Appendix 2: Environmental and Social Impacts of Mining

This appendix is meant to provide a brief review of the literature with regard to environmental and social impacts from mining, as well as key regulatory issues.

Key Environmental and Social Impacts

Environmental and social impacts of mining have been well-documented and an ample literature exists on this topic. The following discussion summarizes those environmental and social issues that formed the basis for the Mining and Critical Ecosystems framework. Environmental and social impacts are divided into waste management issues, impacts to biodiversity and habitat, indirect impacts, and poverty alleviation and wealth distribution. Those seeking additional details may wish to consult the many resources available on this topic.[1]

Waste Management

By nature, mining involves the production of large quantities of waste, in some cases contributing significantly to a nation's total waste output. For example, a large proportion of the materials flows inputs and outputs in the United States can be attributed to fossil fuels, coal, and metal mining (Matthews et al., 2000:107). The amount of waste produced depends on the type of mineral extracted, as well as the size of the mine. Gold and silver are among the most wasteful metals, with more than 99 percent of ore extracted ending up as waste. By contrast, iron mining is less wasteful, with approximately 60 percent of the ore extracted processed as waste (Da Rosa, 1997; Sampat, 2003).

Disposing of such large quantities of waste poses tremendous challenges for the mining industry and may significantly impact the environment. The impacts are often more pronounced for open-pit mines than for underground mines, which tend to produce less waste. Degradation of aquatic ecosystems and receiving water bodies, often involving substantial reductions in water quality, can be among the most severe potential impacts of metals extraction. Pollution of water bodies results from three primary factors: sedimentation, acid drainage, and metals deposition.

<u>Sedimentation</u>

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[1] For more comprehensive reviews of the environmental impacts of mining see: MMSD, *Breaking New Ground: Mining, Minerals and Sustainable Development* . The report of the MMSD Project. (London: Earthscan, 2002); Ashton, P.J., D. Love, H. Mahachi, P.H.G.M. Dirks (2001). *An Overview of the Impact of Mining and Mineral Processing Operations on Water Resources and Water Quality in the Zambezi, Limpopo and Olifants Catchments in Southern Africa*. Contract Report to the Mining, Minerals and Sustainable Development (SOUTHERN AFRICA) Project, by CSIR-Environmentek, Pretoria, South Africa and Geology Department, University of Zimbabwe, Harare, Zimbabwe. Report No. ENV-P-C 2001-042. xvi + 336 pp; J.J. Marcus, ed. *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining* (San Mateo, California: Imperial College Press, 1997); E.A. Ripley et al. *Environmental Effects of Mining* (Delray Beach, Florida: St. Lucie Press, 1996); C.G. Down and J. Stocks *Environmental Impacts of Mining* (New York: John Wiley and Sons, 1977).

Minimizing the disturbed organic material that ends up in nearby streams or other aquatic ecosystems represents a key challenge at many mines. Erosion from waste rock piles or runoff after heavy rainfall often increases the sediment load of nearby water bodies. In addition, mining may modify stream morphology by disrupting a channel, diverting stream flows, and changing the slope or bank stability of a stream channel. These disturbances can significantly change the characteristics of stream sediments, reducing water quality (Johnson, 1997a:149).

Higher sediment concentrations increase the turbidity of natural waters, reducing the light available to aquatic plants for photosynthesis (Ripley, 1996). In addition, increased sediment loads can smother benthic organisms in streams and oceans, eliminating important food sources for predators and decreasing available habitat for fish to migrate and spawn (Johnson, 1997b). Higher sediment loads can also decrease the depth of streams, resulting in greater risk of flooding during times of high stream flow (Mason, 1997).

Acid drainage

Acid drainage is one of the most serious environmental impacts associated with mining. It occurs when sulfide-bearing minerals, such as pyrite or pyrrhotite, are exposed to oxygen or water, producing sulfuric acid. The presence of acid-ingesting bacteria often speeds the process. Acidic water may subsequently leach other metals in the rock, resulting in the contamination of surface and groundwater. Waste rock piles, other exposed waste, mine openings, and pit walls are often the source of acidic effluents from a mine site. The process may occur rapidly and will continue until there are no remaining sulfides. This can take centuries, given the large quantities of exposed rock at some mine sites. Although the process is chemically complex and poorly understood, certain conditions can reduce likelihood of its occurrence. For example, if neutralizing minerals are present (e.g., carbonates), the prevailing pH environment is basic, or if preventative measures are taken, then acid drainage is less likely to occur (Schmiermund and Drozd, 1997:599).

Acid drainage impacts aquatic life when acidic waters are discharged into nearby streams and surface waters. Many fish are highly sensitive to even mildly acidic waters and cannot breed at pH levels below 5. Some may die if the pH level is less than 6 (Ripley, 1996).[2] Predicting the potential for acid drainage can help determine where problems may occur. Methods vary from simple calculations involving the balance of acid-generating minerals (e.g., pyrite) against the existence of neutralizing minerals (e.g., calcium carbonate) to complex laboratory tests (i.e., kinetic testing). However, even laboratory-based tests cannot be relied upon to accurately predict the amount of metals that will be leached if acid drainage occurs, because of the differences in scale and composition that occur when samples are analyzed ex situ (Da Rosa, 1997).

