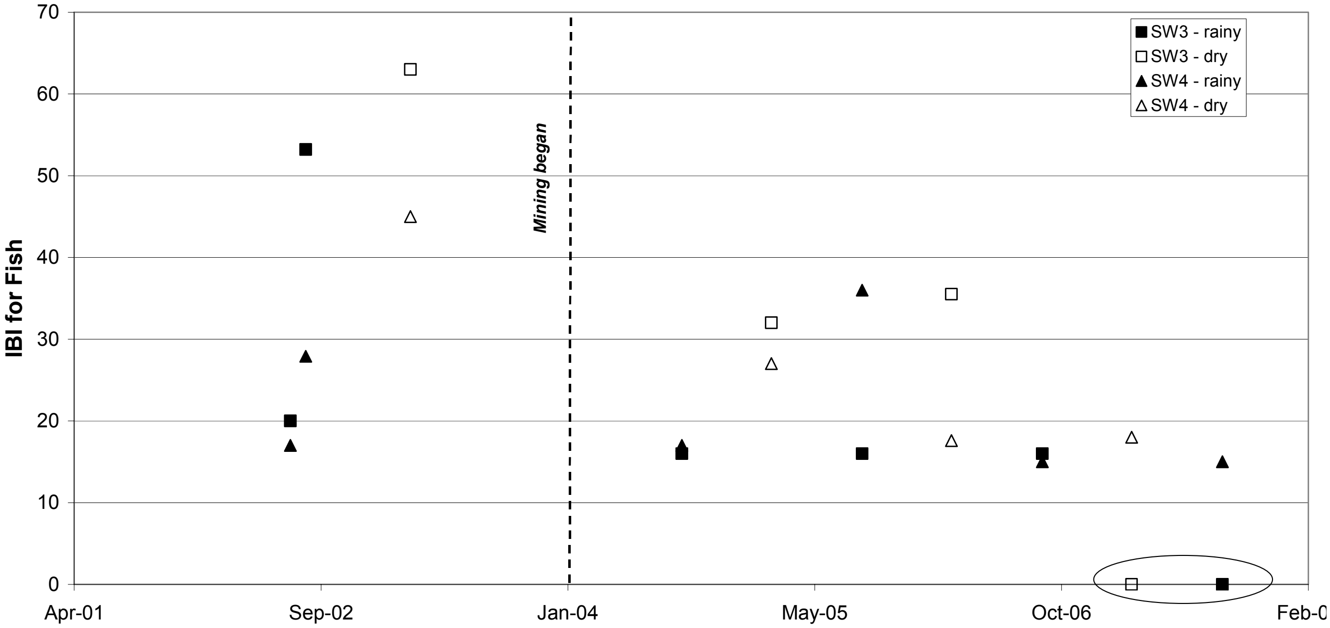
7. Comparison of predictions with operational water quality and quantity conditions

The potential (without mitigation measures) and predicted (with mitigation measures) impacts to water quality and quantity, the proposed mitigation measures, and the operational conditions and outcomes for the Marlin Mine are discussed above and summarized in Table 6.

The Marlin Mine EIA&S (2003) comports with standard practice in the United States and does include predictions of potential impacts, a listing and discussion of proposed mitigation measures, and predicted impacts once mitigation measures are installed. All predictions included in Table 6 derive from the EIA&S with the exception of the last one: prediction of daylighting of tailings seepage to the drainage downstream of the dam. This prediction was made in the 2006 AMR but is included because it is an important environmental effect that may be occurring.

Very few of the predictions are numeric or specific, with the exception of the prediction that tailings water will meet IFC effluent standards. As shown in Table 6, after mitigation measures are installed, no moderately or strongly negative impacts were predicted.

Figure 10. Index of Biotic Integrity (IBI) for fish at SW3 and SW4.



Data sources: EIA&S, 2003, Annex 13.1-J. CTA, September 2002; 2006 AMR; 2007 AMR.

The most important predictions (after mitigation measures are installed) that were either incorrect or not included in the EIA&S were:

- acid generation and contaminant leaching potential are low
- tailings seepage will not migrate to the drainage downstream of the tailings dam (not included in EIA&S)
- water stored in the tailings impoundment will meet IFC effluent standards
- there will be no impacts to actual or potential surface water or groundwater use.

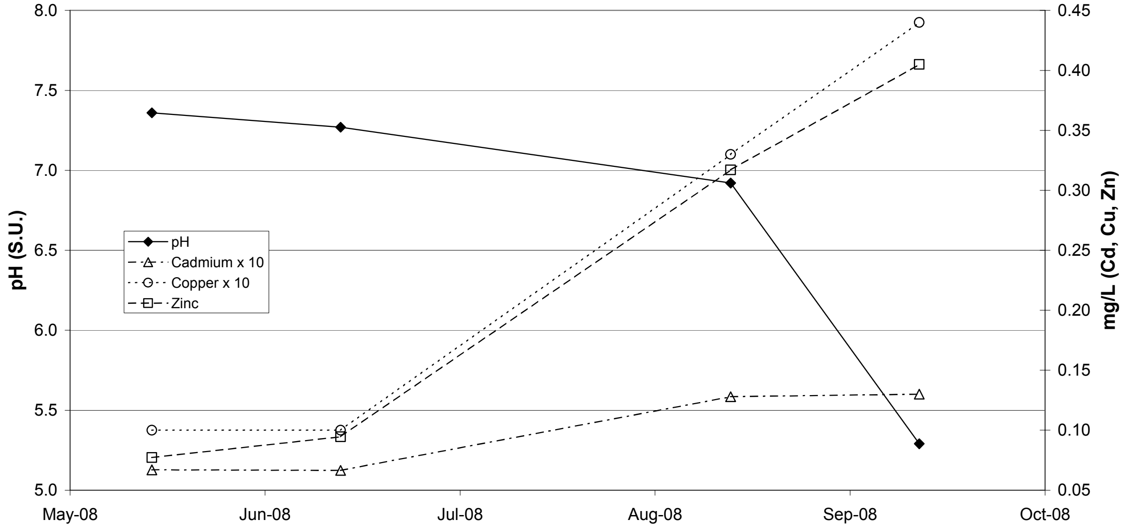
Based on waste rock characterization information available in the Goldcorp AMRs, nearly half of the waste rock is potentially acid generating, and an additional 25 to 35% has uncertain acid-generation potential. The EIA&S predicted that only a minority of the waste rock would be acid generating. Twelve field tests are being conducted on materials identified as non-PAG (4) or uncertain (8). Two samples were identified as PAG using the NP:AP ratio, but both were identified as uncertain using the net neutralizing potential (2008 AMR). As acknowledged in the Goldcorp AMRs, the waste rock field tests are ongoing, and additional information is needed to fully evaluate the contaminant leaching potential. However, even with the short duration of the tests so far (most were started in 2008), five of the 12 samples have already produced acidic water with pH values below 6.0 (2008 AMR, Attachment F). Four of these five samples were identified as uncertain by both ABA methods, one was identified as non-acid producing by both methods, and the other two were identified as uncertain by one method and non-acid producing or PAG by the other method. Therefore, the guidelines for identifying acidic waste rock may underestimate the potential to become acidic and to leach contaminants. Although all waste rock identified as acid generating or uncertain are managed in the same manner, rock identified as non-PAG is not. Rocks identified as acid generating or uncertain are encapsulated in non-PAG rock and placed in certain areas of the waste rock facilities or cemented in the underground mine The field test samples that became acidic produced elevated concentrations of total dissolved solids, sulfate, aluminum, cadmium, cobalt, copper, iron, manganese, nickel, nitrate, selenium, and zinc, and provide an indication of the types of waters that can be produced from rocks identified and managed as non-PAG, uncertain, and PAG. As shown in Figure 11, as the rocks generate acid, concentrations of contaminants such as cadmium, copper, and zinc increase. The highest concentrations of cadmium are above drinking water and aquatic life standards, and the highest values of copper and zinc are higher than aquatic life standards. Given the uncertainty associated with laboratory and field waste characterization, actual measurements of contaminants of concern in mine seepage or waters is preferable, yet very little information is available on underground mine water, tailings water, or waste rock seepage quality. Goldcorp should strive to make all this information available to the public on a regular basis (at least quarterly).

