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GUIDANCE FOR GOVERNMENTS

Environmental Management and Mining Governance

Draft for Consultation

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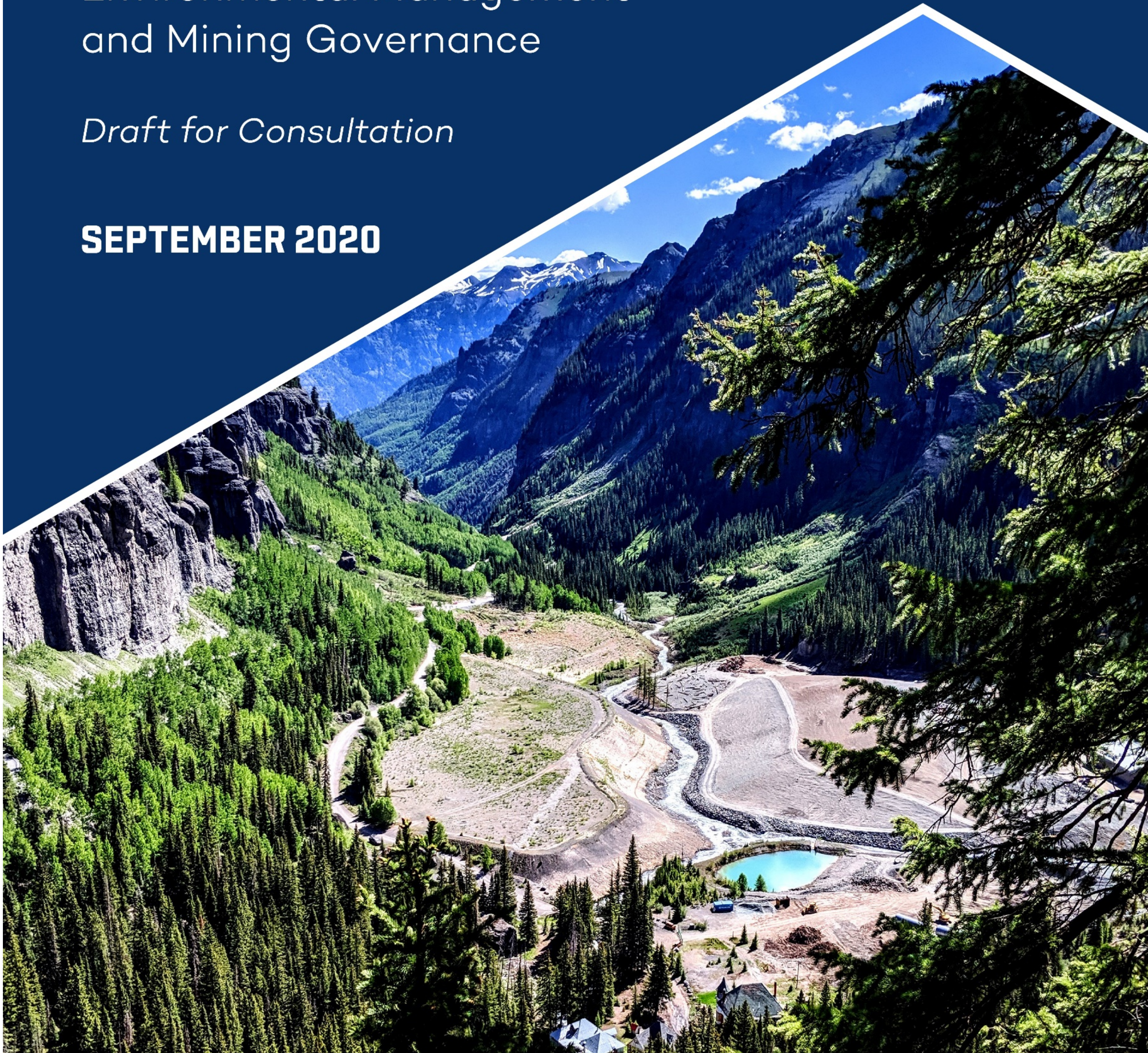

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The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) supports more than 75 nations committed to leveraging mining for sustainable development to ensure negative impacts are limited and financial benefits are shared. It is devoted to optimizing the benefits of mining to achieve poverty reduction, inclusive growth, social development and environmental stewardship.

The IGF is focused on improving resource governance and decision making by governments working in the sector. It provides a number of services to members including: in-country assessments; capacity-building and individualized technical assistance; and guidance documents and conferences which explore good international practices and provide an opportunity to engage with industry and civil society.

The International Institute for Sustainable Development (IISD) serves as Secretariat for the IGF since October 2015. Core funding is provided by the Government of Canada.

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Use of examples and case studies does not endorse a jurisdiction's approach

The examples and case studies in this document present actual legislation and diverse experiences of stakeholders in environmental management in a wide range of jurisdictions. Presentation of legislation from a particular jurisdiction does not indicate endorsement of that jurisdiction's legislation or how it has been implemented or failed to be implemented in particular projects. However, it is useful to compare the various approaches around the world and to easily access actual language from legislation on a particular key topic. Likewise, presenting a case study from a particular jurisdiction does not indicate that the jurisdiction is managing all aspects of its mineral sector optimally. There is room for improvement in all jurisdictions; this guide provides opportunities to learn across different jurisdictions from different types of mining projects.

Unofficial Translations of Legal Texts

The translations of laws and policies referenced and presented in this document are in most cases unofficial translations.

This Guide Is Not a Substitute for Legal Advice

While this guide provides a range of factors and options to consider, this book is not a substitute for legal advice.

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Preface

At their 2019 Annual General Meeting, IGF member governments identified the need for guidance on environmental management practices and policies to help them better balance resource extraction with environmental protection. The health of natural resources and ecosystems underpins the health of communities and economies and must be protected and supported for any society to thrive in the long term.

IGF guidance documents are developed by the IGF Secretariat based on the IGF Mining Policy Framework (MPF) and good international practices. The MPF represents government approaches for managing the minerals sector in a manner that optimizes the sector's contributions to sustainable development.

Drawing from the MPF, this guidance document highlights the key issues, benchmarks and standards in four main areas of environmental management in mining – water, biodiversity, waste, and emergency preparedness and response – and the role of governments in ensuring that each is effectively managed in support of sustainable development.

I am pleased to welcome this guidance, the latest in the IGF "guidance for governments" series of knowledge management products, and look forward to working with our members and other key stakeholders to make sure it is helpful to them in their critically important pursuit of greater sustainable development from mining.

Greg Radford
Director, IGF

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Executive Summary

The Importance of Environmental Management in Mining

The responsible management of natural resources and ecosystems—including soils, plants, animals, water and air, and the services they provide—is central to the efforts of any society seeking to become more sustainable. The health of these resources, ecosystems, and services underpins the health of communities and economies and must be protected and supported for any society to thrive in the long term.

In this context, mineable deposits appear in locations both convenient and inconvenient. They can be close to or distant from human settlements and water sources; they can be surrounded by arable lands, breeding grounds, migration corridors, and ecologically sensitive areas; and they can be in areas prone to fierce storms, unstable hillsides, and seismic activity. Mining these deposits will always impact the environment and its resources to a greater or lesser extent. The active and sustainable management of these ecosystems and natural resources before, during, and after mining will help avoid negative impacts where possible (which may mean excluding mining in certain cases), can minimize them elsewhere, remediate as necessary, and improve when feasible. Conversely, a failure to effectively manage the impacts of mining on the environment can not only threaten the continued viability of operations but can also undermine the relationships between a mining company, affected communities, and all levels of government.

This guidance document is designed to help IGF member states implement the IGF's MPF. It focuses on the role that national governments can play in ensuring the effective and sustainable management of the environment and natural resources by the mining sector, using the legislative, regulatory, and policy tools and mechanisms at their disposal, including, in particular, Environmental and Social Impact Assessments (ESIAs) and Environmental and Social Management Plans (ESMPs). The guidance spans the mine life cycle, looking at what governments must do before, during, and after mining to ensure that the environment and its natural resources are continuously well managed. Drawing from the MPF, it highlights the key issues, benchmarks, and standards in four main areas of environmental management in mining—water, biodiversity, waste, and emergency preparedness and response—and the role of governments in ensuring that each is effectively managed in support of sustainable development.

Water Management

Access to water is a critical issue for mining. Competing demands for water resources—from the mining sector, from agriculture, from households, from other industries and sectors, and for conservation and leisure—ensure that governments will always play a critical role in water management throughout the life of a mine, not only at the site itself but across watersheds and potentially beyond national borders. When poorly managed, water can be a source of grievance and conflict around mining operations, and while water use and management may receive the greatest attention in arid regions—where mining competes with community needs for drinking water and irrigation—it is a crucial issue in most jurisdictions. And its importance is only likely to increase in the context of climate change.

The overall objective of a government's approach to water management is to protect the availability and quality of water for its population and its ecosystems, now and for future generations. This requires balancing competing demands for water while ensuring access to safe drinking water and sanitation. Within a mining context, governments must not only govern the extraction of valuable water resources, but also oversee water use, water discharges, and water quality. The advantage of governments doing this is that they can manage water at the watershed level and regional scale, where it is easier to effect the changes needed to meet sustainability goals.

Broadly, the MPF requires governments to do the following to manage the water issues associated with mining:

- Have appropriate environmental management standards in place for the use of surface and groundwater. These standards must be strictly monitored, and have appropriate penalties should they be compromised.
- Require that mining entities ensure that the quality and quantity of mine effluent streams discharged to the environment—including stormwater, leach pad drainage, process effluents, and mine works drainage—are managed and treated to meet established effluent discharge guideline values.
- Require that mining entities ensure that water-leaching or percolating waste dumps, tailings storage areas, and leach pads have equivalent protection.
- Require that mining entities have in place practices and plans that minimize the likelihood of impacts beyond the mining site, particularly potential transboundary impacts.

Water management in mining is complex and incorporates a range of disciplines and components, including water rights, use, controls, quality, treatment, and conflict. And while new technologies and knowledge have greatly improved mine water management, considerable challenges remain—some of which may extend beyond national borders. It is important for governments to have an overall understanding of the potential water management risks and issues present in their mining sectors, and to obtain expert advice and assistance as and where needed for effective control and governance through all mine phases. This includes water use in the post-mining transition, when responsibility for long-term management reverts to government. Using a risk-based framework that considers risks, their likelihood, and their consequences to determine water management priorities is typically a good place to start, given the broad range of risks that can arise around water management in the mining sector.