Metals Deposition

Most mining operations use metals, reagents, or other compounds to process valuable minerals. Certain reagents or heavy metals, such as cyanide and mercury, are particularly

[2] On a pH scale of 0-14, neutral pH is 7, while pH levels of 2 or lower are not uncommon in acid drainage.

valued for their conductive properties and thus are frequently used. The release of metals into the environment can also be triggered by acid drainage or through accidental releases from mine tailings impoundments.

While small amounts of heavy metals are considered essential for the survival of many organisms, large quantities are toxic. Few terrestrial and aquatic species are known to be naturally tolerant of heavy metals, although some have adapted over time. In general, the number of plant and animal species decreases as the aqueous concentration of heavy metals increases. Some taxa are known to be more sensitive to the presence of heavy metals. For example, salmon species are particularly sensitive to increased concentrations of copper (Kelly, 1998). Furthermore, juvenile fish are more sensitive than adult fish, and the presence of heavy metals may affect critical reproductive and growth stages of fish.

Biodiversity and Habitat

Mining may result in additional indirect impacts that emanate far from the mine site. In order to provide charcoal for pig-iron smelters, Fearnside estimated that the Carajás project in the Brazilian Amazon would result in the deforestation of 72,000 hectares of forest per year over the 250-year life of the project (Fearnside, 1989: 142). The sensitivity of specific ecosystems to mining is examined in Box A2.1.

The most obvious impact to biodiversity from mining is the removal of vegetation, which in turn alters the availability of food and shelter for wildlife. At a broader scale, mining may impact biodiversity by changing species composition and structure. For example, acid drainage and high metal concentrations in rivers generally result in an impoverished aquatic environment. Some species of algae and invertebrates are more tolerant of high metals and acid exposure and may, in fact, thrive in less competitive environments (Kelly, 1998:86). Exotic species (e.g., weedy plants and insect pests) may thrive while native species decline (Ripley, 1997: 94). Some wildlife species benefit from the modified habitat provided by mines, such as bighorn sheep that use coal mine walls as shelter (MacCallum, 1989).

Box A2.1: Sensitivity of Select Ecosystems to Mining

Mining and oil development may pose risks to some environments due to the sensitivity and/or rarity of these ecosystems. These include the following:

Forests

Forests are the most biologically diverse terrestrial ecosystems. Tropical forests are particularly diverse and provide the greatest source of endemic plant species in the world. The key direct impact of mining on forest ecosystems is the removal of vegetation and canopy cover. Indirect impacts include road-building and pipeline development, which may result in habitat fragmentation and increased access to remote areas. While larger intact forest ecosystems may withstand the impacts of mining and oil development, smaller fragments are likely to be particularly sensitive to clearing.

Wetlands and Mangroves

Wetlands (including estuaries, mangroves, and floodplains) act as natural pollution filters, as well as provide unique habitat for aquatic species. Mangroves act as an important interface between terrestrial and marine ecosystems, often providing food and refugia for marine organisms. Wetlands may be destroyed through direct habitat elimination or by pollution from heavy metals and oil spills upstream. Mining and oil development can also contribute to the destruction of mangroves and wetlands through altering upstream watersheds and increased sedimentation. The United States has lost at least 54 percent of its wetlands and European countries have lost up to 90 percent of their wetland ecosystems.

Mountain and Arctic Environments
Extreme northern ecosystems are characterized by cold temperatures and short growing seasons. Arctic ecosystems exhibit far fewer plant and animal species than in the tropics, but they are often highly sensitive to disturbance and the loss of one or two species has a far greater impact. Lichens and mosses are often among the first species to disappear due to pollution and human disturbance. Permafrost degradation associated with mining and oil development may extend far beyond the initial area of disturbance, due to melting of ice, soil degradation, and impoundment of water. The arctic environment often takes longer to recover from pollution due to the slow speed of biological processes. In addition, the lack of sunlight throughout the winter months makes management of some mining wastes (e.g., cyanide-laced tailings) more difficult.

Arid Environments
Water scarcity is the primary constraint in arid environments. Vegetation is limited, but biodiversity is high among insects, rodents, and other invertebrates, especially in semi-arid regions. The main impact of mining and oil development on these ecosystems is the alteration of the water regime, especially lowering of the water table and depletion of groundwater. These impacts may result in increased salinization of the soil and erosion, which eventually lead to a decline in vegetation and wildlife species. In densely populated areas, the competition for scarce water resources makes these ecosystems especially fragile.

Coral Reefs
Coral reefs harbor the most biodiversity of any marine ecosystem. Located primarily in the Indo-Western Pacific and Caribbean regions, coral reefs are important links in maintaining healthy fisheries. Reef systems are highly sensitive to human disturbance. Sedimentation from upstream land-uses and pollution are among the greatest threats to coral reefs. Mining directly impacts coral reefs through increased sedimentation, especially in cases where wastes are dumped directly in rivers and oceans, as well as through increased pollution of heavy metals.