Limited water quality data from Goldcorp, AMAC, and COPAE (using only results for sulfate and specific conductance for COPAE) suggest that tailings seepage may be leaking into the Quebrada Seca tributary downstream of the tailings dam (see Section 6.2.2). An independent evaluation of water quality conditions in the impoundment, in groundwater downgradient of the impoundment, and in the Quebrada Seca tributary should be conducted to resolve the uncertainty. The evaluation should include an analysis of the potential effects of tailings discharge on aquatic biota downstream of the facility.

Goldcorp has acknowledged that water stored in the tailings impoundment does not meet IFC effluent guidelines (2007 AMR, 2008 AMR). The company has constructed a second treatment plant and plans to treat all tailings water discharged to the environment. However, because seepage may already be migrating to the drainage downstream of the dam, Goldcorp should investigate potential seepage pathways and accelerate the proposed plans for treatment and pumping of tailings seepage from the PW wells, if required.

Finally, the EIA&S predicted that there would be no adverse effects to actual or potential water use as a result of mining activity. To our knowledge, Goldcorp has not conducted a study of water use in the area, and importantly, groundwater flow directions and seepage pathways from contaminant sources (pit, underground mine, waste rock piles, tailings impoundment) are poorly understood. If groundwater flow directions are not known, the potential for downgradient transport of contaminants from mining sources, and its effect on water use, cannot be adequately evaluated. Additionally, because there is no groundwater dewatering for the mine and mitigation measures do not currently isolate mine facilities hydrologically, the facilities are not under hydrologic control, and contaminants could migrate from sources to downgradient groundwater and surface water receptors. The groundwater and surface water monitoring network should be expanded, and a hydrogeologic study of groundwater flow directions and transport pathways should be conducted in the near future. The need for and specific locations of any additional groundwater or surface water monitoring locations would be established as part of the hydrogeologic study.

Figure 11. Decreasing pH and increasing metal concentrations in waste rock field sample 2188-29-126.



Data source: 2008 AMR, Attachment F.

Table 6. Comparison of predicted and actual water quality and quantity and aquatic biological impacts for the Marlin Mine, Guatemala, and proposed mitigation measures.

Area/ Resource of Potential Impact	Prediction before Mitigation	Proposed Mitigation	Prediction after Mitigation	Actual Outcome/Comments
Aquatic Biological Resources	Moderately negative impacts from storage and manipulation of combustibles and drainage of the pit during operation and from regrading and closure of the waste rock dump and tailings impoundment. There could be impacts to aquatic life from increases in suspended sediment during the rainy season.	Best management practices (soil erosion, combustibles and chemicals); size, locate, design, maintain, and monitor the septic system (alternative disposal contingency); neutralize cyanide from tailings deposit during operations (contingency) or closure; operational waste characterization; mitigate acid drainage during closure if necessary; mix acid-generating and non-acid-generating rocks; regrade/compact waste rock during operations/closure	No remaining moderately or strongly negative impacts during or after mining.	Decreasing fish numbers and index of biotic integrity in Riachuelo Quivichil below TSF (SW3). Changes ascribed to tailings impoundment ongoing construction; effect of seepage from impoundment not considered.
Groundwater Flow	Moderately negative impacts to groundwater flow from pit drainage (during operation)	None proposed.	Same as before mitigation.	Not enough groundwater level data to evaluate.
Groundwater Quality	It is possible that spills of fuels, chemicals, reagents, or waste water could impact groundwater quality.	Follow guidelines of materials management plan for storing, handling, use of fuels, chemicals and reagents; processing facilities designed to contain process solutions; spill prevention/ containment plans.	Same as before mitigation.	No apparent impact to groundwater quality at this time.