Drawing on international standards and practices, there are a number of key actions that governments can take to effectively manage water resources around mining:

1. Prior to mine permitting, develop water management policies and programs at the watershed level.
2. Prior to mine permitting, set mine effluent criteria and receiving water objectives.
3. Through the ESIA review and mine permitting process, review the plans and set conditions for water use and discharges.
4. Through the ESIA review and mine permitting process, review and approve mine water management plans.
5. During construction, operation, and closure, monitor and evaluate mine water management performance.
6. During construction, operation, and closure, enforce compliance to protect water resources.

Biodiversity

Activities across the mine life cycle—from exploration through the post-mining transition—can have significant direct, indirect, and cumulative impacts on the natural world. From land-use change and deforestation to pollution, greenhouse gas emissions, and the unintended introduction of invasive species, there are many ways in which mining operations can influence local and national biodiversity and ecosystem services. Many of the impacts of mining on biodiversity are unavoidable and must be carefully considered as communities and governments balance their development priorities with their conservation needs. However, through collaborative planning, implementation, and monitoring and evaluation, these stakeholders can work with mining companies to ensure that economic value is generated with no net loss to biodiversity. In the best-case scenario, when properly planned and implemented, mining activities could even lead to a net gain for nature over the life of the mine.

Biodiversity is, most simply, the variety of life on earth, in all its forms and interactions. It is closely related to ecosystem services, though important distinctions should be made between the two. Biodiversity can be thought of as the "stock" that sustains human life and livelihoods through the ecosystem services that it provides; that is, the processes through which the environment produces benefits useful to human populations.

Conserving and protecting biodiversity and ecosystem services have grown in importance for both governments and mining companies, in recognition of the role that biodiversity can play in supporting economies and operations and in maintaining the well-being of surrounding communities. In response, companies are increasingly working with partners to find ways that they can avoid, minimize, and restore any negative impacts their activities have on biodiversity and offset those residual impacts that cannot be avoided.

Governments have a strong role to play here as well. Through their legal and policy frameworks, the MPF requires governments to avoid and minimize potentially adverse effects of mining on biodiversity by:

- Requiring that mining entities submit environmental management programs and updates for approval prior to permitting and whenever there are significant process or operational changes during the operating life of the mine.
- Identifying, monitoring, and addressing potential and actual risks to and impacts on biodiversity throughout the mining cycle.
- Requiring that mining entities conduct monitoring on a continuous basis based on national standards and the conditions of the operating permit, compile and submit performance assessments to government, and publish regular reports that are readily accessible to the public.

As a result of the close relationship between ore bodies and unique environmental conditions, and in order to maintain good relationships with mine-adjacent communities, companies are starting to think about how they can design, build, operate, and close their mines in a way that results in no net loss (NNL) to biodiversity over the life of the mine, or—more positively—results in a net positive impact (NPI) on biodiversity over time. One useful framework for achieving this is the Mitigation Hierarchy (MH), which helps guide companies in reducing the significant negative impacts of their operations on priority biodiversity. It is based on the iterative application throughout the project's life cycle of four sequential steps: the preventive steps of avoidance and minimization, and the remediative steps of rehabilitation/restoration and offsetting.

Governments, when considering the merits of a proposed mining project, will have to weigh the economic and development needs of the country and the local community against its conservation and environmental goals. However, active collaboration on biodiversity management and protection among governments, companies and local communities is increasingly seen as a win–win–win. Governments can follow certain good practices that as they move toward improving the protection of biodiversity and ecosystem services:

1. Develop and adopt a national policy on biodiversity.
2. Integrate biodiversity considerations—including the Mitigation Hierarchy—into their national legislation and regulations, including requirements for ESIAs and ESMPs.
3. Establish and maintain adequate institutions for biodiversity protection.
4. Provide clear guidelines to the mining sector on biodiversity management, including offsets.
5. Establish mechanisms and requirements for sharing information on biodiversity and ecosystems, and for reporting on how companies are implementing their biodiversity commitments.
6. Allocate adequate funding to support the implementation of their biodiversity policy and enforcement of their legal and regulatory requirements on biodiversity.

Waste Management

Mining typically moves and processes large amounts of materials to extract the target commodity, and during these processes produces excess, non-marketable material known as mine waste. This waste can include waste rock, tailings, dissolving solutions from heap leaching, precipitates from water treatment and chemical recovery processes, and dust. Mine wastes typically have some mineralization that is reactive or that could be released from the rock when it is mined, crushed, and exposed to air and water. In combination with the process chemicals needed in the extraction process, there are risks of mining wastes releasing high concentrations of constituents that can be harmful in the receiving environment. In addition, large volumes of non-mineralized materials and excess materials from mineral processing need to be stored in perpetuity in man-made structures, such as tailings dams, that may have physical stability risks.

Waste management often extends well beyond mining operations into the post-mining transition, and the combination of the scale, duration, and magnitude of risk associated with mine waste, alongside recent high-profile accidents around tailings dams, mean that applying a high standard to its management is of utmost importance to companies, communities, and governments.

Given the potentially significant impacts of poor management of mine waste, governments have a central role to play in ensuring that these by-products of the mining sector are managed in an effective way. The MPF requires governments:

- Ensure that structures such as waste dumps and tailings storage facilities are planned, designed, and operated such that geotechnical risks and environmental impacts are appropriately assessed and managed throughout the entire mine cycle and after mine closure.
- Require that mining entities design, operate, and maintain mine waste structures according to internationally recognized standards.

- Require that mining entities commission independent expert reviews and report to governments prior to development approval, when changes in design are proposed, and at regular intervals during the operating phase.

The overall objective of mine waste management is to ensure the long-term physical and chemical stability of all mine waste management facilities. Achieving this objective will protect communities and their water resources and ecosystems, while still supporting the mining needed in many areas to promote local economic prosperity.

As with many aspects of environmental management in mining, waste management should follow a risk-based framework to determine priorities. Waste management in mining is complex and incorporates a range of disciplines, including geology, geochemistry, civil engineering, and geotechnical engineering. In addition, engineered facilities need to incorporate site-specific design criteria for seismic conditions, local climate, and to accommodate climate change scenarios. It is important for governments to have an overall understanding of the potential issues and what affects them and to obtain expert advice and assistance where and as needed for effective control and governance through all mine phases. This includes once mining has finished and the mine has been closed, when responsibility for long-term management of facilities reverts to government. Climatic conditions and the impact of climate change on engineered structures and their systems also need to be considered when contemplating various operating and post-mining transition and closure conditions.

There are key actions that governments should take to ensure the effective and safe management of mine waste. Specifically, governments should:

1. Prior to mine permitting, develop mine waste management standards.
2. Prior to mine permitting, set specific standards for tailings dams.
3. Through the ESIA review and mine permitting process, review and approve the mine waste management plans.
4. Through the ESIA review and mine permitting process, require financial sureties for waste management facilities to manage government risks if the mining company cannot meet its obligations.
5. During construction, operation, and closure, monitor and evaluate mine waste management performance.
6. During construction, operation, and closure, enforce compliance to protect land and water resources, as well as worker and community safety.

Emergency Preparedness and Response

Emergency preparedness, management, communications, response, and recovery are increasingly important in the mining sector. Emergencies, including both internal mine site accidents and external natural and social hazards, can affect operations, workers, and communities, and the impacts can extend well beyond the boundaries of a mine to the communities, rivers, wetlands, farms, and infrastructure that surround the site. Emergency events can also affect operations and communities across the mine life cycle, with the risks extending from construction and operations through mine closure and the post-mining phase.

National governments, working with companies, communities, and all levels of relevant authorities, must ensure that all potentially affected stakeholders identify and understand potential risks across the mine life cycle and that they are well prepared to address and respond to them.

A strong culture of safety starts from the top of an organization, whether it be a government or a mining company. For a country, this culture starts with the government setting a strong example of safe practices and establishing expectations for safety throughout its legal framework. Emergency preparedness and response for mining are not just about what the mining companies put in place; they must be extensions of the regional and national emergency preparedness and response network. Putting in place a strong national culture of safety will not only support community health and well-being, but will help to attract mining companies and investors, as it reduces their risks and liabilities and helps protects their staff and assets.

Preparing for emergencies through formal programs—whether within a mining company, government or community—is above all else about prevention, and about working to protect populations and ecosystems. A series of high-profile accidents in the sector, including the Brumadinho tailings dam failure in Brazil and the jade mine collapse in Myanmar, combined with the increasing impacts of a changing climate, have underscored the need for national and local governments, mining companies, workers, and communities to work together to identify possible risks and develop, test, implement, and improve emergency preparedness before, during, and after mining.

To this end, governments, working with companies and communities, must ensure that all potentially affected stakeholders identify and understand potential risks, that they communicate their efforts, and that these efforts lead to stronger recovery. They should require that mining companies operating in their jurisdiction develop and implement an emergency preparedness and response program, which should include:

- Requiring all mining operations to have an emergency preparedness and response program in place prior to commencement of operations, and ensuring that the program is comprehensive, meets current best practice standards, and is reviewed, tested, and updated on a regular basis. The program should include five principal components: risk assessment; prevention and preparedness; response plans; recovery plans; and crisis communication plans.
- Basing all elements of the emergency preparedness program on ongoing, inclusive consultation and cooperation with local communities, government, and other relevant stakeholders.
- Ensuring that monitoring of the effectiveness and responsiveness of the emergency preparedness program is conducted by companies in cooperation with communities and all levels of government.

Gap Analysis

In order to implement the MPF’s guidance on environmental management, there are several things that governments must do before, during, and after mining to ensure that those operating in their mining sectors effectively manage water resources, protect biodiversity and ecosystems, properly store and dispose of waste materials, and prepare for and respond to emergencies. Using the legislative, regulatory, and policy tools at their disposal, governments can design, implement, and enforce a legal framework that supports responsible and effective environmental management in mining that protects communities, supports the private sector, and helps with the achievement of national environmental objectives and the UN Sustainable Development Goals (SDGs).

Conducting a gap analysis is an effective way for governments to identify their strengths, gaps, and opportunities in environmental management for mining, and to develop a path forward for achieving their environmental objectives.

1. Review the existing legal and regulatory frameworks	As a first step, governments should conduct a review of their existing legal and regulatory frameworks to understand what they are currently doing or requiring on all four aspects of environmental management across the mine life cycle, including in their ESIA and ESMP requirements. This information can be presented in a table listing, for example, everything that the government requires of proponents on water management before, during, and after mining, and so on.
2. Assess strengths, gaps, and opportunities	The country's existing legal and regulatory frameworks can then be compared to international standards and benchmarks. This comparison will help the government see how their legal frameworks on water, waste, biodiversity, and emergency preparedness compare to good international practices. This will help them to identify an initial list of their strengths, gaps, and opportunities for improving legal frameworks on environmental management; it may be, for example, that their requirements on water management before mining commences are largely in line with international standards, but that there are opportunities for further strengthening the laws, policies, and regulations that govern water during mining and after mine closure.
3. Identify priorities for reform and the risks of inaction	Looking at gaps and opportunities, the government can next identify the risks associated with inaction and the benefits of reform, and subsequently prioritize those actions it must take to minimize any risks, maximize any benefits, and strengthen its legal frameworks for environmental management. If, for example, the gap analysis reveals that there is significant risk to local communities as a result of inadequate requirements for developing emergency preparedness and response plans prior to permitting, governments may prioritize addressing this in the legal framework reform process.