Sources: H.A. Mooney et al., “Biodiversity and Ecosystem Functioning: Ecosystem Analyses,” In V.H. Heywood and R.T. Watson *Global Biodiversity Assessment* (London: Cambridge University Press/ UNEP, 1995); J.A. McNeely et al., “Human influences on Biodiversity,” in V.H. Heywood and R.T. Watson, *Global Biodiversity Assessment*; World Resources Institute, *World Resources Report 2000-2001* (Washington, DC: World Resources Institute, 2001).

Recognizing the importance of natural ecosystems, many governments have set aside areas for protection in national parks and other protected areas. The World Conservation Union (IUCN) maintains a list of all of the world's protected areas and categorizes them according to management objective (see Table A2.1). International conventions also establish guidance and mechanisms for listing areas with special global significance (see Box A2.2). The United Nations Educational, Cultural and Scientific Organization (UNESCO) maintains a list of World Heritage Sites and reported threats to these sites. Mining, oil, and gas development have been reported to threaten a significant number of these sites (see Table A2.2).

Table A2.1: UNESCO World Heritage Sites Impacted by Extractive Industries

Site Name	Country	Type of Activity	Date Inscribed
World Heritage in Danger			
Mt. Nimba Strict Nature Reserve	Guinea and Côte d'Ivoire	Iron ore	1992
Okapi Wildlife Reserve	Democratic Republic of Congo	Gold mining	1996
World Heritage Sites			
Peninsula Valdes	Argentina	Oil tanker traffic	1999
Kakadu National Park	Australia	Uranium mining	1981
Tasmanian Wilderness	Australia	Small-scale mining	1982
Wet Tropics of Queensland	Australia	Tin mining	1988
Blue Mountains National Park	Australia	Coal mining	2000
The Sundarbans	Bangladesh/ India	Oil transport	1997
Southeast Atlantic Forest Reserves	Brazil	Calcareous, gold, and lead mining	1999
Pantanal Conservation Complex	Brazil	Small-scale gold mining	2000
Dja Faunal Reserve	Cameroon	Calcareous mining	1987
Dinosaur Provincial Park	Canada	Gas wells	1979
Canadian Rocky Mountain Parks	Canada	Oil/gas/coal	1984
Kluane National Park/ Wrangell-St. Elias National Park and Preserve	Canada/ U.S.	Oil pipeline/ unsettled mine claims	1979
Waterton Lakes National Park	Canada	Gas wells	1995
Talamanca Range	Costa Rica/ Panama	Copper mining	1983
Tai National Park	Côte d'Ivoire	Illegal gold mining	1982
Sangay National Park	Ecuador	Gold mining	1983
Ujong Kulon National Park	Indonesia	Oil transport	1991
Lorentz National Park	Indonesia	Gold/copper mining	1999
Kinabulu National Park	Malaysia	Copper mining	2000
Whale Sanctuary El Vizcaino	Mexico	Oil drilling	1993
Huascaran National Park	Peru	Gold mining	1985
Manu National Park	Peru	Oil drilling/ gold mining	1987
Volcanoes of Kamatchka	Russia	Gold mining	1996

Greater St Lucia Wetland Park	South Africa	Oil transport	1998
Donana National Park	Spain	Mining	1994
Sinharaja Forest Reserve	Sri Lanka	Illegal gem mining	1988
Central Suriname Nature Reserve	Suriname	Gold mining	2000
Bwindi Impenetrable National Park	Uganda	Gold mining	1994
St. Kilda National Nature Reserve	Scotland	Oil transport	1986
Selous Game Reserve	Tanzania	Oil exploration	1982
Grand Canyon National Park	United States	Mining	1979
Redwoods National Park	United States	Offshore oil/gas development	1980
Mammoth Cave National Park	United States	Oil/gas wells	1981
Olympic National Park	United States	Oil transport	1981
Kahuzi-Biega National Park	Democratic Republic of Congo	Gold mining	1981
Canaima National Park	Venezuela	Gold mining	1994
Mana Pools National Park	Zimbabwe	Oil exploration	1984

Source: World Conservation Monitoring Centre, "World Heritage Sites" List available online at: http://www.wcmc.org.uk/protected_areas/data/wh/. Last accessed May 14, 2003.
Note: Reflects sites threatened by proposed, current or past extractive activity. Sites listed under "World Heritage in Danger" are categorized as such by UNESCO. Degree of threat to each site from extractive activities varies.