Area/ Resource of Potential Impact	**Prediction before Mitigation**	**Proposed Mitigation**	**Prediction after Mitigation**	**Actual Outcome/Comments**
Water Quality	Cyanide in the tailings could represent a threat/danger to the environment	Tailings neutralized before impoundment; impoundment designed/ constructed to minimize infiltration to groundwater; treatment before release	Cyanide in the tailings will not represent a threat/danger to the environment; water stored in TSF will meet IFC effluent standards; no negative impacts to groundwater	Two bird mortality incidents from cyanide in October 2005, repaired pump near cyanide mix tank; pH, total and WAD cyanide, copper, and mercury exceeded IFC discharge standards and are “parameters of interest;” Goldcorp stated that treatment will likely be required when/if TSF effluent is discharged to the environment
Water Quality	Moderately negative impact to water quality from mining and blasting (during operation)	Put in place the erosion control plan and the plan for management of surface runoff.	No remaining moderately or strongly negative impacts during or after mining.	Results from COPAE suggest blasting impact, but Goldcorp’s do not: additional sampling needed.
Water Quality	Moderately negative impact to water quality from pit drainage and waste rock dumps (during operation) and closure of the heap and the tailings impoundment; potential for acid drainage and release of metals from the waste rock is low.	Continue monitoring during operations to determine if mitigation measures are needed before closure. Use monitoring wells below the pit, tailings, and waste rock to detect any impact. Determine acid generation and contaminant leaching potential during operations; if necessary, the waste rock dump will be regraded and covered with a low-permeability cap.	No remaining moderately or strongly negative impacts during or after mining; low acid-generation and contaminant leaching potential	Acid drainage potential higher than predicted; five of 12 field column tests have already become acidic. EIA&S predicted that majority of waste rock would be acid-neutralizing
Water Quantity	Pits will be dry and no dewatering will be required	None required	Same as before mitigation.	No dewatering required, but because of that and lack of mitigation, facilities are currently not under hydrologic control
Water Quantity	Moderately negative impact to water use related to mining and blasting (during operation)	None: there is currently no or little use of the water and no foreseeable future use.	There will be no impacts to actual or potential surface water or groundwater use	Groundwater and surface water are used for human consumption/livestock watering; does not consider possible future uses; groundwater flow directions and seepage pathways poorly understood

Area/ Resource of Potential Impact	Prediction before Mitigation	Proposed Mitigation	Prediction after Mitigation	Actual Outcome/Comments
Water Quantity/ Quality	The potential was identified (after mining began - 2006 AMR) for an increase in the phreatic surface in the TSF abutment, which could potentially result in seepage daylighting in the drainage to the east (tributary of Quebrada Seca)	Impoundment will be designed and constructed to minimize infiltration of water to groundwater. Convert monitoring wells to pump back wells if "significant" increases in water levels or decreased water quality (proposed in 2008 AMR).	Seepage of tailings water can be controlled	Not predicted in EIA&S; increased water levels in PW7, but no adverse effects to water quality in this well. Increasing concentrations of COCs in drainage to east of dam suggest that tailings seepage has surfaced in drainage.
Water Quantity/ Quality	First discharge from TSF to environment will occur in late 2007 during rainy season, or during 2008 rainy season, depending on precipitation and storm intensity in 2007 and construction schedule for dam	None - depends on climatic conditions	Same as before mitigation.	Direct discharge from TSF to environment still has not occurred. The water balance model did not consider infiltration through the impoundment; infiltration could explain why discharge has not been required and why concentrations of tailings COCs have been increasing in the drainage to the east of the dam.
Water Quantity	During the dry season, ~85% of the water needed for mining will come from the tailings impoundment; the remainder (0.019 m^3/s) will be pumped from the Río Tzalá. During the wet period, no water will be pumped from the Río Tzalá for the mine	None	Same as before mitigation.	No mention of pumping from Río Tzalá was found in any of the Goldcorp AMRs.

Sources: EIA&S, 2003 (especially Table 6.1-6); 2005 AMR, 2006 AMR, 2007 AMR, 2008 AMR, availability water quality data from Goldcorp, AMAC, COPAE, MARN.

8. Closure and Post-Closure

There is some limited information in the EIA&S on closure of the Marlin Mine, but little information is available on the post-closure period. According to Goldcorp (Personal

Communication, Lisa Wade, email, September 22, 2009), they have recently updated the closure plan, but it is not yet publicly available.

Guatemala does not have a mechanism for closure bonding. However, Goldcorp has taken the following steps related to bonding (Personal Communication, Lisa Wade, email, September 22, 2009):

- Posted a voluntary closure bond with the Guatemalan Ministry of Energy and Mines for $1 million US, the largest bond available in Guatemala. Goldcorp acknowledges that closure costs would be well in excess of this amount.
- Posted a voluntary bond with the Guatemalan Ministry of the Environment for approximately $30,000/year to guarantee that Goldcorp will conduct the environmental monitoring activities as required (this is unrelated to closure).
- All Goldcorp sites are audited annually by Deloitte & Touche to evaluate their closure cost provisions according to the Financial Accounting and Standards Board (FASB) Statement 143 in the United State and the equivalent rules in Canada. Deloitte & Touche audits the Marlin Mine under conditions in FASB 143 even though it is not in the United States.

Closure/post-closure bonding is important because potential impacts from gold mining may not surface quickly, and they can continue for many decades after closure. Actual bonding for equivalent size gold mine reclamation in the United States may be in the many millions of dollars, and liability for actual cleanup costs can be in the billions of dollars (Kuipers, 2002).

Closure/post-closure and bonding/financial assurance issues should be investigated in more detail, including an evaluation of a supportable bond amount that would cover reasonable environmental eventualities after operations cease. Such an evaluation is beyond the scope of our work, but should be conducted by an independent expert in mine bonding and financial assurance that has the trust of the local communities, the mine, and relevant Guatemalan governmental entities. The Ministry of Energy and Mines should devel[illegible]gulations and mechanisms for bonding of hardrock mines in Guatemala.

9. Summary of Findings and Recommendations

9.1 Summary of findings

9.1.1 Summary of Major Shortcoming with EIA&S

- The baseline water quality monitoring period was too short (only 8 to 9 months) to evaluate seasonal and inter-annual changes in water quality. For groundwater quality, only two springs were sampled; deeper groundwater was not sampled during the short EIA&S period.
- There is not enough information on groundwater levels to know the degree of connection of aquifers on the site or the hydrologic connection between aquifers and surface water.

- There is no information on groundwater flow directions, which is a common component of EISs in the United States. Without information on groundwater flow directions, it is impossible to know the potential for the migration of contaminants from mine sources to receptors. A reliable monitoring network cannot be established for the Marlin Mine before groundwater flow directions have been determined.
- Essentially no information on geochemical testing was included in the main body of the EIA&S. The EIA&S summarizes the results by stating that the acid generation and contaminant leaching potential of the rocks are low, but no supporting tables or figures are provided. More extensive geochemical testing should have been conducted on more samples during the exploration phase, or certainly before mining began, and a comprehensive summary of the results should have been included in the main body of EIA&S. Testing should have included at a minimum, whole rock chemistry, acid-base accounting, short-term leach testing, long-term kinetic testing, and mineralogic analysis. This type of information is crucial for developing effective waste rock and tailings management plans.
- A tailings water balance model was conducted for EIA&S. However, infiltration through the impoundment was not considered in the model. The model predicted that direct discharge to the environment would be required by 2007, yet it has not yet been needed at the writing of this report (early 2010). If infiltration through the impoundment has been occurring, it could explain why the prediction was wrong.