4. Develop a roadmap	With a list of priorities in hand, the government can develop a roadmap for how it will adjust or reform its legal framework on environmental management to achieve its policy objectives and meet its international commitments. In this roadmap, the government will outline where changes in policy, law, institutions, capacities, and resourcing will be needed; the best legal instruments for making positive change; the steps that the government will follow to revise the legal framework; and a timeframe for the process (changes to be made in the next 5 to 10 years, for example). This roadmap will help the government articulate how they will get from where they currently are to where they need to be. It should be developed in a participative way, to ensure that it reflects a variety of stakeholder perspectives and has their support. The roadmap should also reflect the roles and responsibilities of those that will implement it. It should also be feasible; the roadmap should adequately and realistically reflect the time, resources, and capacities needed from the government for this work and not be so ambitious that it ceases to be implementable.
5. Implement the roadmap	Once a realistic roadmap has been developed and adopted, the relevant parties can set about implementing it. This will likely require considerable resources and the participation of several different ministries, departments, and agencies, as well as the participation of relevant outside stakeholders.
6. Continuous improvement	The government should establish systems and capacities to continuously monitor and evaluate its legal framework on environmental management to ensure that it continues to meet international standards and benchmarks. Ongoing monitoring and evaluation efforts will allow the government to manage change and adjust frameworks as needed over time to reflect changing best practices and evolving knowledge.

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Acronyms and Abbreviations

APELL	Awareness and Preparedness for Emergencies at the Local Level
AMD	acid mine drainage
ARD	acid rock drainage
BAP	Biodiversity Action Plan
BBOP	Business and Biodiversity Offsets Programme
BC	British Columbia
CBD	Convention on Biological Diversity
CH	Conservation Hierarchy
CSBI	Cross-Sector Biodiversity Initiative
DMIRS	Department of Mines, Industry Regulation and Safety
DRBMP	Danube River Basin Management Plan
EHS	Environment, Health and Safety
ESIA	environmental and social impact assessment
ESMP	environmental and social management plan
EU	European Union
GARD	Global Acid Rock Drainage
GHG	greenhouse gas emissions
GIBOP	global inventory of biodiversity offset policies
GWA	Government of Western Australia
ICMM	International Council on Mining and Metals
ICOLD	International Commission on Large Dams
IGF	Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development
IISD	International Institute for Sustainable Development
IFC	International Finance Corporation
INAP	International Network for Acid Prevention
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IWRM	Integrated Water Resources Management
MAC	Mining Association of Canada
M&E	monitoring and evaluation
MH	Mitigation Hierarchy
MPF	Mining Policy Framework
NGO	non-governmental organization

NNL	No Net Loss
NPI	Net Positive Impact
PDAC	Prospectors and Developers Association of Canada
PRI	Principles for Responsible Investment
PS	Performance Standard
SADC	Southern Africa Development Community
SDG	United Nations Sustainable Development Goal
SEA	Strategic Environmental Assessment
TBC	The Biodiversity Consultancy
TSM	Towards Sustainable Mining
UN	United Nations
UNEP	United Nations Environment Programme

Chapter 1: Introduction

The Importance of Environmental Management in Mining

The responsible management of natural resources and ecosystems—including soils, plants, animals, water, air, and the services they provide—is central to the efforts of any society seeking to become more sustainable. The health of these resources, systems, and services underpins the health of communities and economies and must be protected and supported for any society to thrive in the long term.

In this context, mineable deposits appear in locations both convenient and inconvenient. They can be close to or distant from human settlements and water sources; they can be surrounded by arable lands, breeding grounds, migratory corridors, and ecologically sensitive areas; and they can be in areas prone to fierce storms, unstable hillsides, and seismic activity. Mining these deposits will always impact the environment and its resources, to a greater or lesser extent. The active and sustainable management of these ecosystems and natural resources before, during, and after mining will help to avoid negative impacts where possible (which may mean excluding mining in certain cases), can minimize them elsewhere, remediate as necessary, and improve when feasible. A failure to effectively manage the impacts of mining on the environment can not only threaten the continued viability of operations but can also undermine the relationships between a mining company, affected communities, and all levels of government.

This guidance document is designed to help IGF member states implement the IGF's Mining Policy Framework (MPF). It focuses on the role that national governments can play in ensuring the effective and sustainable management of the environment and natural resources by the mining sector, using the legislative, regulatory, and policy tools and mechanisms at their disposal. Drawing from the MPF, it focuses on four main areas of environmental management in mining: water management, biodiversity management, waste management, and emergency preparedness and response.

Key Themes for Environmental Management

Water Management is a critical issue for mining. Water is a common resource, and clean water is a human necessity. Its management frequently raises questions around access, rights, availability, control, and quality, often due to competing water requirements from agriculture, industry, conservation, and domestic use. Given that mining requires considerable quantities of water for ore processing, cleaning, maintenance, and staff use, companies typically need to spend a considerable amount of time, energy, and resources managing the water that comes into and flows out of their operations. This includes constantly controlling and managing any excess water (such as rainfall, runoff, or groundwater) that may come in contact with mine operations. Governments working with mining companies to ensure that water resources are properly and effectively managed will help balance the company's needs with those of other users while minimizing the risk of tensions and conflict between competing users.

Biodiversity and ecosystem services can be significantly affected by mining due to factors such as: land clearance for facilities and infrastructure, pressures linked to increasing human populations, habitat loss, pollution, and the unintended introduction of invasive species. Conserving and protecting biodiversity and ecosystem services have grown in importance for both governments and mining companies, in recognition of the role that biodiversity can play in supporting economies and operations and in maintaining the well-being of surrounding communities. In response, companies are increasingly working with partners to find ways that they can avoid, minimize, and restore any negative impacts their activities have on biodiversity and offset those residual impacts that cannot be avoided.

Waste Management is of crucial importance to both governments and companies. Mining usually exposes mineralized rock at a much quicker rate than natural erosion processes, and the newly exposed materials release metals and chemicals as they are exposed to water and air. In combination with the process chemicals needed in the extraction process, there are risks of mining wastes releasing high concentrations of constituents that can be harmful in the receiving environment. In addition, large volumes of non-mineralized materials and excess materials from mineral processing often need to be stored in perpetuity in manufactured structures (e.g., tailings dams) that may have physical stability risks. Waste management often extends well beyond mining operations into the post-mining transition, and the combination of the scale, duration, and magnitude of risk associated with mine waste, alongside recent high-profile accidents around tailings dams, meaning that applying a high standard to its management is of utmost importance to companies, communities, and governments.

Emergency Preparedness and Response are increasingly important in the mining sector. Emergencies, including both internal mine site accidents and external natural and social hazards, are sudden, unintended events that can significantly affect the ability of a mining company to carry out its business. They can affect operations, workers, and communities, and their impacts can extend beyond the boundaries of a mine to the villages, waterways, wetlands, and farms that surround the site. Emergencies can affect operations and communities across the mine life cycle, with the risks extending from construction and operations through mine closure and the post-mining phase. Governments, working with companies and communities, must ensure that all potentially affected stakeholders identify and understand potential risks, and that they are well prepared to prevent, minimize, and manage emergencies, that they can communicate their efforts and that these efforts lead to stronger recovery.

In addition to the four main MPF areas of environmental management outlined above, this guidance document incorporates and addresses some important cross-cutting issues associated with environmental management, including climate change, worker health and safety, and the UN SDGs. Climate change is crucially important to environmental management. Through increasing temperatures, more variable precipitation rates, sea-level rise, and increasing intensity and frequency of extreme weather events, climate change could negatively affect such things as the effectiveness of water management practices, the stability of waste and chemical storage facilities, and the health of local biodiversity and ecosystems. Worker health and safety is linked to sound water management, pest and invasive species management, the physical and chemical stability of mine waste management facilities, and emergency response measures. Effective environmental management will also be needed for meeting the SDGs, through the protection of water resources, terrestrial and marine biodiversity, and the health and well-being of staff and communities.

Environmental Management Before, During, and After Mining

The focus of this guidance spans the mine life cycle, looking at what governments must do before, during, and after mining to ensure that the environment and its natural resources are continuously well managed. Many of the activities described below—including risk assessment and management, and the participatory preparation of Environmental and Social Impact Assessments (ESIA) and Environmental and Social Management Plans (ESMP)—will be undertaken prior to the granting of the mining permit or licence. Others, including the implementation of control measures and their monitoring and evaluation, will take place throughout production. The closure of the mine is not the end of this process; several activities will continue on into the post-mining transition, as watersheds continued to be protected and waste storage facilities inspected and maintained.

This includes looking at how these four areas of environmental governance are incorporated into both a country's policy and legal frameworks and its requirements for the ESIA process and ESMPs. Both the broad legal framework and more specifically the ESIA and ESMP requirements are central to a government's effective environmental management and are briefly described below. The integration of environmental management into these tools, mechanisms, and processes, backed up by enforcement, will help to ensure that effective plans are developed, that they are adequately resourced, and that they are implemented, tested, monitored, and evaluated throughout operations and beyond the mine's eventual closing.

The Role of Governments: Legal frameworks for environmental management

The legal frameworks for environmental management in mining typically stretch across several different laws, ministries, departments, and agencies. These range from the overarching principles of environmental rights and natural resource management enshrined in a country's constitution, to specific water and land protection requirements in a range of laws and regulations, to guidance on best practices, to international commitments ratified by the state. The wide breadth of applicable national legislation and international commitments requires that governments work hard to ensure these laws, regulations, and policies are consistent and compatible across ministries. Mining, environmental, and water ministries are likely the key ministries administering the applicable legislation; however, other relevant ministries may include those administering transportation, agriculture, energy, land use, and health. The types of laws and regulations linked to the management of water, biodiversity, mine waste, and emergency response include a country's:

- Mining Act
- Environmental Protection and/or Management Act
- Environmental and Social Impact Assessment regulations
- Water Act
- Land Act
- Biodiversity or Protected Areas Act
- Waste Management Act
- Health and Safety Act
- Hazardous Materials or Waste Act
- Emergency Preparedness Act

A long-standing legal challenge for managing natural resources is that they are common resources with often uncertain ownership and rights. Granting rights to nature is an emerging trend in national legal frameworks, originating from Indigenous views of the rights of nature. Bolivia has granted nature rights in its Laws on the Rights of Mother Nature; Ecuador granted rights to Mother Earth in its constitution in 2008. Legal rights have also been granted to the Atrato River in Colombia, the Ganges River and Yamuna River in India, and the Whanganui River in New Zealand. The legal rights allow the river to litigate for damages from pollution or use. Representatives such as individuals or communities can enforce the rivers' rights.

