MINE-RELATED IMPACTS ON WATER SUPPLIES FOR DEVELOPING COMMUNITIES: CASE STUDY IN THE PHILIPPINES

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ABSTRACT

As multinational mining ventures continue to expand their operations into developing countries, there will undoubtedly be escalation in impacts on indigenous societies. Mining in developing communities is generally associated with infrastructure works and community development programs designed to assist the country's indigenous communities in self-development activities. These activities often include water supply projects in the vicinity of mine development, commonly located in rural communities.

Mining activities are often associated with large-scale dewatering and water disposal operations during mine development, operation and shutdown. Thought must be given to how surrounding communities are best able to adapt to and take advantage of a changing social and physical environment brought about by mine development.

This paper highlights key issues in addressing how to achieve and protect sustainable water supply systems affected or instigated by mine development and ensure that the community's use of those facilities is consistent with their social and environmental values. A case study is presented for the development of an alternative water supply source for a community affected by mine development in the Philippines.

INTRODUCTION

A mine development in any society will bring about changes in social and physical environments both in the immediate vicinity of the mine and over a broader regional scale. Development and management of community water supply systems are included amongst these changes brought about by mining.

The impacts of mining on local communities, especially those concerning water supply issues, will be greater with mine developments in countries where there is only basic water supply infrastructure. Mining ventures located in equatorial developing countries, with distinct wet and dry seasons, have specific challenges associated with mine water management and its effect on local communities.

This paper will present an overview of the short-term and longer-term implications that mine water management may have on developing communities. Discussion will include mine-related changes to surface water and groundwater regimes and potential impacts on communities that live in the mine development areas.

POTENTIAL WATER REGIME CHANGES FROM MINE DEVELOPMENT

Mine water management involves modification of surface and groundwater regimes. Changes during mine development and operation may typically include:

- mine dewatering and consequent lowering of the groundwater table;

- changes in groundwater recharge and discharge;
- modification of surface water flows and storage;
- water usage for mining activities;
- discharge of mine wastewater to surface and groundwater sources;
- catchment modification; and
- sediment discharge (erosion and tailings disposal) to containment structures and/or downstream water courses.

Longer term waste disposal and water management issues associated with mining may include:

- the presence of void water in open pits;
- flooding of underground workings;
- discharge of chemically altered mine water;
- associated changes to downstream aquatic environments; and
- stability of mine-waste emplacements.

WATER SUPPLY SOURCES AND USES IN DEVELOPING COMMUNITIES

All communities need a water supply that is clean and safe, close, and provides enough water for their needs. This is not always the case in developing communities, demonstrated by the continuing need for aid-related assistance projects for water supply development. Rural communities in developing countries often source their water supply from rainwater, springs, shallow wells and bores, rivers and surface water bodies.

Water storage infrastructure is typically small capacity and easily contaminated. As such, the usage of and quality of these sources is seasonally dependent and typically there is a greater reliance on groundwater sources and springs during the dry season as surface water sources are depleted and quality becomes degraded. Ideally, water supplies must;

- provide clean water for many years;
- be close by and easy to use so people will be encouraged to use the water;
- be acceptable to all users and should not go against people's beliefs and customs;
- be able to use local materials and labour where appropriate - to promote ownership and get local communities involved;
- be easy to maintain - to minimise disruption of water supply and allow communities to maintain infrastructure;
- allow for improvements and modifications to suit changing conditions; and
- be low cost and simple.

The benefits of improving a water supply to a community are not only the direct ones of increased water availability and improved water quality. There are also many associated indirect benefits that may include:

- improved health of communities;
- easier life (convenience) for the collectors of water (usually women and children);
- prestige and increased status associated with reliable water supplies;
- opportunity for using extra time and energy usually spent collecting water;
- development of new skills;
- better opportunity for economic activity;
- improved productivity with improved health; and
- improved standard of living and quality of life.

WATER RELATED IMPACTS ON LOCAL COMMUNITIES

Mine development and operation will generally result in a redistribution of water resources in the immediate vicinity of the mine. This effect may be both beneficial and detrimental to community water supply sources. Table 1 lists a summary of potential effects to community water supplies.

Impact	Benefits	Detrimental Effects
Mine water discharge to surface water sources	Increased surface water flows from mine discharge, regulating seasonal variations to river flows.	Water quality may be adversely affected by mine discharge. Possible increase in suspended solids and toxic elements.
Mine dewatering and lowering of piezometric heads	Potential benefit by increasing infiltration rates and reducing surface water ponding in low-lying areas, thus reducing water-borne diseases.	Lowering of water table and decreased spring discharge rates. Wells need to be dug deeper and water sourced from alternative springs
Social change brought about by mine development	Availability of technology and funding derived from mine activities.	Development of inappropriate infrastructure that is not sustainable after mine closure.

Table 1. Examples of potential benefits and adverse impacts of mine water management and water supply development.

Water related effects of mining might often have a relatively small impact when considered on a regional scale. However, in a subsistence community where resources may not be available outside the immediate area of habitation, these effects are generally large and can dramatically alter the social and physical framework of local communities.