9.1.2 Predictions and Mitigation Measures

- According to the EIA&S, the Marlin project was designed to conform to North American standards and will employ the best practices of environmental management to minimize environmental impacts and comply with Guatemalan regulations, international guidelines for environmental management, and the environmental policies of Glamis Gold and Montana
- As with U.S. Environmental Impact Statements, positive and negative impacts were identified for conditions with mitigation and without mitigation. We distinguish between "potential" impacts (without mitigation measures) and "predicted" impacts (after mitigation measures are in place). In the United States, permits are granted on the basis of "predicted" rather than "potential" impacts.
- The Marlin Mine EIA&S also identified mitigation and contingency measures that would help prevent or minimize negative impacts to the environment.
- Very few of the predictions are numeric or specific, with the exception of the prediction that tailings water will meet IFC effluent standards.
- No strongly negative impacts were identified for water quality, water quantity, or water use.
- The most important potential water quality impacts identified included:
    - The potential for acid drainage and contaminant leaching is low
    - Cyanide in the tailings could represent a threat/danger to the environment

  - Moderately negative impact to water quality from mining and blasting during operation
  - Moderately negative impact to water quality from pit drainage and waste rock dumps during operation and closure of the heap and the tailings impoundment.
  - Surface water could see increases in TSS
  - It is possible that spills of fuels, chemicals, reagents, or waste water could impact groundwater quality
  - Water stored in TSF will meet IFC effluent standards
- The potential water quantity or water use impacts identified included:
  - The potential for an increase in the phreatic surface in the TSF abutment that could result in seepage daylighting in the drainage to the east (identified in 2006 AMR, not in the EIA&S)
  - First discharge from TSF to environment will occur in late 2007 or early 2008
  - During the dry season, ~85% of the water needed for mining will come from the tailings impoundment and the remainder will be pumped from the Río Tzalá; no water will be pumped from Río Tzalá during the wet season
  - The pit will be dry and no dewatering will be required
  - There will be no impacts to actual or potential surface water or groundwater use.
- The potential impacts to aquatic biological resources identified in the EIA&S and the early Annual Monitoring Reports by Montana Resources included:
  - Moderately negative impacts from storage and manipulation of combustibles and drainage of the pit during operation and from regrading and closure of the waste rock dump and tailings impoundment
  - There could be impacts to aquatic life from increases in suspended sediment during the rainy season.
- After mitigation measures are installed, no moderately or strongly negative impacts to water resources or aquatic life were predicted.
- The EIA&S also identified a number of moderately or strongly *positive* impacts related to water bodies, most of which were associated with revegetation/reforestation after operations or ceasing construction during operations. None of these positive impacts should have been identified as such, because impacts should be evaluated relative to baseline (pre-mining) conditions rather than conditions resulting from mining operations.
- The mitigation measures for water bodies and aquatic life generally included:
  - Limiting disturbance, where possible
  - Limiting the amount of stored chemicals and combustibles, where possible
  - Using best management practices or plans for erosion, surface runoff, storage and use of combustibles and chemicals, disposal of wastes, wildlife, and forests
  - Designing containment for process solutions, only discharging treated process solutions
  - Remediation, revegetation, neutralization of cyanide during closure

  - Sizing, location, design, maintenance, and monitoring of sanitary and septic systems
  - Monitoring of groundwater, potential for acid generation and metal leaching, noise during operations.

9.1.3 Monitoring, Sampling Efforts, and Data Quality

- The monitoring network, especially for groundwater, needs to be expanded. More upstream control locations, especially in Río Quivichil, and more groundwater monitoring sites are needed to reliably determine if releases from mining are adversely affecting water resources. More groundwater and surface water monitoring points are needed to evaluate potential impacts to drainage downstream and downgradient of the mine and to determine groundwater flow directions.
- There are no designated water quality standards for surface water or groundwater. Water quality standards for surface water and groundwater should address all foreseeable uses, including habitat for aquatic biota, drinking water, agricultural use, and livestock watering.
- The primary entities that have collected and analyzed water quality samples from the Marlin Mine are: Goldcorp/Montana Resources, AMAC, COPAE, MARN, and MEM. We formally requested data from all five sources via email and telephone and received reports and monitoring data and information from all except MEM.
- All of the entities conducting water quality sampling at the Marlin Mine had some shortcomings in their field or analytical approaches.
- For all monitoring entities, detection limits for certain constituents at certain times were too high relative to potentially relevant water quality standards, especially those for the protection of aquatic life.
- The laboratory methods used by AMAC and Goldcorp are reliable and similar to those commonly used in the United States and Canada.
- Detection limits for COPAE and MARN are generally too high, especially for metals and arsenic. COPAE's sulfate concentrations and specific conductance values appear to be reliable, based on the good comparison results with the outside laboratory and Goldcorp, while the quality of their results for metals, arsenic, and nitrate is likely less reliable, based on the elevated detection limits and comparisons with their outside laboratory, URL.

9.1.4 Enforcement and Public Access to Information

- There is a low level of regulation and enforcement by Guatemalan agencies.
  - No surface water or groundwater water quality standards exist.
  - Federal agencies have limited roles in monitoring the mine.
  - Enforcement and water quality standards must be linked, with firm numeric or narrative standards that can be checked against monitoring data and accountability to the public.
- The environmental monitoring data are generally not available to the public or are not adequately explained to the public.

  - Results for discharge monitoring points (e.g., underground mine water; tailings impoundment seepage) were generally not publicly available
  - Monitoring results from governmental entities are generally not available to the public.
  - Although Goldcorp's data are generally available to the public and AMAC is presenting its results to the public, it is not clear that the implications of the results are described or understood.