Relevant international commitments to improved environmental management could include: the UN Framework Convention on Climate Change, the Convention on Biological Diversity (CBD), the Ramsar Convention on Wetlands, the Basel Convention for Controlling Transboundary Movements of Hazardous Wastes and Their Disposal, the Stockholm Convention on Protecting Human Health and the Environment From Persistent Organic Pollutants, and the Minamata Convention on Mercury.

The legal framework pertaining to environmental management in mining should cover the ministries and agencies responsible for implementation, monitoring and enforcement, the government's environmental objectives and goals, the required content of and review process for ESMPs and ESIAs, permitting conditions and requirements, specific criteria for environmental protection, financial assurance requirements (particularly for mine closure), and penalties for non-compliance.

Country-specific conditions and capacities for implementing the legal framework for environmental management should be an underlying theme when developing and revising the legal framework. Implementation of the legal framework will have the most chance of achieving a country's sustainability goals if it is simple, clear, consistent, and easy to implement. Opportunities should also be considered in the legal framework for requiring financial and independent technical support from mining proponents for information review and inspections, should the government be lacking the resources needed to fully carry out these functions.

The Role of Governments: ESIAs and ESMPs

Beyond the broader legal framework, ESIAs and ESMPs are both critical tools for ensuring effective environmental management in mining.

ESIAs are a tool used to identify and evaluate the potential environmental and social impacts of a proposed mining project prior to the granting of a mining licence or permit (IGF, 2020). While the legal frameworks that guide the development of ESIAs will vary across jurisdictions, broadly, these assessments should describe in ample detail the baseline conditions at the site (including water and biodiversity), possible risks and impacts associated with proposed project-related activities, and proposed mitigation and management actions required to limit impacts to acceptable levels.

ESIAs, as with all work on managing water, waste, biodiversity, and emergency preparedness, are grounded in risk management: systematically evaluating the risks that might emerge around particular project activities or interventions. The risk management process involves identifying the hazards associated with the (proposed) mine site that might threaten staff or operations and the surrounding communities and environment; analyzing and assessing the risks associated with these potential hazards; and designing and implementing the control measures needed to eliminate the hazard or minimize the risk of injury or harm (Department of Mines, Industry Regulation and Safety [DMIRS], 2018). Throughout the process, the proponent should consult and communicate with potentially affected stakeholders, and once implemented, the implementation of control measures should be monitored, evaluated and modified as needed (DMIRS, 2018).

The proposed mitigation and management measures to respond to and address these project risks and impacts will form the basis of the project's ESMP (IGF, 2020). This plan, or plans, should provide the details of how the proponents will implement across the mine life cycle the protection and mitigation measures they have committed to, including any relevant legal commitments. Within each ESMP, there may be standard operating procedures that present the steps and protocols workers need to follow to implement the ESMP. While the degree of complexity of the ESMP should be commensurate with the level of activity and risk of the project, common elements include (IGF, 2020):

- Mitigation plans
- Environmental and social monitoring programs
- Emergency response plans
- Stakeholder engagement and capacity-building plans
- Budgets
- The process by which the ESMP will be integrated into the mining project.

While often paid for by the permit applicant, ESIAs should be conducted by independent experts, and—as with ESMPs—they should be developed in a consultative manner, involving communities and other potentially affected parties in risk and impact assessment and the design of mitigation and management measures. Governments should provide clear guidelines to proponents on what is required from them in their ESIAs and ESMPs; these guidelines will help to align the ESIAs and ESMPs with the government's own environmental management objectives (IGF, 2020).

Both documents will be prepared as part of the application process for a mining permit or licence, and the government's careful review of each will be central to their decision making on whether or not a proposed mining project should be approved. The process helps governments to carefully consider how the proposed project will be implemented, to ensure that it only proceeds in a manner that protects the environment and advances the social and economic interests of current and future generations. Where a mining permit or lease is granted, ESMPs then serve as the reference document for the permit holder, government monitoring agencies, communities, and other key stakeholders throughout the life of the mining project (IGF, 2020).

Overview of the Guidance

The purpose of this document is to help IGF member states implement the MPF. It includes a summary of good international practice in governing environmental management in the mining industry. Case studies, tools, and additional resources are included throughout to help the user in understanding and improving their governance options for the management of water, biodiversity, waste, and emergency preparedness. While professional organizations have published technical guides on environmental management, guidance focused on governments on environmental management remains largely lacking in the literature. This guide aims to fill this gap for governments and other stakeholders who would like to improve environmental management in the mining sector.

Not all of the guidance is applicable for every jurisdiction. Environmental management issues will vary according to a host of factors, including underlying environmental and climatic conditions and the types of mineral deposits for each site. Governments should take these unique characteristics into consideration when designing their approach to environmental management. And while the guidance presented in this document is designed particularly for IGF member states, the good practices and examples provided may also be useful for non-members, companies, civil society organizations, community leaders, and others who are interested in optimizing sustainable outcomes from mineral development and governance.

Organization of the Guidance

This guide is organized as follows:

- Chapter 1: Introduction
- Chapter 2: Water Management
- Chapter 3: Biodiversity
- Chapter 4: Mine Waste Management
- Chapter 5: Emergency Preparedness
- Chapter 6: Environmental Management Gap Analysis
- Annex: Additional resources that can be consulted for more information on each topic

The topic chapters will each provide an overview of the topic linked to the IGF's MPF; explore the key issues that governments, communities, and companies are grappling with; present the international standards and best practices that are currently applied to that issue; and discuss the role that governments can play in ensuring strong environmental management. Chapter 6 will discuss what governments can do before, during, and after mining across all four topics to ensure effective environmental management across their country's mining sector. Where applicable and available, examples are provided to highlight good practice, lessons learned, opportunities, and challenges.

How to Use the Guidance

Governments are encouraged to use the following steps to incorporate the guidance into their legal frameworks.

1. Understand the legislative context for each management topic within their jurisdiction, through a thorough review of national laws, regulations, and policies, along with international commitments.
2. Review the international benchmarks and best practices presented in this guidance document and in the additional resources provided.
3. Complete a gap analysis to determine the differences between international best practices and the country's current legislative framework and performance, while factoring in any contextual or situational limitations.
4. Use the guidance to develop an action plan for addressing any existing gaps, including a detailed estimate of the tasks, required human and financial resources, and schedule.

Limitations of the Guidance

The guidance presented in this document, while incorporating the input of technical experts, does not detail the technical aspects of environmental management, but instead focuses on good international practices. This guidance is not a substitute for the level of informed, multidisciplinary expert guidance that is needed to address the unique characteristics of any local development project. Accordingly, this guidance presents good practices, examples, and tools instead of attempting to provide law or policy models. Governments will need to build a diverse team with the requisite skills to address environmental management issues in their unique circumstances.

The guidance focuses mainly on land-based, large-scale mining, and does not address artisanal, deep-sea, or riverine mining. Discussions on climate change, as it relates to environmental management, are limited to the implications of climate change on environmental management; the guidance does not address, for example, the impact that carbon emissions from a mine site will have on a changing climate (i.e., direct and indirect greenhouse gas emissions and carbon sequestration). Industrial wastes that cover multiple industries are also not covered in detail in this guidance. In particular, the following are excluded: hydrocarbon use, storage, transport, disposal, and spill remediation; putrescible wastes; non-putrescible wastes; and wastes from general maintenance of equipment and vehicles. Dust is included in the waste management section since there are mineral-specific dust issues to be considered; however, other airborne emissions are excluded from this guidance. Noise and light pollution are also excluded.

Additional Resources

In addition to the resources provided in the references and Annex to this guidance document, you can find additional materials in a range of languages at www.IGFMining.org. This guidance document may lead to additional future resources, including training courses and online materials. If you are interested in more information or would like to request additional training or materials, please contact the IGF Secretariat at secretariat@igfmining.org.

Chapter 2: Water Management

Overview

Mining is one of the most water-intensive industries in the world. From mineral processing and slurry transport, to dust suppression and meeting the water needs of employees, large-scale mining operations extract and use a significant amount of both groundwater and surface water across the mine life cycle. The same is true of artisanal and small-scale mining operations, as well as quarries. In the United States in 2015, for example, 5,526 million cubic metres (m^3) of water was used in mining operations, accounting for 1% of the country's total water use (Dieter et al., 2018). For drought-stricken Australia in 2017, it was 4.4%, with water-efficient mining operations still using 760 million m^3 of water (Commonwealth of Australia, 2017). An estimated 516 million m^3 of water were required in 2018 to operate Chile's copper mines in the country's arid north (Lutter & Giljum, 2019).

Competing demands for water resources—from the mining sector, from agriculture, from households, from other industries and sectors, and for conservation and leisure—ensure that governments will always play a critical role in water management throughout the life of a mine, not only at the site itself but across watersheds and potentially beyond national borders. This role involves not only governing the extraction of valuable water resources, but also overseeing water use, water discharges, and water quality. When poorly managed, water can be a source of grievance and conflict around mining operations, and while water use and management may receive the greatest attention in arid regions where mining competes with community needs for drinking water and irrigation, it is a crucial issue in most jurisdictions. And its importance is only likely to increase in the context of climate change. Balancing competing demands for water while guaranteeing the human right to safe drinking water and sanitation (UN Resolution A/RES/70/169), is a central responsibility of governments, and will be paramount to the achievement of SDG6 on water and sanitation. As noted by former UN Secretary-General Kofi Annan, "Fierce national competition over water resources has prompted fears that water issues contain the seeds of violent conflict. If all the world's peoples work together, a secure and sustainable water future can be ours" (UN, 2002).

According to the IGF MPF, governments need to broadly do the following to manage the water issues associated with mining:

- Have appropriate environmental management standards in place for the use of surface and groundwater. These standards must be strictly monitored, and have appropriate penalties should they be compromised.
- Require that mining entities ensure that the quality and quantity of mine effluent streams discharged to the environment—including stormwater, leach pad drainage, process effluents, and mine works drainage—are managed and treated to meet established effluent discharge guideline values.
- Require that mining entities ensure that water-leaching or percolating waste dumps, tailings storage areas, and leach pads have equivalent protection.
- Require that mining entities have in place practices and plans that minimize the likelihood of impacts beyond the mining site, particularly potential transboundary impacts.