CASE STUDY: IMPACT OF SIBUTAD MINE SITE DEVELOPMENT ON COMMUNITY WATER SUPPLIES

Background

The Philex mine site at Sibutad, Northwest Mindanao, Philippines, is located in close proximity to the coastal village of Libay and a number of smaller neighbouring village communi-

Figure 1. Location map.

ties (Figure 1). Communities of the region are engaged predominantly in subsistence type agriculture and fishing. There are numerous small-scale mining operations located in the region. These operators win gold from alluvium and slope wash colluvium. Small-scale miners as part of the gold collection process use mercury.

The Libay community water supply was sourced from a series of perennial springs located immediately downgradient of the mine heap leach pad. A cyanide solution infiltrated through the heap leach pad is used as part of the gold recovery process. As such, it was considered essential as part of mine development to establish an alternative water supply for the village, with water sourced from an area which will not be threatened by mining activities.

The investigation included an appraisal of social implications of relocating the water source, potential supply yields, water quality analyses, cost of supply, sustainability, security of supply, and protection from mining related contamination effects.

Site characteristics

The Sibutad mine site is located on a broad ridge between the coastal village of Libay and the inland township of Sibutad (Figure 2). Elevation of the ridge is up to 300 m asl with an average gradient from ridgeline to sea level of 1 in 3. The mineralised area and open pit site is located on this steep slope down to the coast.

The geology of the Sibutad region comprises a complex assemblage of andesitic volcanic materials with a highly weathered profile in some places down to tens of metres depth. Strong linear features dissect the region and are indicative of remnant caldera features and associated fault zones. The area is seismically active with frequent seismic events.

Water resources - surface water

The Sibutad area is drained by numerous small steep catchments. Runoff is highly variable with rapid flood peaks following rainfall events. Stream baseflow appears to be sustained by groundwater discharge with numerous small springs in the upper and middle catchment zones. Many streams are ephemeral with baseflow ceasing in the dry season. Those streams and springs that maintain a reliable discharge throughout the dry season appear to be associated with discharges from mineralised zones. This variability may be related to increased water storage capacity in the brecciated materials associated with mineralised zones.

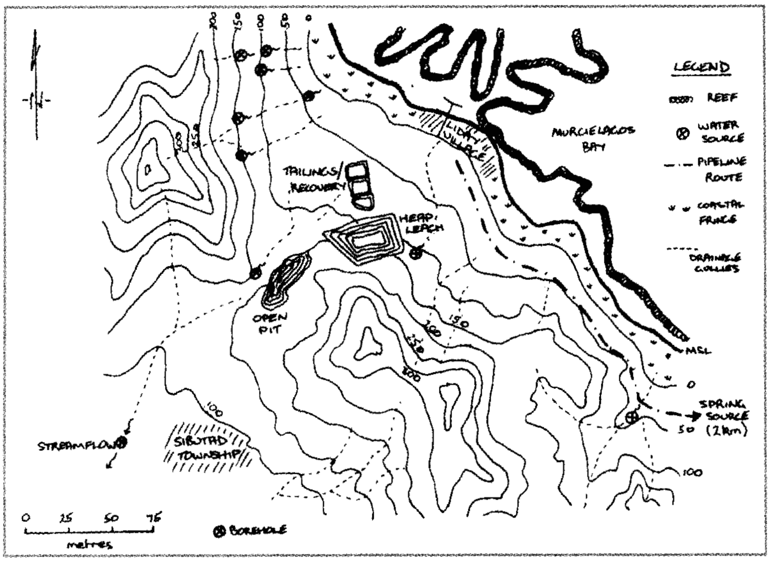

Figure 2. Location of water supply sources.

Surface water quality in the area is directly related to the presence or otherwise of mineralised material in contact with the water. In areas of mineralisation, pH values measured in the field typically range from 3 to 4. Total dissolved solids (TDS) values are generally low and in the range 50 mg/l to 100 mg/l. In contrast, surface water derived from non-mineralised zones has typical pH values in the range 6 to 7 and TDS values in the range 50 mg/l to 100 mg/l. The low pH condition of waters derived from mineralised zones can be attributed to oxidation of sulfide minerals associated with the ore body.

Water resources - groundwater

Only limited use is made of groundwater in the Sibutad area. This is most likely for a combination of reasons, including poor yield, poor quality, effort and cost involved in construction of wells and purchase of handpumps. There are usually sufficient spring supplies and surface water resources to cater for the community's water supply requirements.

Some local tubewells exist, but they are in poor condition. These sources are located in a mixed assemblage of alluvial deposits and brecciated volcanic debris. Water quality is slightly alkaline with TDS ranging from 100 mg/l to 500 mg/l.

Community and mine water supply requirements

The main investigation for identifying and developing an alternative water supply source was for the village of Libay, which sourced its water downgradient of the mine site. As the mine develops, it is likely that there will be an influx of people to the area, placing increased pressures on water resources. The predicted increase in local village population should be taken into account when identifying water supply sources with sufficient yield to meet future demands.