9.1.5 Operational Conditions

Sources of Contamination and contaminants of concern (COCs)

- Potential sources of contamination related to the Marlin Mine include the open pits, the underground mine, the tailings impoundment, the waste rock dumps, and the processing facilities (vat leach operations).
- The primary contaminants of concern at the Marlin Mine are:
  - nitrogen compounds from blasting agents (ammonia, nitrate, nitrite)
  - cyanide compounds (beneficiation compound)
  - sulfate and total dissolved solids (from weathering of sulfide minerals in the ore body, waste rock, and tailings)
  - total suspended solids (erosion from construction of mine and runoff from mine facilities)
  - metals and metalloids such as arsenic, lead, copper, mercury, cadmium, selenium, zinc, and nickel
  - pH (high pH in the tailings water, low pH in waste rock seepage)
- A number of the contaminants of concern had markedly increasing concentrations in the underground mine water at the middle and end of 2006. Results are not available for underground mine water after 2006.
- In the tailings water, pH values exceeded IFC discharge standards at different points in 2006. Based on these results, Goldcorp decided that when tailings water is discharged to the environment, active treatment will be required.
- Nearly half of the long-term waste rock test samples were potentially acid generating. These results do not match with predictions from the EIA&S, which predicted that the minority of the waste rock would be acid-generating and the majority would be acid-neutralizing.

Groundwater Resources

- The underground mine, pits, waste rock, and tailings areas are not under hydrologic control; there is no cone of depression under these facilities. Dewatering occurs only by a sump in the underground mine. In addition, no leachate collection systems are in place under or downgradient of the mine facilities. Therefore, contamination from these mining sources can migrate to downgradient groundwater and surface water.
- Concentrations of sulfate and arsenic have been increasing in the production well, MW5, over time. Goldcorp believes that the increases may be due to a deep, geothermal source. However, the temperature from this well is no higher than that from other wells, and the silica concentrations, which can often be elevated in

geothermal sources, are not higher than those from other monitoring wells on the site. The increases in concentrations of sulfate and dissolved arsenic, which are COCs for the underground-mine, may be related to increased leaching of wall and fractured rock from blasting in the underground mine and pit.

- Arsenic and sulfate concentrations are elevated in wells MW10 and MW11, which are located downgradient of the tailings impoundment (arsenic was as high as 261 μg/l As and 450 mg/l sulfate in MW10). Arsenic concentration in the tailings supernatant water (D4) in 2006 were only as high as 38 μg/l, but pore water values in the tailings themselves have not been reported and could be higher or lower. Sulfate concentrations in the tailings water are as high as 1,830 mg/l. The source of the elevated arsenic concentrations in MW10 and MW11 is uncertain at this time.
- No other groundwater wells had elevated concentrations that would be indicative of mining influence. However, the number of groundwater wells should be increased to effectively monitor groundwater flow directions and concentrations, especially downgradient of mine facilities. An independent hydrogeologic study is needed to determine the necessary number and locations of groundwater monitoring wells.

Surface Water Resources

- Río Tzalá: The most upstream location on Rio Tzalá, SW1, is reportedly upstream of any mining activity and has generally good water quality. However, cyanide was detected in several samples by Goldcorp, and MARN data also showed cyanide detections as high as 123 μg/l. The detections are likely anomalous, but additional monitoring by an independent entity should be conducted to evaluate the detections. Results for SW1-2 and SW2, which may be located downgradient of the Marlin open pit and access roads, were very similar to those for SW1. Total aluminum and iron concentrations appeared to increase after mining began at SW2, but the increases were also seen at the upstream location, SW1. However, in recent samplings, concentrations of TSS, iron, and aluminum were higher at SW2 than at the more upstream locations, even though concentrations increased at the same time at all locations.
- Riachuelo Quivichil: The Riachuelo Quivichil drainage basin contains the Cochis open pit, the small and large waste rock piles, and the tailings impoundment. Processing facilities (cyanide vat leach operations) are also located in this drainage. Goldcorp's and COPAE's results for sulfate and specific conductance in the mainstem Quivichil (downstream of Quebrada Seca) are very similar and fluctuate seasonally. COPAE's sulfate and specific conductance results upstream of mining influence (Goldcorp does not have an upstream location) suggest that weathering of sulfide minerals in wastes (waste rock and/or tailings) may have begun to adversely affect the Riachuelo Quivichil mainstem. Additional monitoring is needed to evaluate this possibility.
- Quebrada Seca: AMAC's results for D6, tailings seepage, indicate that the seepage has elevated concentrations of sulfate, TDS, and cyanide. Farther downstream in Quebrada Seca (Goldcorp's SW8 and COPAE's $SW3_C$), analytical

results from Goldcorp and COPAE show that sulfate concentrations and field specific conductance were elevated in 2004/05 and again recently in 2009, suggesting that seepage from mine sources may be adversely affecting this location. Quebrada Seca should be evaluated more thoroughly for possible seepage from the tailings impoundment and waste rock pile. If seepage is affecting the drainage, adaptive management measures should be taken to decrease concentrations at the sources.

- Río Cuilco: The limited data available for the Río Cuilco drainage suggest that mining impacts are not currently important at the sampled locations.

Aquatic Life

- Goldcorp monitored aquatic life (fish and macroinvertebrate populations, habitat, and the Index of Biotic Integrity (IBI)) at surface water stations SW1, SW2, SW3, SW4, SW5, and SW10.
- A large drop in fish populations occurred in July 2002, September 2004, September 2005, and September 2006 and was ascribed to an aggregate extraction project in the Cuilco drainage upstream of the confluence with Riachuelo Quivichil. A decrease in population numbers was also observed in Riachuelo Quivichil downstream of the tailings impoundment and was attributed to construction in the tailings area.
- Compared to fish IBIs measured before active mining began (2002 and 2003), IBI values have decreased noticeably for most locations during the dry season over time, especially for location SW3, located downstream of the tailings dam. Although IBIs for fish have decreased upstream and downstream of Riachuelo Quivichil in Río Cuilco, IBIs have decreased to zero in the stream draining the tailings impoundment and the waste rock dump. The influence of possible deteriorating water quality in Quebrada Seca on aquatic life should be evaluated in future studies.

9.1.6 Comparison of predictions with operational water quality and quantity conditions

- The most important predictions (after mitigation measures are installed) that were either not included in the EIA&S or were incorrect in the EIA&S were:
    - acid generation and contaminant leaching potential are low
    - tailings seepage will not migrate to the drainage downstream of the tailings dam (not included in EIA&S)
    - water stored in the tailings impoundment will meet IFC effluent standards
    - there will be no impacts to actual or potential surface water or groundwater use.
- Based on waste rock characterization information available in the Goldcorp AMRs, nearly half of the waste rock is potentially acid generating, and an additional 25 to 35% has uncertain acid-generation potential.
- Limited water quality data from Goldcorp, AMAC, and COPAE (using only sulfate and specific conductance values for COPAE) suggests that tailings and/or waste rock seepage may be leaking into the Quebrada Seca tributary downstream of the tailings dam.