This chapter will provide an overview of the central water management issues in mining, including water use, rights, control, quality, and conflict. It will then outline some of the key international standards and best practices that can be applied to effectively manage water resources. The chapter will close with more detailed guidance on what governments can do to support sound water management in the sector.

In this chapter, you will learn why it is important to:

1. Consider water management at the watershed level when setting objectives for water use and discharges.
2. Set effluent quality and quantity guidelines based on receiving water objectives.
3. Control water use and discharges through surface water and groundwater permitting.
4. Review and approve water management plans prior to permitting and monitor results of implementation throughout all mine phases.
5. Allocate financial and human resources for timely and effective reviews of monitoring data.
6. Enforce compliance with water permits.

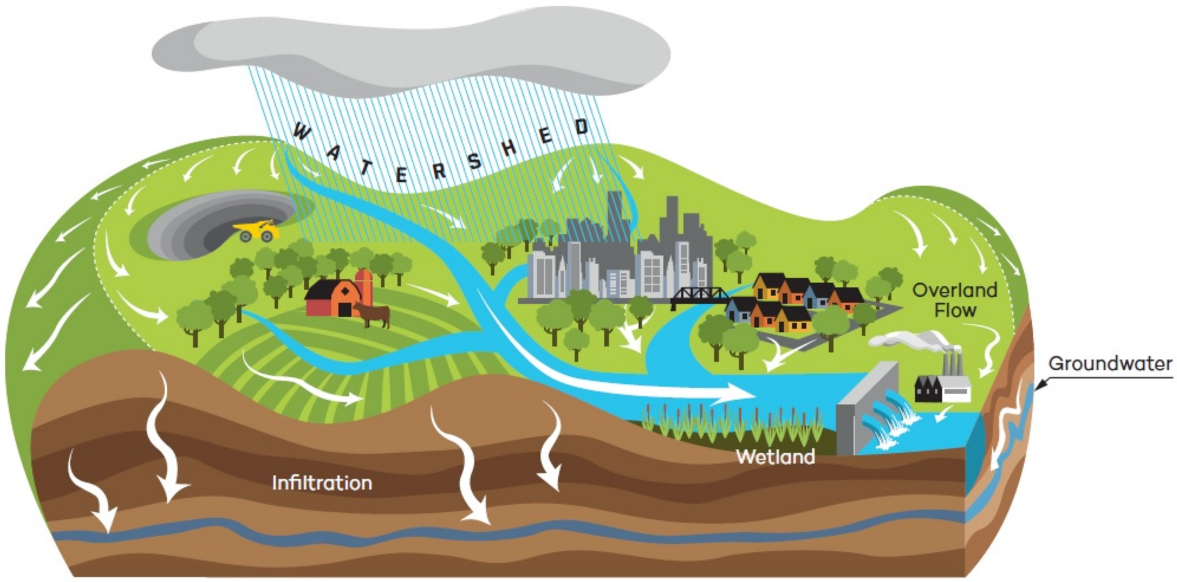
Key Issues

The overall objective of a government's approach to water management is to protect the availability and quality of water for its population and its ecosystems, now and for future generations. Doing so will help to protect the population's basic human right to clean and safe water, and to achieve Sustainable Development Goal 6: Clean Water and Sanitation, which supports these rights by calling for the availability and sustainable management of water and sanitation for all.

The protection of water resources applies to both surface and groundwater and recognizes that these two systems are linked. Unfortunately, global water resources are increasingly under strain: rising temperatures and more variable precipitation rates are altering the supply of water, while demand continues to grow alongside global populations and expanding industrial and agricultural output. As a result of competing demands, water extraction, use, and quality all need to be controlled. This is difficult, however: water is mobile, varies by season, dissolves and transfers pollutants, is difficult to quantify, and is both underground and at surface (Young & Loomis, 2014). It is also a common resource and should not be individually owned but rather open and shared by all. These innate characteristics make water vulnerable to the tragedy of the commons, with everyone using the resource for their individual needs and goals and no one taking responsibility for the common good of all users (Hardin, 1968).

It falls on governments to control and oversee the protection of this common resource. The advantage of governments doing this is that they can manage water at the watershed level and regional scale, where it is easier to effect change to meet sustainability goals. Figure 1 illustrates the types of uses water has as it moves through the watershed from rainfall through surface and groundwater flows.

Figure 1. Schematic showing watershed dynamics and multiple uses of water



Source: BeWaterFriendly.com

Mining operations need water to process ore and run camp operations. Mines also need to manage any water that comes in contact with operations, through high rainfall events, for example, to avoid contaminants from being released from the rock materials or from any chemicals transported, used or stored by the mine. The mining sector has not always been good at water management; historically, mining has often resulted in the overuse of water resources and the contamination of watercourses. This has not been intentional, but rather due to a number of compounding factors: limited understanding of the issues, an absence of risk-based approaches to water management (including risk identification and monitoring), a lack of information to support forecasting, poor regulatory oversight, and unexpected events. Some effects have been detected only decades after the fact, as technology has improved and understandings of the sources of contamination and pollution have developed.

While new technologies and knowledge have greatly improved mine water management, considerable challenges remain. Many governments must work toward meeting the overall sustainability objective for water management, while also accommodating those stakeholders whose water-dependent activities are tied to jobs, economic development, and food security—including mining. To compound this challenge, the management of water resources is rarely solely local; governments must work at the watershed and often transboundary level to ensure water security for communities and water quality for all users while protecting the environment.

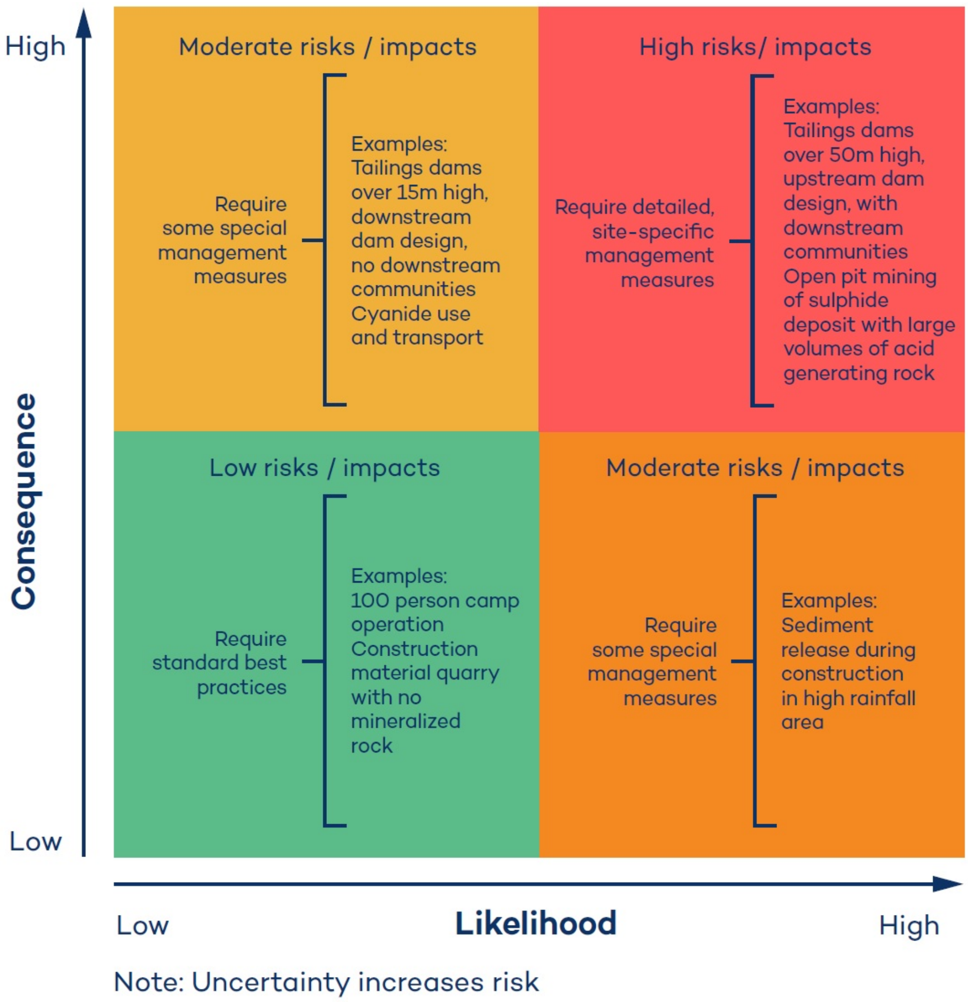
Water management in mining is complex and incorporates a range of disciplines. It is important for governments to have an overall understanding of the potential water management risks and issues with mines and to obtain expert advice and assistance as and where needed for effective control and governance through all mine phases, including water use in the post-mining transition, when responsibility for long-term management reverts to government. Using a risk-based framework that considers risks, their likelihood, and their consequences to determine water management priorities is typically a good place to start, given the broad range of risks that can arise around water management in the mining sector (see Table 1 and Figure 2).

Table 1. Commonly encountered risks to water management

Risk category	Examples
Water security in the catchment	Climate-induced rainfall variability and supply system variability
Water supply system reliability	Failing or inadequate supply infrastructure
Dewatering and drawdown	Failure to dewater ahead of the mine plan
Regulatory compliance	Challenging or changing compliance standards
Surplus water management	Water treatment, temporary water storage, and controlled release to meet receiving water protection requirements
Deterioration of receiving water from operation activities	Airborne contaminants emitted by smelting operations affecting sensitive water and terrestrial ecosystems in the catchment
Cumulative impacts	Impacts of multiple mining or metals companies operating in the catchment affecting both the physical operation of the mine or the regulatory regime for mine approvals
Post-closure water treatment	Re-establishing the hydrological regime post-closure to meet stakeholder expectations

Catchment water degradation by other water users	Pollution from other water users that affect the quality of drinking water
Community issues and concerns	Communities opposed to development of the operation due to water-related concerns; failure to engage communities and respond to their priorities
Catchment governance (social, economic, environmental)	Changes in the developmental priorities of policy-makers that impact licensing or availability
Institutional performance	Variable or limited institutional capacity to manage and administer water
Flooding	Extreme rainfall events causing excess surface runoff requiring emergency discharge of untreated water

Figure 2. Risk-based framework for water management



The key components of water management that should be considered include water rights, use, controls, quality, treatment, and conflict.

Water Rights

UN Resolution 64/292 (2010) recognizes the right to safe and clean drinking water and sanitation as a human right, and calls upon states and the international community to provide the financial resources, capacity building, and technology necessary to scale up efforts—particularly in developing countries—to provide safe, clean, accessible, and affordable drinking water for all people. At the national level, this is often complicated by the fact that rights can be claimed by communities in some areas, granted by the government in some areas, or be undefined. As a result, water rights can often become a source of conflict among large-scale mines, communities, local authorities, and artisanal and small-scale miners, and governments need to control and fairly define the rights of users to minimize the risk of these conflict.