Table A2.2: IUCN Protected Area Management Categories

IUCN Management Category	Primary objective	Examples
Ia-Strict Nature Reserve	Scientific research	Beni Biological Station (Bolivia)
1b-Wilderness Area	Wilderness protection	Cape Torrens Wilderness Area (South Australia)
II- National Park	Ecosystem protection and recreation	Kakadu National Park, Yellowstone National Park
III-Natural Monument	Conservation of specific natural features	Victoria Falls, Machu Picchu
IV-Habitat/ Species Management Area	Conservation through management intervention	Arctic National Wildlife Refuge, Galapagos Marine Resource Reserve
V- Protected Landscape/ Seascape	Landscape/ seascape for conservation and recreation	Glen Canyon National Recreation Area (U.S.), Titicaca National Reserve (Peru)
VI- Managed Resource Protected Area	Sustainable use of natural ecosystems	Great Barrier Reef, Annapurna Conservation Area

Source: IUCN (1994), "Protected Area Management Categories," Available on line at: http://www.wcmc.org.uk/protected_areas/categories/index.html

Box A2.2: International Conventions on Globally Significant Natural Areas

The World Heritage Convention was adopted in 1972 by UNESCO and has been signed by 176 countries. By signing the convention, each party commits to protecting natural and cultural sites listed on the World Heritage list. Countries must nominate sites for their inclusion on the World Heritage list. The World Heritage Committee reviews nominated sites and determines the merits of inclusion based on the technical evaluation of the IUCN and the International Council on Monuments and Sites (ICOMOS). Criteria for inscription of natural sites include exceptional scientific and conservation value, outstanding scenic or natural value or phenomena, outstanding examples of ecological or biological phenomena (such as evolutionary processes), and outstanding examples of major stages in earth's history (such as development of landforms). Because commitment to protecting and managing prospective sites is also considered, many World Heritage Sites are often protected areas according to IUCN Categories I-IV.

The World Heritage Convention provides a mechanism for identifying endangered and threatened sites through the World Heritage in Danger List. The list is meant to call attention to sites that are threatened by natural processes or human-induced activities. Once listed on the Danger list, countries must address the threats posed to the site in question or risk having their sites de-listed from the World Heritage list. More than 700 cultural and natural sites have been designated for inclusion on the World Heritage List, of which 33 are currently designated "in danger."

The International Convention on Wetlands was signed by governments in Ramsar, Iran in 1971 and currently has more than 130 parties. Like the World Heritage Convention, the Ramsar Convention lists wetlands of international significance according to ecological, biological, or hydrologic criteria. Signatories are obliged to take necessary steps to ensure the conservation of listed wetland sites and contracting parties may place those sites that require special attention due to ecological changes on the "Montreaux Record." In addition, signatories commit to nominating at least one wetland for the Ramsar list and to the "wise use" of wetlands within their territories. To date, more than 1200 wetland sites have been listed under the Ramsar Convention, covering nearly 2 million square kilometers.

The UN Convention on Biological Diversity (CBD) was adopted by governments during the Earth Summit in Rio de Janeiro in 1992. More than 175 governments are now parties to the Convention, which has three main goals: the conservation of biodiversity, its sustainable use, and the sharing of its benefits. The CBD requires governments to identify processes and activities that have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects. Where a significant adverse effect on biological diversity has been determined, governments must regulate or manage the relevant processes and categories of activities. Governments are also mandated to introduce appropriate procedures requiring environmental impact assessment of proposed projects that are likely to have significant adverse effects on biological diversity, with a view to avoiding or minimizing such effects and, where appropriate, allow for public participation in such procedures.

Sources: UNESCO (1972), World Heritage Convention. Available on line at http://whc.unesco.org/nwhc/pages/doc/main.htm. Last accessed May 28, 2003; Ramsar Convention Bureau, "The List of Wetlands of International Importance," Available on line at: http://www.ramsar.org/index_about_ramsar.htm#info. Last accessed May 28, 2003.

Indirect impacts

In addition to waste management issues, mines also pose environmental and social challenges due to potential disruptions to ecosystems and local communities. Mining requires access to land and natural resources, such as water, which may compete with other land uses (Ashton et al., 2002). Although the size of most mining operations is small compared to other land uses (e.g., industrial agriculture and forestry), mining companies are limited by the location of economically viable reserves, some of which may overlap with sensitive ecosystems or traditional indigenous community lands.

Often the larger-scale impacts from mining occur from indirect effects, such as road-building and subsequent colonization. An area of approximately 400-2,400 hectares has been colonized in the Amazon Basin for every kilometer of oil pipeline built (Ledec, 1990:592). In the Philippines, upland ecosystems are under pressure as a result of the migration of small-scale farmers. Mining could threaten these sensitive ecosystems by stimulating additional migration (ESSC, 1999).

Recent concerns regarding the potential conflicts between mining and other land uses has prompted some communities to pass non-binding referendums banning mineral development. For example, in June 2002 the Peruvian community of Tambogrande voted to reject mining in their community due to concerns regarding the projected displacement of half of its residents and fears regarding the potential impacts of mining on the community's traditional livelihood (Oxfam, 2002). According to a study commissioned by the mining industry, displacement may result in serious social problems, including marginalization, food insecurity, loss of access to common resources and public services, and social breakdown (MMSD, 2002:158-159).