- Water stored in the tailings impoundment does not meet IFC effluent guidelines for cyanide, copper, and mercury, and treatment will be required before the water is discharged to the environment.
- Goldcorp has not conducted a study of water use in the area, and, importantly, groundwater flow directions and seepage pathways from contaminant sources are poorly understood. The potential for impacts to water use cannot be adequately evaluated before flow directions are known. Because the mine facilities are not under hydrologic control, contaminants could migrate from sources to downgradient groundwater and surface water receptors and affect water use.

9.1.7 Closure and Post-Closure

- There is limited information available in the EIA&S, but little additional information is available on the closure and post-closure period. The closure plan has recently been updated but is not yet publicly available.
- Guatemala does not have a mechanism for closure bonding.
- Goldcorp has posted a voluntary closure bond with MEM for $1 million US, posted a voluntary bond with MEM for $30,000/year for monitoring, and conducted auditing of their closure cost provisions.

9.2 Recommendations

9.2.1 Technical Recommendations

- All monitoring data should be publicly available in electronic format (i.e. Excel or Access).
- Monitoring entities should strive for analytical detection limits that are three to five times lower than the lowest water quality standards.
- An adaptive management plan with citizen involvement and annual meetings should be created. Monitoring results from the previous year should be reviewed and compared, and changes in operations should be recommended and carried out.
- The groundwater, surface water, and discharge monitoring systems should be expanded. Groundwater monitoring wells should be expanded so that a reliable estimate of groundwater elevations and flow directions can be established. More surface water monitoring points are needed upstream (especially on Río Quivichil) and more immediately downstream of mine facilities. All groundwater, surface water, and discharge monitoring data should be made available to the public.
- A hydrogeologic study of groundwater flow directions and transport pathways should be conducted in the near future. The study should include an analysis of the extent of hydrologic connection between mine facilities and water resources and the pumping well and Río Tzalá.
- Future sampling efforts should incorporate the following elements to ensure data quality, especially at a site as contentious as the Marlin Mine
    - Field sampling and analysis plans created before sampling occurs

  - Training of all sampling personnel on methods outlined in the sampling plan
  - Use of field sampling sheets or notebooks and chain of custody forms and seals.
  - Sample preservation
  - Collection and analysis of field replicates, trip and equipment blanks
  - Photographing or videoing collection of water quality samples.
  - Use of analytical methods that achieve required detection limits
  - Adhering to sample hold times
  - Use of standard reference water as an external check against analytical measurements
  - Use of laboratory quality control/quality assurance methods, including matrix spikes, laboratory duplicates, continuing calibration blanks, etc.
- Any surface water and groundwater areas that may be adversely affected by discharges from the tailings impoundment, waste rock piles, the open pit, and the underground mine should be investigated as part of an independent study of the site.

9.2.2 Policy Recommendations

- MARN should develop water quality standards for protection of all possible uses in surface water and groundwater.
- The Ministry of Energy and Mines should develop regulations and mechanisms for bonding of hardrock mines in Guatemala. Actual costs of reclamation, closure, and post-closure may run into the hundreds of millions of dollars and should be incorporated into bonding.
- A well-funded, truly independent, transparent, and scientifically rigorous monitoring system is needed with participation from all stakeholders. Human health and environmental monitoring should form coordinated components of the monitoring system.

9.2.3 Discussion of a Potential Independent Monitoring Program for the Marlin Mine

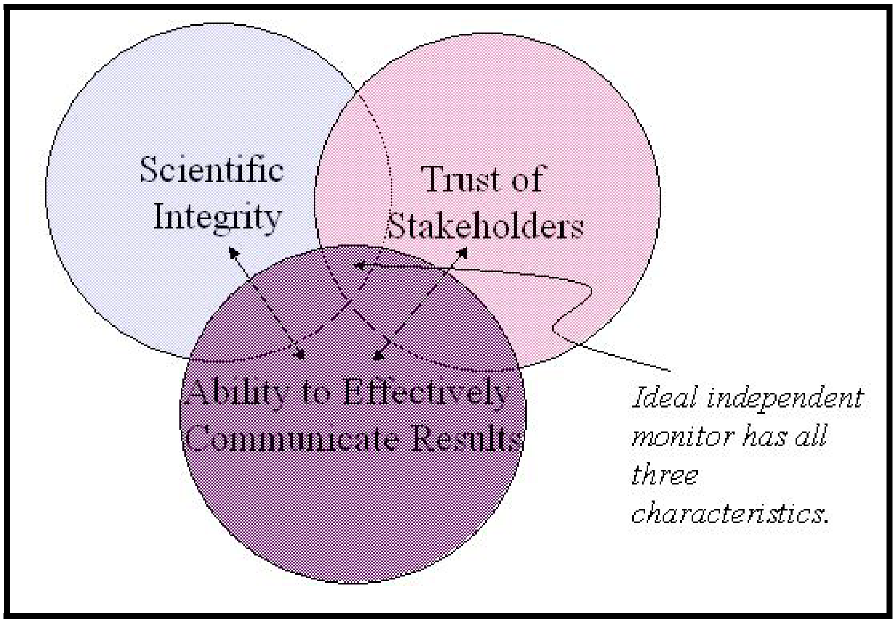
The discussion that follows is based on the authors' personal experiences in participating in the development of different independent monitoring programs, including a nine-year Northeast Sonora Water Project program in Mexico, the independent monitoring conducted for the CAO at the Yanacocha Mine in Peru, and a number of other independent monitoring programs conducted at gold mines in the United States.

The authors have visited neither the Mine nor surrounding communities. Therefore, we can only reflect back on in what we have learned from our technical review and our experience with community monitoring in other locations.

General Considerations

Three important components of a successful independent monitoring program are illustrated in Figure 12. Based on our technical review and experience in other areas, we believe that fulfilling the component related to stakeholder trust is the most challenging for creation of a successful independent monitoring program.

Figure 12. Elements of an ideal independent monitoring program.



The second most challenging issue is communicating the monitoring results to the public. The results should be presented in a clear and unbiased fashion. Enough information should be presented for the community members to know whether or not they need to be concerned about the potential impacts of the mine on their health and livelihoods. The ability to effectively communicate the monitoring results to the public relies on gaining the confidence of the stakeholders and scientific integrity and knowledge. Through effective communication of results to the public, and incorporation of the stakeholders in the monitoring, the technical experts participating in the investigations gain stakeholder trust.