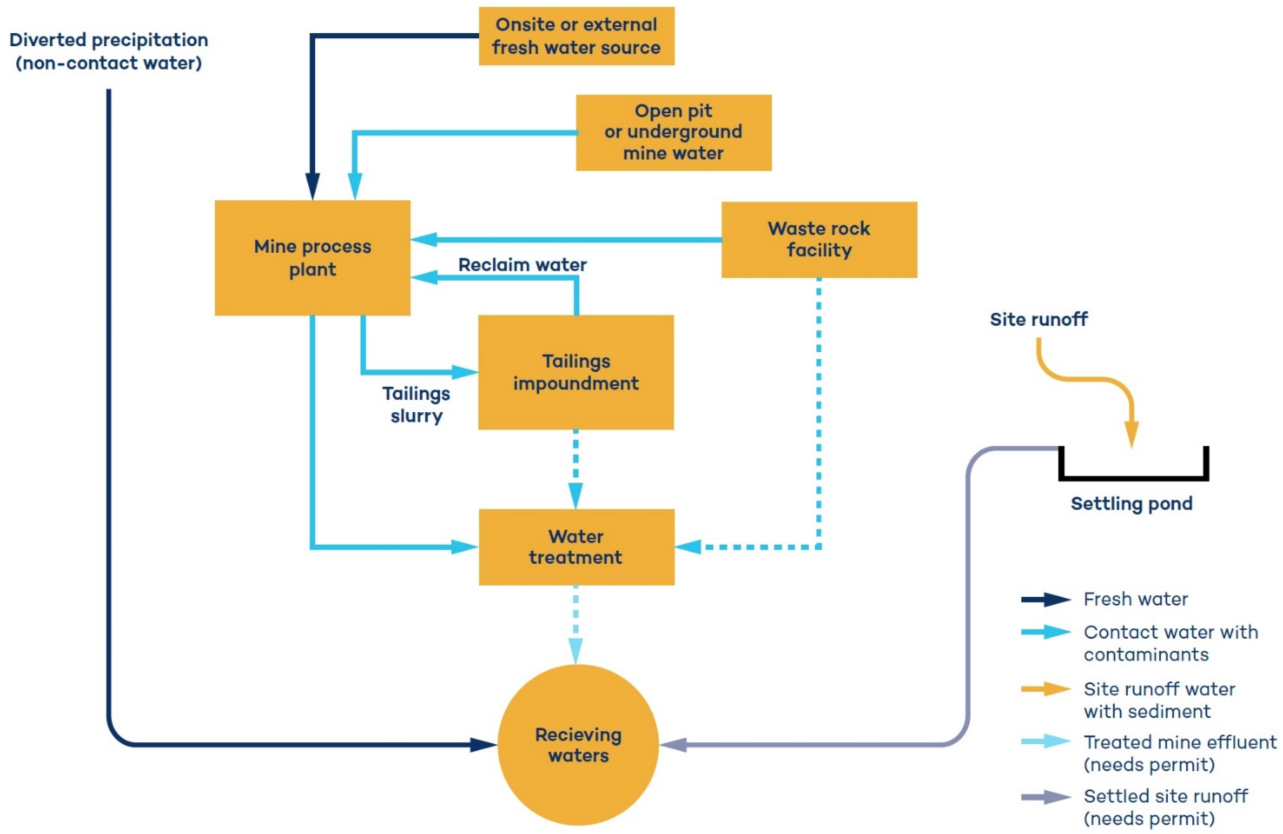
Water Use

The extraction and processing of ore in mines, and the operation of those mines, requires a significant amount of water. In metal mines, hydrometallurgy is used to recover minerals through a process by which the ore is ground finely, and water and chemicals are added to leach or float the targeted minerals. Cyanide and acid heap leaching, when employed, also require water to wet the ore material and leach out the target minerals. Water is also needed to wash coal. In addition, mine operations need water to meet the needs of their employees (drinking water, sanitation), as well as water for on-site cleaning and dust suppression. Water use and reuse must be optimized to allow for efficient operations, and to ensure that sufficient clean water is maintained in the lakes, rivers, and natural systems around the mine site for community use and to support ecosystems and biodiversity.

Water Control

Controlling the quantity and quality of water that comes into and leaves a mine site is a central part of all operations. Current best practices for water control in mine design include: using water diversions to minimize the amount of water contacting mine and processing materials; recycling water to minimize the operation's freshwater requirements; collecting and managing contact water in a manner that minimizes treatment requirements; and controlling and treating water to meet discharge requirements. Controls need to consider all scenarios, including stormwater, drought conditions, and the implications of climate change. Figure 3 presents a simplified mine water balance and water quality schematic that shows one example of the primary flow paths of clean and contact water around a mine.

Figure 3. Simplified example of mine water balance and water quality model schematic



Source: Goldsim.com

Water management and control around tailings impoundments is particularly important and must follow the best design practices defined by various national and international dam associations (as discussed further in Chapter 4). The overall goal of tailings dam design is to maintain the physical stability of the dam and the chemical stability of the tailings within the impoundment, and water control is of paramount importance to both. Key water management features for this are the dam design itself, water diversion systems, and emergency spillway design. Water management facilities should be based on minimizing impacts during extreme precipitation and drought events. Factoring climate change forecasts into water management and controls will be particularly important going forward, given expectations of increasingly variable and volatile precipitation rates and storm events. Management systems should be able to hold and treat for a specific recurrence storm event (often a 100-year return period). Freshwater use should be able to accommodate extreme droughts without depriving the local population of water.

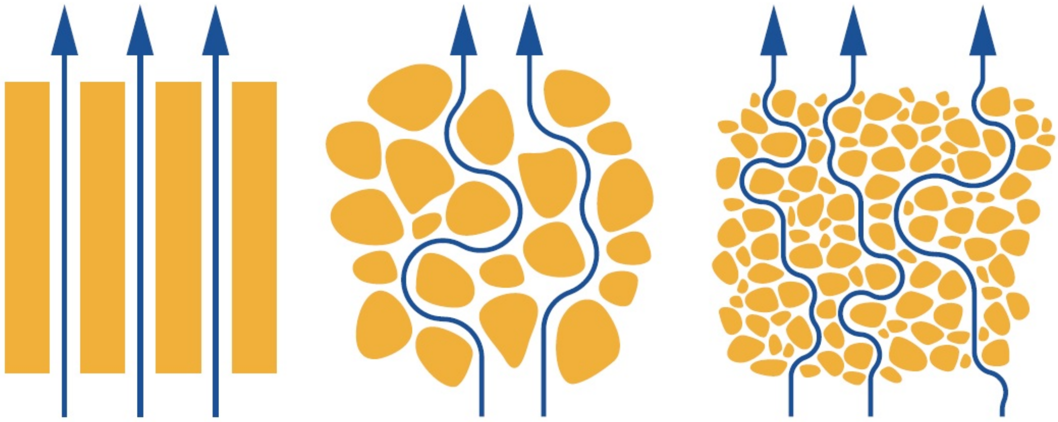
Box 1. Adapting to Climate Change

Effective water management is becoming increasingly important as the world's climate changes. Increasing temperatures, changing rainfall patterns, rising sea levels, and a growing intensity and frequency in extreme weather events will affect how much water is available throughout the year in many parts of the world. These changes could increase water scarcity in some areas and may cause increased frequency and intensity of rainfall, snowfall, and flood events in other areas. Governments need to adapt their legal and policy frameworks on water to respond to these changes: these frameworks, particularly around mine water management, should provide clarity on the government's position and plans on climate change adaptation. Government climate change policies may specify the country's goals, objectives, and accepted climate change scenarios for engineering designs and predictive modelling for mine water management. Companies must also adapt their water management planning and processes to be effective in this dynamic environment.

Water Quality

Each type of rock or material that is mined has unique characteristics that not only produce a commodity that humans need, but also have distinct potential effects on the environment—and on water quality. Mining accelerates the rate of exposure of rocks to both air and water by increasing the exposed surface area (see Figure 4), which can result in the release of toxic chemicals into the receiving environment. Potential sources of water contaminants from mining can come from ore stockpiles, waste rock, tailings, spent leach piles, mine and waste residue stockpiles, as well as from mining operations, including mineral processing reagents such as mercury, explosives residues, and from the use of fuel, oil, and grease. If released uncontrolled into the receiving environment, these contaminants may be toxic and can have severe impacts on ecosystems, biodiversity, and human health. The complex nature of water systems means that these impacts are often long-lasting and can be very costly to remediate.

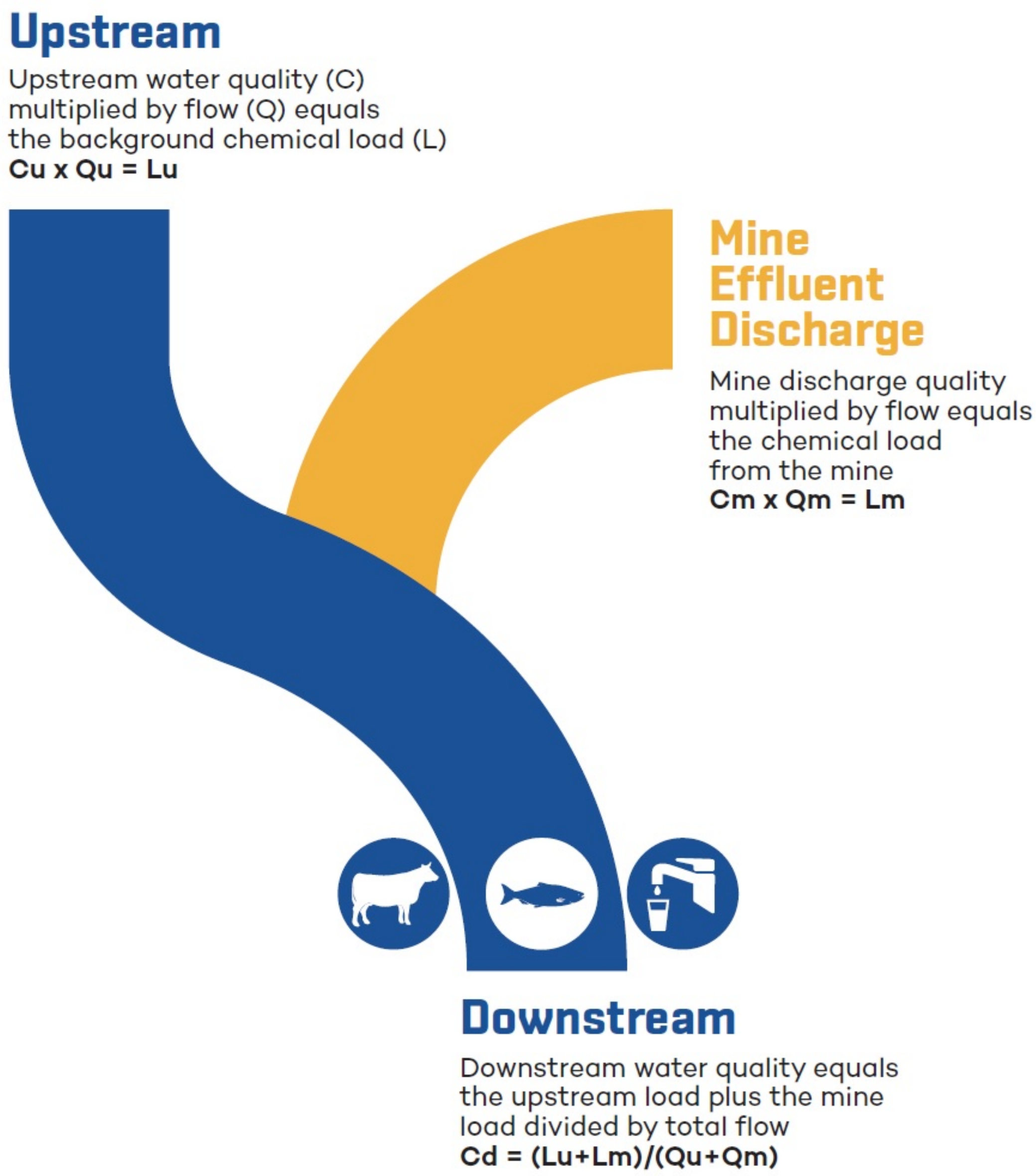
Figure 4. Increasing reactive surfaces with particle size allowing for increased air and water to react and release chemical constituents