Poverty Alleviation and Wealth Distribution

Developing countries often seek to exploit mineral resources as a way of providing much needed revenue. According to some, mineral wealth is part of a nation's natural capital and the more capital a nation possesses the richer it becomes (Davis and Tilton, 2003). Papua New Guinea receives almost two thirds of its export earnings from mineral deposits (GoPNG, 2002). Diamond mining accounts for approximately one third of Botswana's GDP and three quarters of its export earnings.

Although mineral exports may make up a significant share of a country's exports, mineral development does not always boost a country's economic growth and may, in some cases, contribute to increased poverty (Sideri and Johns, 1990; Auty, 1990; Ross, 2001a; Gelb et al., 1988). The reasons for the lack of economic growth in oil- and mineral-dependent states are not entirely conclusive (Ross, 1999). However, low levels of employment in the sector, use of mostly imported technology, high market volatility of minerals, competition with agricultural sectors, and institutional corruption and mismanagement may be contributing factors (Sideri and Johns, 1990; Gelb et al., 1988; Auty, 1990). In addition, lack of full cost accounting can result in overestimating the benefits if subsidies offered to the mining sector are not taken into account. For example, a study of the economic contributions of mining in Canada found that in 2000-2001 Canadian taxpayers subsidized the industry by C$13,095 per job created (Winfield et al., 2002).

Even when mineral development results in national economic growth, the benefits are not always equitably shared, and local communities closest to the source of mineral development can suffer the most. In some cases, mining has provided jobs in an otherwise economically marginal area (Redwood, 1998). However, typically these jobs are limited in number and duration. In addition, communities that come to depend on mining to sustain their economies are especially vulnerable to negative social impacts, especially when the mine closes. Mining tends to raise wage levels, leading to displacement of some community residents and existing businesses, and elevated expectations (Kuyek and Coumans, 2003). Mining may also trigger indirect negative social impacts, such as alcoholism, prostitution, and sexually transmitted diseases (Miranda et al., 1998).

In a worst-case scenario, mines have even fueled conflict in some developing countries by providing revenue for warring factions to purchase weapons. The best-known and publicized of these cases have been in Africa, where control over diamond mines has become an objective for rebels seeking income to finance civil wars (Sherman, 2002). Angola's UNITA rebels derived approximately $3.7 billion in diamond sales between 1989 and 2000 to pay for continued resistance to the Angolan government—more than they received from anti-communist governments during the cold war. An estimated 500,000 Angolans died during this time period. In the meantime, the Angolan government itself allegedly used profits from oil development to procure weapons (Global Witness, 1999).

Civil war erupted in Bougainville, Papua New Guinea, largely due to unresolved community grievances against the Panguna copper mine (Hyndman, 2001). Civil society uprisings have often been met with increased militarization, as well as sometimes brutal crackdowns on the part of the government, such as in the separatist conflicts in Aceh and West Papua, Indonesia. In these cases, the presence of mining has exacerbated conflicts and human rights abuses have been widely reported (Ballard, 2001). In West Papua, the military is known to have a direct financial connection to natural resource extraction through protection fees paid to it by the mining and logging industries. In some cases, the military has been known to engage in violence and human rights abuses in order to extort additional payments from companies operating in West Papua (ICG, 2002).

Key Regulatory Issues

The degree to which mining contributes to economic development and wise use of natural resources depends in large part on the quality of national regulations. Countries lacking strong regulations and the ability to enforce the law lack an important safeguard for ensuring that mining, oil, and gas development do not result in the destruction of important natural resources critical to ensuring the livelihoods of their citizens. The key components of a regulatory framework are discussed below.

Regulatory Framework

A strong regulatory framework allows countries to set standards that companies must follow. Some experts contend that a more flexible regulatory framework is preferable than the more traditional command-and-control approach (Otto and Cordes, 2002:8-16). Others acknowledge that a minimum set of rules by which companies must operate is necessary (Warhurst, 1999:46). Key components of a regulatory framework for mineral development include environmental impact assessments, environmental quality and social laws, environmental liability, and monitoring capacity.

Environmental Quality and Social Laws

A framework of environmental laws and regulations provides guidance to mining and oil companies regarding a country's expectations for environmental and social performance. Some countries have strong laws and regulations on the books, including soil, water and air standards; indigenous/local community rights; and requirements for decommissioning and site clean-up.

However, there are gaps in legislation in many countries. For example, none of the Andean countries has legislation addressing employment benefits, training opportunities, or social benefits from oil development. The need for consultation, land titles, and compensation is also not adequately covered (ESMAP, 1999: 16). In the United States, hardrock mining is exempt from many regulations applied to other polluting industries, and specific standards are left to the discretion of state governments. As a result, there are no federally mandated minimum reclamation standards and government agency investigations have revealed that reclamation is inadequate at many mines on federal land (Galloway and Perry, 1997: 193-218). Papua New Guinea and Zimbabwe routinely provide mining companies with exemptions from meeting water quality standards (Hughes and Sullivan, 1989:36; Shearman, 2001:175-177; Maponga and Mutemererwa, 1995:22).