Due to the steep nature of the terrain, it is difficult and not economically viable to construct adequate water storage facilities for industrial water demands of the mine. Consequently, spring sources that were previously used as village water supplies would be required during mine operation.

Potential water supply options for community needs

Existing water supplies in the area are generally taken from surface water streams or springs. Within the mineralised area, potential water quality problems raise concerns regarding the long-term use of such supplies. In particular, low pH conditions provide a high likelihood that water will be contaminated with heavy metals. Acid waters are also undesirable in terms of corrosion problems for water supply infrastructure (pipes, fittings) and provide on-going maintenance issues. Water supplies collected from streams close to and downstream of mineralised zones have an additional threat of the potential for contamination from mercury residues derived from small-scale mining operations. Because of these factors, surface water sources located within the mineralised zone were not considered as a long-term water supply option.

Surface water sources in the non-mineralised area were considered potentially suitable for community water supply, but are less reliable in terms of sustainable flow. It was reported that these sources often dried up over the dry season. It was considered unlikely that secure, sustainable water supplies could be obtained from non-mineralised catchments.

Major surface streams of the area are the Magsaysay River and the Kanim River, located several kilometres from the mine site. Both rivers are reported to carry permanent flows of suitable quality water. The distance between source and point of demand would hamper development of these river sources. Several kilometres of pipeline would be required and a pumping system would have to lift water more than 100 m from the rivers over several ridges. This option was not considered to be suitable, due mainly to the ongoing running costs and maintenance requirements of such a system.

Groundwater supply sources developed using tube wells offer potential security of supply in most instances and would also reduce the risk of contamination inherent in surface water sources. Within the Sibutad area, groundwater prospects are relatively limited. As with surface water options, mineralised areas would not be favoured due to likely acidic conditions and associated heavy metal concentrations.

Two groundwater supply options existed outside the mineralised region. These were:

- Development of water supply bores in the Sibutad basin area. Disadvantages of this option included high associated costs; on-going pumping and maintenance costs; and interference effects on existing groundwater users in the area.
- Development of groundwater supplies from non-mineralised volcanic material in the area. A drilling investigation and test pumping program indicated the potential groundwater yield from this material to be highly variable. This feature can probably be attributed to the near-vertical trend of major structural features. Vertical boreholes generally ran parallel to fracturing. If any high-angle fracture was encountered, drilling became extremely difficult and collapsing formation resulted in borehole abandonment. Boreholes drilled at an angle to intersect structural features exhibited higher airlift yields but would be difficult to equip as water supply bores.

Preferred community water supply option

The preferred option to cater for the needs of the local community was to develop an alternative spring source as a gravity fed supply. Community consultation indicated that this was an acceptable solution to the village's water supply needs. The community requested that this supply be piped to the village, allowing easier access to water supply. The source was located 2 kilometres from the existing spring used by the community and up gradient from the mine site.

Even though this option is considered to be the most sustainable and acceptable to the community, there is still the possibility of detrimental impacts by relocating this village's water supply. These impacts could include:

- No historic information available as to extreme dry season yield of the new source. A few families had only previously used the source.
- If water supplies become inadequate to meet future demands, ownership of the source may be disputed;
- Control of development and land use activities in catchment and spring recharge areas may prove difficult to enforce;
- The new pipeline runs through areas where there are ongoing small-scale mining activities. These miners may sabotage the water supply for their own use.
- It is likely that some villages will still source their water from surface flows downstream of the mine.
- The potential exists for an increase in water-borne diseases due to the water source discharging close to the village where it may pond.

Aspects of the water supply design aimed to minimise adverse affects of developing the new source and relocating the spring discharge point to the village include assessment of:

- Community involvement in water supply system construction to promote ownership;

- Information, education and communication programs to promote knowledge about water supply and sanitation;
- Training on maintenance requirements of the new system; and
- Waste water disposal options and sanitation practices.

Water supply issues after mine closure

Closure of the mine will result in an exodus from the region of skilled labour, technology and an income-generating source. The most significant long-term physical impact of the mine development will be the presence of an open pit, heap leach pads, tailings containment structures, runoff and sedimentation dams and liquor recovery ponds.

It is likely that without an operating mine the local community will resort to a traditional subsistence agricultural and fishing culture. It could be expected that small-scale mining operations, particularly within the mine site, would continue and possibly expand. If there are no controls in place for monitoring and enforcing water supply practices in the local villages, the potential exists for long-term adverse effects to water supply sources from the mine. These may include:

- Collection of water from the pit void for water supply during periods of low spring discharge. This water is expected to be characterised by low pH and high heavy metals concentration;
- Erosion of heap leach pads, transporting fine grained ore material into downgradient water courses;
- Breaching or overtopping of tailings and sedimentation dams; and
- Re-establishment of village water supply sources at traditional sources located downstream of the dam. This scenario is highly likely, as reliable springs will be most affected by mining due to water bearing mineralised zones targeted for ore recovery. The problem will be further enhanced if the piped water supply system is allowed to fall into disrepair.

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