Water quality predictions for a mine should be based on detailed modelling in the ESIA process and should take into consideration: the detailed seasonal variability in meteorological, hydrological, and water quality conditions; the geochemical characterization of mine materials; the proposed mine designs; and the chemical dynamics of the operation. Figure 5 illustrates the basic principles of mine water impact analysis that are dependent on water chemistry, flow rates, and the downstream users that need to be protected.

Prior to permitting and the approval of mine designs, the proponent's ESIA needs to assess the expected effects of mine effluents on the receiving environment (see Figure 5). The predicted quality of effluents leaving the mine should meet accepted standards for the protection of downstream uses, which may include aquatic life (i.e., fish, benthic invertebrates, and algae), livestock, crop irrigation, and household consumption. Much of this information is available since extensive work has been conducted to determine the parameters for the acute and chronic toxicity of water quality and to define water quality guidelines to protect environmental receptors.

Figure 5. Basic principles of mine water impact analysis



Water Treatment

Water treatment is a crucial component of mine water quality and water management and can include both active and passive treatment options. The water treatment options chosen will depend on several factors: the ore and waste rock characteristics, the mine's design, the water quality predictions in the ESIA, and testing. Treatment is then optimized during mine construction and across the operation.

Figure 6 provides a summary of the mine drainage treatment options that can be used for addressing the range of water quality issues at a mine site, which can range from active to passive approaches to treatment. A number of different technologies and techniques are typically used to control water quality at a site, including neutralization, metals removal, desalination, and target pollutant treatment.

Active water treatment is needed for those mines using specific chemicals in minerals processing. For example, cyanide, which is typically used to recover gold, can be treated in tailings slurry or in plant water, most commonly by using hydrogen peroxide or a sulphur dioxide and air destruction process. The treatment process is focused on reducing cyanide concentrations in the tailings to levels that are not toxic to wildlife, aquatic life or humans in the receiving environment. Residual cyanide further breaks down in the tailings pond or receiving environment through its exposure to light and oxygen. Ammonia, nitrates, and nitrites, all residual products from cyanide destruction, will also need to be managed until they reach non-toxic levels. Gold mines using cyanide are often signatory to the Cyanide Management Code and, as signatories, must follow principles for the safe and environmentally sound sourcing, transportation, storage, use, and disposal of cyanide. Conversely, the active water treatment of acid mine drainage and heavy metals typically uses liming, and current technology uses a process that creates a high-density sludge to improve the density and storage requirements for the residual metal sludge after treatment. Salinity and sulphate treatment may also be needed and require nano-filtration or reverse osmosis.

Passive or semi-passive treatment options are also available. These tend to use in situ treatment, anaerobic and aerobic flow through systems and wetlands. These systems attenuate residual contaminants through precipitation processes and wetland vegetation uptake and can also include bacterial processes. The in situ treatment of pit lakes and underground flooded mine workings consists of adding food sources to the water to promote bacteria that then precipitate out heavy metals. Passive and semi-passive treatment systems are proven technologies, but there are usually uncertainties in the treatment rates and effectiveness, and large areas are often needed for the development of the required, extensive wetlands.

Water runoff from mine facilities will also require treatment, as this runoff picks up fine sediments that need physical settling prior to release to protect aquatic life in the receiving environment. Sediment control often uses sediment control ponds that are sized to allow for sediments to settle out through the pond before the water is discharged through either seepage to ground or overflow. For finer sediments, a coagulant and/or flocculant may be required. Coagulants are often iron or aluminum-based and help to form larger particles that can settle, such as in a sediment pond. Flocculants can be cationic, anionic, or non-ionic. The toxicity of these chemicals should be checked before use, since iron is less toxic than aluminum, and anionic or non-ionic flocculants are less toxic than cationic flocculants.

Box 2. Key Challenges in Water Treatment

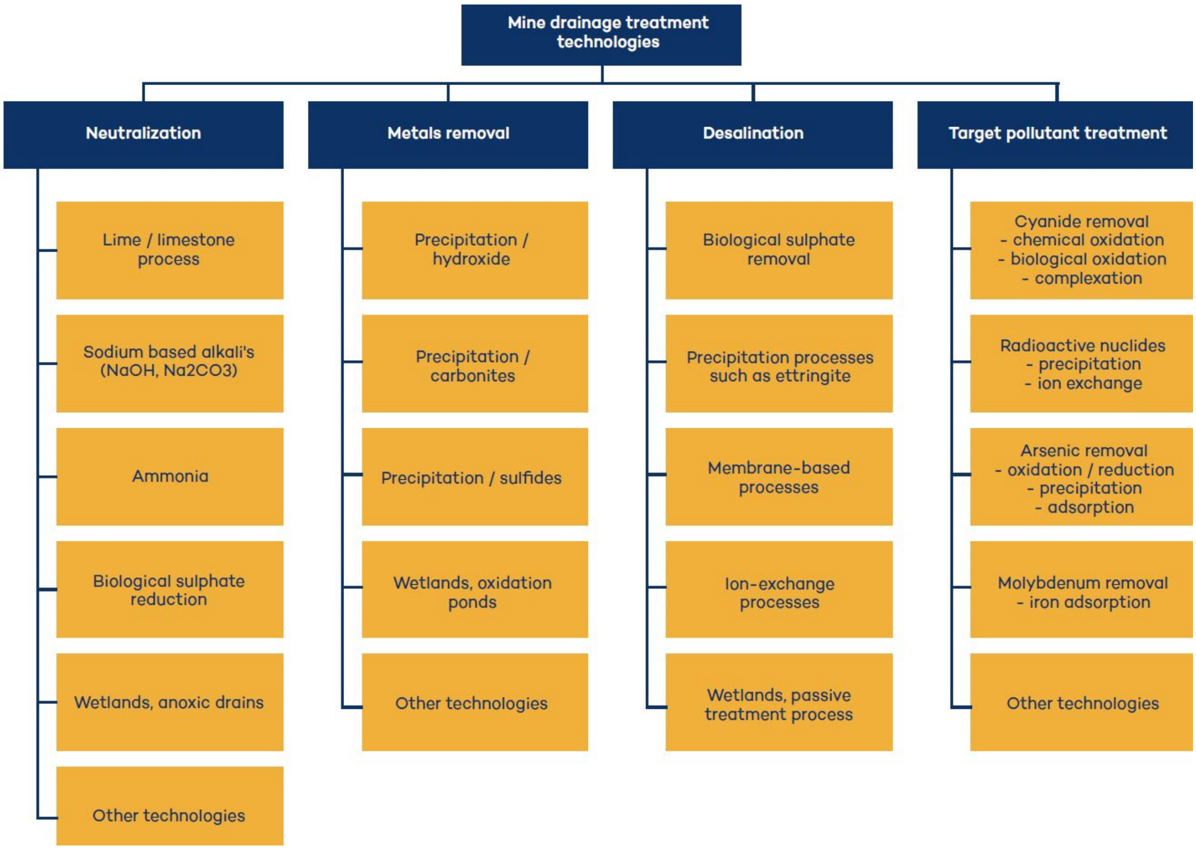
Selenium, arsenic, sulphate, and nitrate are challenging substances for mine water treatment because of their chemical properties. In addition, the flow rates required for their treatment are often high, resulting in expensive treatment systems. Constructed wetland systems have some success at removing selenium, arsenic, sulphate, and nitrate; however, the effectiveness depends on the design and maintenance of the facility. Large land areas are often required for constructed wetlands to reach the required residence time for effective treatment.

Selenium is associated with many coal mines and metal mines. It causes chronic toxicity in the reproductive systems of fish, aquatic birds, amphibians, and reptiles at low concentrations (US Environmental Protection Agency criterion of 5 ppb). Selenium is leachable at neutral pH, is soluble in selenite, selenate, and organoselenium forms, and is challenging to remove from water. Treatment processes have, however, recently been developed that can reach the required low concentrations to protect aquatic life, including membrane filtration, the AnoxKaldnes Moving Bed Biofilm Reactor by Veolia Water Technologies and the Selen-IXTM Process by BQE Water Inc. (an ion exchange process that creates an iron-selenium solid).

Arsenic is a metalloid associated with metal mines. It is toxic to aquatic life and humans, soluble at neutral pH, and occurs in aqueous form mainly as arsenite (As(III)) and arsenate (As(V)). Arsenic removal is generally accomplished using ferric co-precipitation and can also be completed using biological systems.

Sulphate and **nitrate** are anions when dissolved in solids at neutral pH. Biological treatment systems have been successful for nitrate and sulphate removal. Sulphate removal to required concentrations can partially be achieved with liming. Lower concentrations can be met using systems such as reverse osmosis, nano-filtration or ion exchange, but these systems produce brines and sludges that are difficult to dispose of. Biological sulphate reduction combined with a lime treatment system for metals removal has been noted as an effective option, but is not as widely applied as membrane filtration.