Implementation of existing legislation may also be lacking. For example, Chile boasts 2,200 laws and presidential decrees relating to the environment, but most are not implemented, due to a lack of political will (Lagos and Velasco, 1999: 111). Difficulty implementing laws may stem from conflicting mandates amongst government agencies. For example, a major dilemma facing policy makers in Papua New Guinea is balancing its role as advocate (and beneficiary) of mining projects with its mandate to protect the country's natural resources for future generations (Hughes and Sullivan, 1989:45). In the Philippines, more than 20 government agencies are involved in the regulation of water resources, resulting in fragmented management and overlapping jurisdictions (ESSC, 2003).

Environmental Liability

Another important component of sound environmental legislation is the ability to hold polluters accountable. This may be accomplished through a requirement to post a reclamation bond, which is held until the company has satisfactorily complied with government standards for closure and remediation of a mine site.

There are no set international standards for the amount that should be retained in reclamation bonds, and estimates of potential environmental damages are often provided by the companies, which have an incentive to underestimate true costs. Seventeen mines have recently closed in the Philippines, many of which did not have the resources to implement post-closure measures. In 1999, 5.7 million cubic meters of acidic waste were discharged from the abandoned Atlas mine on the island of Cebu. The resulting impact to the marine environment, including an extensive fish kill, was considered one of the country's top 10 recent environmental disasters (DENR-PAB, 2000).

Countries may also pass legislation that establishes fines and punishment for those found guilty of polluting. However, most countries lack any kind of legislation making polluters liable for clean-up (Warhurst, 1999:35). Where fines are collected, they are often low. Since 1977, the Mines and Geosciences Bureau in the Philippines has collected a flat-rate "mine waste and tailings fee" of $0.001 per ton, which is set aside to compensate for negative impacts caused by mining. As this rate has remained flat since 1977, environmental liability is capped at a relatively low level, providing an incentive for companies to surreptitiously discharge tailings rather than pay for more costly environmental remediation measures.

Monitoring Capacity

Although many countries have legislation requiring mitigation of environmental and social impacts of mining and oil development, the ability to enforce laws and monitor performance is largely lacking. Even in the United States, a lack of resources and staff means that many mines are not frequently inspected. A survey by the Mineral Policy Center revealed that eight western states have less than one inspector per 100 active mine sites (Galloway and Perry, 1997:205-206). Table A2.3 highlights the lack of monitoring and enforcement in a select group of developed and developing countries.

In the Philippines, each regional office of the Mines and Geosciences Bureau is staffed with roughly the same number of technical inspectors. As a result, monitoring capacity is uneven across provinces; Region XII has more than 72,000 hectares of approved mining areas, which amounts to approximately 400 hectares per person. Nine of the other 15 regions have less than 5,000 hectares of approved mining areas, resulting in a more manageable monitoring target of approximately 30 hectares per person.

Lack of funding, staffing, and training are common constraints in many countries (Maponga and Mutemererwa, 1995: 24; ESMAP, 1999: 23). In the Philippines, inspectors rely on companies to provide access and additional resources, eliminating the element of spontaneity required for auditing (ESSC, 2003). Due to the lack of available resources for monitoring the performance of mines in Papua New Guinea, the government relies on company reports rather than conducting periodic site visits to determine compliance with standards set in the mine contract.

Table A2.3: Capacity to Monitor and Enforce Laws

Country or State	Number of Inspectors	Number of Mines	Ratio of Inspectors to Mines
Zimbabwe	4	300	1:75
Venezuela	3	400*	1:133
Arizona, USA	13	538	1:41
Colorado, USA	15	1,944	1:129

Idaho, USA	6	65	1:11
Montana, USA	20	1,100[1]	1:55
Nevada, USA	13	225	1:17
New Mexico, USA	7	185	1:26
Utah, USA	4	766[2]	1:191

*Includes exploratory concessions
[1]Includes 1,000 “notice mines” (5 acres or less)
[2]Includes 334 “notice mines” and 326 mining exploration projects
Sources: M. Miranda et al., *All That Glitters is Not Gold*, p. 16; O. Moponga and A. Mutemererwa, “Management of Natural Resources and the Environment in Zimbabwe,” p. 5; L. T. Galloway and K.L. Perry, “Mining Regulatory Problems and Fixes,” pp. 208-209.

Bibliography

Ashton, P.J., D. Love, H. Mahachi, and P.H. Dirks (2001), "An Overview of the Impact of Mining and Mineral Processing Operations on Water Resources and Water Quality in the Zambezi, Limpopo, and Oilfants Catchments in South Africa," Contract Report to Mining, Minerals, and Sustainable Development Project/Southern Africa, CSIR-Environmentek: Pretoria, South Africa and University of Zimbabwe, Geology Department: Harare, Zimbabwe.

Auty, R.M. (1990), *Resource-Based Industrialization: Sowing the Oil in Eight Developing Countries*. Oxford: Clarendon Press.

Ballard, C. (2001), "Human Rights and the Mining Industry in Indonesia: A Baseline Study," MMSD Working Paper No. 182. Available online at: http://www.iied.org/mmsd/mmsd_pdfs/indonesia_hr_baseline.pdf

Bryant, D. et al. (1998), *Reefs at Risk: A Map-Based Indicator of Threats to the World's Coral Reefs* WRI: Washington.