There are some elements of scientific integrity of a monitoring program that are relatively easy to address given adequate financial resources. These include using state-of-the-art methods and quality assurance and control approaches for collection and analysis of samples. The other elements of scientific integrity are impartiality and transparency in interpretation of results. Adequate financial resources do not resolve questions surrounding these elements. Full disclosure of monitoring results to the public, a deep foundation in the scientific or technical issues (i.e. professional experience), and evidence-based interpretation are required to fulfill this aspect of scientific integrity.

Structure of a Possible Independent Water Monitoring Program

Currently, there are multiple entities conducting environmental monitoring of the Marlin Mine. Ideally, based on international best practice, the Marlin Mine would have one independent monitoring program accepted and trusted by a wide range of stakeholders and any important changes in monitoring approach would be discussed before they occurred. Initial review of technical issues and potential impacts of the mine by an independent auditor/oversight observer could add confidence to the independent monitoring program.

The independent monitoring results could be used by regulatory agencies, such as MARN or MEM, to direct investigations of the site. An independent montiroing program could include representatives from MARN or MEM, to the degree that all participants are comfortable with this participation. However, regulatory agencies should not have the authority to make decisions regarding independent monitoring or the use of information from the independent monitoring program. In Guatemala, an independent monitoring program could provide resources not currently available to the national government.

Possible Funding Mechanisms

Independent monitoring could be funded from multiple sources. A long-term commitment is important to the stability of a program through closure, reclamation, and post closure conditions. The independence and transparency of funding is critical.

Specifics of Independent Monitoring and Analysis

Independent environmental monitoring should consist of surface water and groundwater water quality and quantity/level measurements of surface water, groundwater, and discharges, sediment quality and amount of suspended material in streams, habitat conditions, aquatic biota (fish, macroinvertebrates), air – or whatever is of highest concern to the communities. Goldcorp should allow regular access to the mine (upon request) by an independent monitoring team. At a minimum, Goldcorp should allow on-site independent monitoring on a monthly or quarterly basis (depending on whether constituents of concern are found above certain levels) and notify the independent monitoring team about “upset” conditions if an accidental release takes place.

A national certified laboratory for analyzing samples from industrial projects in Guatemala is a long-term necessity and would require a long-term financial commitment. Another option would be to create a Central American regional laboratory that could be used by governments or other entities in the region and would enhance the capacity of Central American governments to effectively monitor mining and other types of industrial development. Funding could be provided by different sectors through an independent funding structure.

Coordination of separate independent environmental and human health monitoring programs is essential. Health and environmental monitoring programs can evaluate the degree of connection between perceived health concerns and measured contaminant concentrations in the environment. A report by Physicians for Human Rights (2010) indicated that mercury, copper, arsenic, and zinc concentrations in urine, and concentrations of lead in blood from some residents living near the Marlin Mine, might be higher than those living seven kilometers away. Good coordination of water, air, and soil environmental monitoring with community health monitoring would provide a means of evaluating the relationship between the mine and the health of local residents.

Final Thoughts

There are high levels of emotion, protest, distrust, and conflict surrounding operations at the Marlin Mine. Independent environmental monitoring for the Marlin Mine must operate separately from political issues in order to be credible and survive over the long term. Independent monitoring can be a regulatory and public information tool throughout mine operation, potential expansion, closure, reclamation, and post-closure periods.

We hope that this discussion and the recommendations in the report form a basis for continued dialogue on how to improve trust and the communication of important information related to the potential environmental effects of the Marlin Mine.

10. References

AMAC. 2006, 2007, 2008. Analytical Laboratory Results from ALS Laboratory Group, Vancouver, British Columbia, Canada. Received by email from AMAC.

Asociación de Monitoreo Ambiental Comunitario (AMAC). Undated. Protocolo de Muestreo y Analisis: Aguas Subterránea, agua Superficial y Descargas. 14pp.

Author Unknown. 2006. Procedimientos estándar de operación, muestreo de la calidad del agua, Proyecto Marlin, San Miguel Ixtahuacan, San Marcos. (assume the author is Goldcorp). March., Revised August 2008.

Banco Interamericano de Desarrollo (**BID**). 2001. Curso de Gestión y Evaluación Ambiental de Proyecto de Inversión, Manual del Instructor.

Bianchini, F. 2006. Estudio Tecnico: Calidad de Agua del Río Tzalá. November.

Business Week. 2010. "Guatemala Says No Evidence of Pollution Found at Goldcorp Mine." June 17.

CNN.com. 2009. "Guatemala declares calamity as food crisis grows." September 9.

COGUANOR. 2003. Norma guatemalteca obligatoria. Agua potable. COGUANOR NGO 29.001.98. Primera edición. Departamento de Regulación de los Programas de Salud y Ambiente. Septiembre. Available: http://www.cepis.ops-oms.org/bvsacg/e/normas2/Norma-Gua.pdf.

Comisión Extraordinaria Nacional por la Transparencia. 2009. Informe de Investigación y Verificación del Proceso de Autorización de las licencias otorgadas a la Cementera en San Juan Sacatepequez y empresas afines, así como al Proyecto Marlin en San Miguel Ixtahuacán San Marcos, para la identificación y habilitación de soluciones por la problemática producida por la Cementera y la Actividad Minera. 27 octubre.

Compliance Advisor Ombudsman (CAO). 2005. Assessment of a complaint submitted to CAO in relation to the Marlin Mining Project in Guatemala.

Compliance Advisor Ombudsman (CAO). 2009. CAO Cases: Guatemala/Marlin-01/Sipacapa. Available: http://www.cao-ombudsman.org/cases/case_detail.aspx?id=95

COPAE. 2008. Informe Anual Del Monitoreo y Analisis de Calidad de las Aguas. "Situacion actual del Agua Alrededor de la Mina Marlin, Ubicada en Los Municipios de San Miguel Ixtahuacan y Sipacapa, Departamento de San Marcos, Guatemala." Prepared by Comision Pastoral Paz y Ecologia (COPAE). Diocesis de San Marcos. August.

COPAE. 2009. Informe Anual Del Monitoreo y Analisis de Calidad de los Rios Tzalá y Quivichil en el Area de Influencia de la Mina Marlin, Ubicada en Los Municipios de San Ixtahuacan y Sipacapa, Departamento de San Marcos, Guatemala. Prepared by Comision Pastoral Paz y Ecologia (COPAE). Diocesis de San Marcos. August.