Christmann, P. and N. Stolojan (2002), "Management and Distribution of Mineral Revenue in PNG: Facts and Findings from the Sysmin Preparatory Study A Consultant's Perspective," Report Commissioned by the Mining, Minerals and Sustainable Development (MMSD) project of the IIED. London, England: MMSD.

Collier, P. and A. Hoeffler (2001), "Greed and Grievance in Civil War," World Bank Paper.

Collier, P. and A. Hoeffler (1998), "On Economic Causes of Civil War," *Oxford Economic Papers* 50: 563-573.

Da Rosa, C.D. and J.S. Lyon (1997), *Golden Dreams, Poisoned Streams: How Reckless Mining Pollutes America's Waters and How We Can Stop It*. Washington, DC: Mineral Policy Center.

Davis, G.A. and J.E. Tilton (2003), "Should Developing Countries Renounce Mining?: A Perspective on the Debate," Paper contributed to Extractive Industries Review (EIR). Available online at www.eireview.org.

Department of Environment and Natural Resources – Pollution Adjudication Board (DENR-PAB) (2000), "Mining Related Incidents." Unpublished public records (used with permission from PAB), Quezon City, Philippines.

Environmental Science for Social Change (ESSC) (2003), "Mining and Critical Ecosystems: Philippines Case Study." Case Study commissioned by World Resources Institute. ESSC: Manila, Philippines.

Environmental Science for Social Change (ESSC) (1999a), *Decline of the Philippine Forest*. Makati City, Philippines: Bookmark Inc.

Environmental Science for Social Change (ESSC) (1999b), *Mining Revisited: Can an Understanding of Perspectives Help?* Quezon City, Philippines: ESSC.

Energy Sector Management Assistance Programme (ESMAP) (1999), *Environmental and Social Regulation of Oil and Gas Operations in Sensitive Areas of the Sub-Andean Basin*, Report 217/99. Washington, DC: The World Bank, 1999.

Fearnside, P. (1989), "The Charcoal of Carajás: A Threat to the Forests of Brazil's Eastern Amazon Region," *Ambio* Vol 18 (2): p. 142.

Galloway, L.T. and K.L Perry (1997), "Mining Regulatory Problems and Fixes," In C.D. Da Rosa (ed.) *Golden Dreams, Poisoned Streams*

Gardner, G. and P. Sampat (1998), *Mind Over Matter: Recasting the Role of Materials in our Lives*, Worldwatch Paper No. 144 Washington, DC: Worldwatch Institute.

Gelb. A. et al. (1988), *Oil Windfalls: Blessing or Curse?* New York: Oxford University Press.

Government of Papua New Guinea (GoPNG) (2002), "Fourth Quarter Bulletin: Annual Bulletin, 2001" PNG Department of Mining. Port Moresby, PNG: GoPNG.

Global Witness (1998), *A Rough Trade: The Role of Companies and Governments in the Angolan Conflict*, London: Global Witness, available at http://www.globalwitness.org). Last accessed 11/5/01.

Global Witness (1999), *A Crude Awakening: The Role of the Oil and Banking Industries in Angola's Civil War and the Plunder of State Assets*, London: Global Witness, available at http://www.oneworld.org/globalwitness/. Last accessed Nov. 5, 2001.

Hughes, P. and M. Sullivan (1989), "Environmental Impact Assessment in Papua New Guinea: Lessons for the Wider Pacific Region," *Pacific Viewpoint* Vol 30 (1).

Hyndman, D. (2001), "Digging the Mines in Melanesia," *Cultural Survival Quarterly* Vol 15(2): 32-39.

Johnson, S.W. (1997a), "Hydrologic Effects," In J.J. Marcus (ed.) *Mining Environmental Handbook*. London: Imperial College Press

Johnson, S.W. et al. (1997b), "Effects of Submarine Mine Tailings Disposal on Juvenile Yellowfin Sole (*Pleuronectes asper*): A Laboratory Study," *Marine Pollution Bulletin* Vol. 36 (4)

Kelly, M. (1998), *Mining and the Freshwater Environment*. London: Elsevier Applied Science/ British Petroleum

Kuyek, J. and C. Coumans (2003), *No Rock Unturned: Revitilizing the Economies of Mining Dependent Communities*. MiningWatch Canada: Ottawa, Canada. Available online at: http://www.miningwatch.ca. Last accessed September 6, 2003.

Lagos, G. and P. Velasco (1999), "Environmental Policies and Practices in Chilean Mining," In A. Warhurst (ed.) *Mining and the Environment: Case Studies from the Americas*, Ottawa, Canada: International Development Research Center.

Ledec, G. (1990), "Minimizing Environmental Problems from Petroleum Exploration and Development in Tropical Forest Areas," *Proceedings of the First International Symposium on Oil and Gas Exploration and Production Waste Management Practices*, New Orleans, Louisiana, September 10-13, 1990.

Mapong, O. and A. Mutemererwa (1995), "Management of Natural Resources and the Environment in Zimbabwe: The Case of Gold," Paper prepared for UNCTAD, United Nations Conference on Trade and Development.

Mason, R.P. (1997), "Mining Waste Impacts on Stream Ecology," In C.D. Da Rosa (ed), *Golden Dreams, Poisoned Streams, How Reckless Mining Pollutes America's Waters and How We Can Stop It* . Washington, DC: Mineral Policy Center.

Matthews, E et al. (2000), *The Weight of Nations: Material Outflows from Industrial Economies* Washington, DC: World Resources Institute.

MacCallum,B (1989), "Seasonal and spatial distribution of bighorn sheep at an open pit coal mine in the Alberta foothills," In D.G. Walker et al. *Proceedings of the Conference: Reclamation, A Global Perspective, Vol. 1* Report #RRTAC 89-2, Edmonton, Alberta: Alberta Conservation and Reclamation Council.

Miller, K.R (1995), *Balancing the Scales: Guidelines for Increasing Biodiversity's Chances Through Bioregional Management*, World Resources Institute: Washington, DC.

Mining, Minerals and Sustainable Development (2002), *Breaking New Ground*, Earthscan Publications: London.

Miranda, M. A. Blanco-Uribe Q., L. Hernández, J. Ochoa G., E. Yerena (1998), *All That Glitters is Not Gold: Balancing Conservation and Development in Venezuela's Frontier Forests*, World Resources Institute: Washington, DC.

Otto, J. and J. Cordes (2002), *The Regulation of Mineral Enterprises: A Global Perspective on Economics, Law and Policy*. Westminster, Colorado: Rocky Mountain Mineral Law Foundation.

Oxfam America (2002), "Tambogrande Speaks Out," Oxfam America Issue Update. Available online at: http://www.oxfamamerica.org/advocacy/art2763.html?backresults=TRUE, last accessed April 30, 2003.

Peres, C.A. and J.W. Terborgh (1995), "Amazonian Nature Reserves: An Analysis of the Defensibility Status of Existing Conservation Units and Design Criteria for the Future," *Conservation Biology*, Vol 9(1): 34-46

Power, T.M. (2002), "The Role of Metal Mining in the Alaskan Economy," A report prepared for the Southeast Alaska Conservation Council and Northern Alaska Environmental Center.

Redwood, J. (1998), "Social Benefits and Costs of Mining: The Carajás Iron Ore Project, In G. McMahon (ed.) *Mining and the Community: Results of the Quito Conference*, Washington, DC: The World Bank, 1998.

Ripley, E.A. et al. (1996), *Environmental Effects of Mining*. Delray Beach, Florida: St. Lucie Press.

Ross, M.L. (2001a), *Extractive Sectors and the Poor*, Oxfam America: Washington, DC.

Ross, M. (2001b), "Natural Resources and Civil Conflict: Evidence from Case Studies," Paper prepared for the World Bank/UC Irvine Workshop on "Civil Wars and Post-Conflict Transitions," May 18-20, 2001, Irvine, CA.

Ross, M.L. (1999), "The Political Economy of the Resource Curse," *World Politics* Vol. 51(2): 297-322.

Sampat, P. (2003), "Scrapping Mining Dependence," In C. Bright et al., *State of the World:2003* Washington, DC: Worldwatch Institute

Schmiermund R.L. and M.A. Drozd (1997), "Acid drainage and Other Mining-Influenced Waters (MIW)" in J.J. Marcus (ed.), *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining*. London: Imperial College Press.

Shearman, P. (2001), "Giving Away Another River," In B.Y. Imbun and P.A. McGavin, *Mining in Papua New Guinea, Analysis and Policy Implications* Port Moresby: University of Papua New Guinea.

Sherman, J.H. (2000), "Profit vs. Peace: The Clandestine Diamond Economy of Angola," *Journal of International Affairs*, 53 (2): 699-719.

Sideri, S. and S. Johns (eds) (1990), *Mining for Development in the Third World: Multinational Corporations, State Enterprises and the International Economy*. New York: Pergamon Press.

Stratigos, C. (1993), "Mining, Resistance, and Nationalism in the Republic of Bougainville," *Social Alternatives* Vol 12(1): 55-62.

United Nations Environment Programme (UNEP) (1996), "Environmental and Safety Incidents concerning Tailings Dams at Mines," Results of a Survey for the years 1980-1996, London: Mining Journal Research Services.

Warhurst, A. (1999), "Environmental Regulation, Innovation, and Sustainable Development," In A. Warhurst (ed.) *Mining and the Environment: Case Studies from the Americas* (Ottawa, Canada: International Development Research Center

Winfield, M. et. al (2002), *Looking Beneath the Surface: An Assessment of the Value of Public Support for the Metal Mining Industry in Canada*. MiningWatch Canada and Pembina Institute: Ottawa, Canada. Available online at: www.miningwatch.ca. Last accessed September 6, 2003.