Espíndola, E., A. Leon, R. Martinez, A. Schejtman. 2005. Poverty, hunger and food security in Central America and Panama. Prepared for: United Nations, World Food Program, CEPAC, Politicas Socials, Serie #88. Santiago, Chile, May. Available: http://www.eclac.org/publicaciones/xml/1/21981/sps_88_ing.pdf

Fulmer, A.M., A.S. Godoy, and P. Neff. 2008. Indigenous Rights, Resistance, and the Law: Lessons from a Guatemalan Mine. *Latin American Politics and Society, Winter*. Available: http://findarticles.com/p/articles/mi_qa4000/is_200812/ai_n31425453/?tag=content;col1

Goldcorp. 2008. Annual Report, Strength in Reserve. Available: http://www.goldcorp.com/_resources/2009_ar/index.htm

Goldcorp. 2009. Electronic groundwater and surface water quality and flow data for the Marlin Mine, Guatemala. Received by email from Lisa Wade.

Kuipers, J.K. 2002. A Hearing on “Availability of Bonds to Meet Federal Requirements for Mining, Oil and Gas Projects.” CSP2, July 23.

Kuipers, J.R., Maest, A.S., MacHardy, K.A., and Lawson, G. 2006. Comparison of Predicted and Actual Water Quality at Hardrock Mines: The reliability of predictions in Environmental Impact Statements. Prepared for Earthworks. 195pp. Available online at: http://www.mine-aid.org/predictions/

International Finance Corporation, World Bank Group., 2004. Montana Exploradora: Marlin gold project. http://siteresources.worldbank.org/INTOGMC/Resources/marlinfactsheetenglish.pdf

Ministry of Energy and Mines. 2009a. Technical report of the first Direccion General de Mineria – Unidad de Gestion Socio Ambiental (DGM-UGSA) monitoring of the Marlin Mine. Pilot monitoring of the quality of water in the area around the Marlin Mine I, October.

Ministry of Energy and Mines. 2009b. Technical Report: Extraordinary Monitoring Report of DGM-UGSA. Pilot monitoring of the quality of water in the area around the Marlin Mine I, December.

Ministry of Energy and Mines. 2010a. Technical Report: Monitoring Corresponding to October to December 2009 by DGM-UGSA. Pilot monitoring of the quality of water in the area around the Marlin Mine I. INF-UGSA-07-01-03-10, March.

Ministry of Energy and Mines. 2010b. Tailings spill monitoring report by DGM-UGSA. Pilot monitoring of the quality of water in the area around the Marlin Mine I. INF-UGSA-03-28-01-10, January.

Montana Exploradora de Guatemala, S.A. 2003. (EIA&S) Estudio de Evaluación de Impacto Ambiental y Social. “Proyecto Minero Marlin.” Municipio de San Miguel Ixtahuacan, Departamento de San Marcos, Guatemala. June.

Montana Exploradora de Guatemala, S.A. 2005. International Finance Corporation. Environmental and Social Performance Annual Monitoring Report (AMR). Reporting Period: 2004. March 31.

Montana Exploradora de Guatemala, S.A. 2006. International Finance Corporation. Environmental and Social Performance Annual Monitoring Report (AMR). Reporting Period: 2005. March 31.

Montana Exploradora de Guatemala S.A. 2008a. Mina Marlin Plan de Monitoreo Ambiental. Fecha de Realizacin, 12 de April. Fecha de Revision, agosto 2008 Revisión 3.0.

Montana Exploradora de Guatemala, S.A. 2007. Environmental and Social Performance Annual Monitoring Report (AMR). Reporting Period: 2006. April 1.

Montana Exploradora de Guatemala, S.A. 2008. Environmental and Social Performance Annual Monitoring Report (AMR). Reporting Period: 2007. May 15.

Montana Exploradora de Guatemala, S.A. 2009. Environmental and Social Performance Annual Monitoring Report (AMR). Reporting Period: 2008. May 1.

MWH. 2009. Technical Memorandum: Liner Seepage Calculation. From Clint Strachan and Roslyn Stern to Andy Robertson, Robertson Geoconsultants LLC. November 12, 2pp.

Organización Internacional para las Migraciones. 2009. Available: www.oim.org.gt/index2.html. Accessed December 2009.

Physicians for Human Rights. 2010.Toxic Metals and Indigenous Peoples Near the Marlin Mine in Western Guatemala: Potential Exposures and Impacts on Health. An Expert Scientific Report by Niladri Basu, MSc, PhD and Howard Hu, MD, MPH, ScD with the assistance of the International Forensic Program of Physicians for Human Rights, May./Indígenas cerca de la Mina Marlin en Guatemala Occidental: Posibles Exposiciones e Impactos a la Salud: Un Reporte Científico preparado por Niladri Basu, MSc, PhD y Howard Hu, MD, MPH, ScD con la Asistencia del International Forensic Program de Physicians for Human Rights, mayo.

Prensalibre.com, 2010. *Política.* Gobierno acepta suspender explotación de la mina Marlin. June 23.

Robinson, R. 2007. Water Quality Monitoring: Marlin Mine. Sipakapa, San Marcos, Guatemala. April 20.

SRK Consulting. 2003. Summary Review of 2002 Environmental Baseline Studies, Marlin Mining Project,
San Marcos, Guatemala. Prepared for: Montana Exploradora de Guatemala S. A.

Tribunal Agua Veredicto. 2008. Rio Cuilco, September 12.

The World Bank. 1998. Environmental Assessment of Mining Projects. An Update of the Environmental Assessment Sourcebook, Number 22.

World Health Organization (WHO).2008. Guidelines for Drinking-water Quality. Third Edition, Incorporating the First and Second Addenda. Volume 1 Recommendations. Geneva. Available: http://www.who.int/water_sanitation_health/dwq/fulltext.pdf.

IFC. 2007. Environmental, Health and Safety Guidelines for Mining. Dec. 10. Available: http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_Mining/$FILE/Final+-+Mining.pdf.

U.S. EPA. 2005. USEPA Contract Laboratory Program, Statement of Work for Inorganic Analysis. Multi-Media, Multi-Concentration. ILM06.X Draft November.

U.S. EPA. 2009a. 2009 Edition of the Drinking Water Standards and Health Advisories. EPA 822-R-09-011. Office of Water. Date of Update: October, 2009. Available: http://www.epa.gov/waterscience/criteria/drinking/dwstandards2009.pdf.

U.S. EPA. 2009b. National Recommended Water Quality Criteria. Office of Water, Office of Science and Technology (4304T). Available: http://www.epa.gov/ost/criteria/wqctable/.