Figure 6. Mine drainage treatment options (adapted from INAP, 2014)



Water Conflict

Water is a primary source of conflict between mining companies and communities. Whether driven by competition over accessing limited water supplies, or grievances arising from pollution and water quality issues, social conflicts around water and mining can carry with them significant impacts for all parties. These can include higher operating costs, job losses, project delays, fraying trust, threats to human health, and permitting challenges. Recent examples of social conflicts around water in mining include:

- The **Oyu Tolgoi copper-gold mine development** in Mongolia. The project required the diversion of the Undai River, which led to grievances among the local population of herders. High tensions between the company, government, and the herders (who were supported by non-governmental organizations), eventually resulted in the development of a tripartite agreement on water management among the three stakeholder groups (OAC, 2019).
- The **PolyMet copper-nickel project** in the United States. The company has been trying to secure approvals and permitting for over 10 years and has yet to obtain water discharge permits in the Saint Louis River watershed (Boissoneault, 2020). The local population, concerned about the mine's potential impact on the river, are working to secure legal rights for the river itself, so that citizens could represent the waterway in court (Levang, 2020).
- **Yanacocha Mine** in Cajamarca, Peru. To date, two conflict cases directly related to water have been heard by the Compliance Advisor/Ombudsman (IFC, 2014).

It is imperative that governments put in place a legal framework to address the high risk of water-related social conflict with mining. Governments are in a unique position to address the drivers of these conflicts; they have the required authority to do so and the power to directly influence many of the causes and effects of water-related conflicts.

Box 3. Women at the Heart of Water Security

Women play a central part in the provision, management, and safeguarding of water (ICWE, 1992). They are the primary collectors of water for families around the world, and it is important that governments recognize this key role and provide opportunities for women to meaningfully participate in the development and implementation of water management policies and programs. This will support development, which is accelerated by ensuring that women and girls have access to clean water and facilities for drinking, cooking, sanitation, and hygiene. Placing women at the heart of water security will also help move toward the achievement of two SDGs: Goal 5, achieve gender equality and empower all women and girls; and Goal 6, ensure access to water and sanitation for all.

International Standards and Best Practices

Many international standards and best practice guidelines are available for mine water management. These standards and best practices cover: (1) the overarching principles of water stewardship and integrated management; (2) international conventions; and (3) technical standards, as outlined below.

Water Stewardship and Integrated Management Standards

Central to many international standards and best practices is the concept of **Integrated Water Resource Management (IWRM)**, which is an international best practice strategy for managing water resources by governments at the national level. Water management at the scale of an individual mine then fits within this broader government management framework. From the accepted definition, IWRM is "a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (UNEP & DHI, 2009, n.p.).

Water management is a cross-cutting theme across all eight **International Finance Corporation (IFC) Environmental and Social Performance Standards** and is central to Performance Standard 3 (PS3) on Resource Efficiency and Pollution Prevention. PS3 calls on clients of the IFC to avoid or minimize the adverse impacts of their activities on human health and the environment through pollution avoidance and minimization, and to promote the more sustainable use of water resources (IFC, 2012).

The Mining Association of Canada's Towards Sustainable Mining (TSM) program includes a **TSM Water Stewardship Protocol and Water Stewardship Framework** that sets benchmarks against which companies can measure their water management programs (Mining Association of Canada [MAC], 2017, 2018b). The water management programs are rated against criteria for water governance, operational water management, watershed-scale planning, and water reporting and performance indicators.

Guidance on catchment-based water management from a mining perspective is provided by the International Council on Mining and Minerals (ICMM) in their ***Practical Guide to Catchment-Based Water Management for the Mining and Metals Industry*** (ICMM, n.d.a). This catchment-based approach for companies recommends that ICMM members gain awareness about the water issues surrounding the project, assess the issues, and respond with an appropriate and comprehensive water management plan. This guidance ties in well with how governments can approach watershed-based management.

International Conventions

National legal frameworks for water management need to be consistent with international agreements. International conventions that pertain to water management and mining include: the **Ramsar Convention** on the conservation and use of wetlands; the **Minamata Convention on Mercury** to limit the use of mercury in mining to protect water resources and human health; and the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (**Water Convention**) to govern cooperation on transboundary water resources. There are also other transboundary water agreements that may need to be considered in the water management framework. There are over 3,600 transboundary water agreements that work to manage and protect the shared water resources of neighbouring countries throughout the world, including agreements, initiatives, and commissions managing rivers like the Nile, Mekong, and Indus (UNDESA, 2014).

Technical Standards

The **IFC Environmental, Health and Safety (EHS) Guidelines** also provide standards for water management and water quality in the general guidelines and guidelines specific for mining (IFC, 2007a). These EHS guidelines provide recommendations on how mines should manage water resources, including use of a detailed water balance plan, implementing a sustainable water supply management plan, minimizing water use, managing impacts, and consulting with communities (IFC, 2007a). The guidelines for mining include effluent quality guidelines, but also indicate that the criteria must consider whether there is sufficient assimilative capacity in the receiving environment.

The **Global Acid Rock Drainage (GARD) Guide**[1], developed by the International Network for Acid Prevention (INAP), also provides best practice guidance on mine water management. It includes guidance on how to predict, prevent, mitigate, treat, manage, communicate, and consult about acid rock drainage and metal leaching, both significant challenges for mine sites. This guidance has been used by mining companies and recommended by governments as a required standard worldwide to guide sustainable mine design and protect water quality in the long term.

Another industry-specific standard is the **International Cyanide Management Code**. It provides principles for best management practices for gold mines, silver mines, and producers that use cyanide in the areas of production, transportation and storage, handling and use, operations,

[1] INAP, 2014.

decommissioning, worker safety, emergency response, training, and engagement. These management measures are geared towards worker and public health and safety and making sure that cyanide does not get released and harm the environment. The International Cyanide Management Code was developed as a result of a cyanide spill in Barskoon near the Kumtor mine in Kyrgyzstan in 1998, and a tailings spill into the Danube River at the Aural Mine near Baia Mare in Romania in 2000. It was developed by a multistakeholder Steering Committee under the guidance of the United Nations Environmental Program (UNEP) and the then-International Council on Metals and the Environment (ICME, now ICMM) and has been shown to have improved the performance of the industry (International Cyanide Management Code, 2020).

The **US Environmental Protection Agency** and **European Commission** also have water quality standards to guide mine permit conditions that were developed and continue to be updated based on scientific literature on toxicity.

Guidance for best practices for water management during exploration is provided in the **E3 Plus: A Framework for Responsible Exploration** developed by the Prospectors and Developers Association of Canada (PDAC), specifically their Excellence in Environmental Stewardship Toolkit (EES) on Water Use and Conservation (PDAC, 2009). This framework provides technical details on water protection measures to be followed during exploration, covering details such as management of drilling water, hazardous materials, water conservation, and sediment control measures to protect water resources. The framework also provides guidance on consultation with surrounding communities and users to prevent social conflict over water.

Role of Government

Drawing on international standards and best practices, there are a number of key actions that governments can take to effectively manage water resources around mining. These key actions are aligned with the MPF and are presented in a sequence related to policy development and the mine life cycle. Specifically, the key actions of governments include:

1. Prior to mine permitting, develop water management policies and programs at the watershed level.
2. Prior to mine permitting, set mine effluent criteria and receiving water objectives.
3. Through the ESIA review and mine permitting process, review the hydrology, water chemistry predictions, and management plans and set conditions for water use, reuse, and discharges.
4. Through the ESIA review and mine permitting process, review and approve mine water management plans.
5. During construction, operation, and closure, monitor and evaluate mine water management performance.
6. During construction, operation, and closure, enforce compliance to protect water resources.

Watershed Management: Consider water management at the watershed level when setting objectives for water use and discharges

Beyond their responsibility to ensure the water rights of their citizens and to support agriculture and industry, governments are uniquely placed to manage water resources at the watershed scale. This stands in contrast to an individual, private entity, or company, each of which can only manage their actions around water at a small scale within the footprint of their control. In order to effectively manage watersheds, governments require an understanding of the watershed's meteorology, hydrology, hydrogeology, water quality, community water uses, and industrial water uses, for both surface and subsurface water flows.

The first step for governments is to generate or acquire this data set. Once the dataset is built and understood, the government can establish its water management objectives, policies, and legal requirements. A strategic environmental assessment (SEA) is one tool that can be employed by governments to analyze these data and assess the potential impacts and risks within the watershed. An SEA for a watershed should address the range of users, impacts and risks, and governance options. It should be a transparent process and should include engagement with all relevant stakeholders.

The European Union's (EU) river basin management plans are good examples of using a strategic assessment in developing watershed management plans. Under the EU Water Framework Directive 2000/60/EC, management plans have been developed and are being implemented for most river basins in the EU, and these plans integrate the needs of all countries within each river basin.

Some of the options for watershed management that exist for governments include to:

- Legally designate water protection or conservation zones (for example, for headwaters feeding a reservoir used for potable water for the community).
- Regulate maximum water extraction limits for the watershed that maintain flows for communities and for the survival of fish and other aquatic life.
- Set water quality guidelines to protect humans, agriculture, livestock, fish and other aquatic life.
- Set policies for accepted water uses.
- Develop water remediation programs if the watershed is already impacted.
- Establish setbacks from open water, significant groundwater seepages, and sensitive near-surface aquifers.
- Set policies for permittable water uses, including mining if mineral concessions exist in the watershed.

Box 4. Case Study: Mongolia
The prohibition of mining in headwaters and the protection of water in environmental management plans

Mongolia's legal framework sets boundaries for the protection of its water resources through its Law on Prohibition of Mineral Exploration and Mining Activities in Areas in the Headwaters of Rivers, Protected Water Reservoir Zones and Forested Areas 2009.

To abide by the law, environmental management plans must contain "measures to ensure that mining operations are conducted in the least damaging way to the environment" (Minerals Law, Article 39.1.3). The plans must "identify comprehensive preventive measures to protect air and water, humans, animals and plants from the adverse effects of mining operations" (Minerals Law, Article 39.1.3). Additional details required in EMPs include:

1. Storage and control of toxic and potentially toxic substances and materials;
2. Protection, utilization and conservation of the surface and underground water;
3. Construction of tailings dams and ensuring safety in the mine area;
4. Reclamation measures; and
5. Other measures as may be appropriate for the particular mining operation (Minerals Law, Article 39.1.4).

The potential for mining in a watershed should be considered when selecting governance options. If there are mineral resources and mineral concessions within the watershed, provisions should be made to allow for water use by a potential mine. However, mining concessions should only be allowed in those watersheds that have the capacity to accommodate all users, including the potential development of full-scale mines. By allowing mineral concessions in a watershed, it is often implied that water permits could be obtained to support mining.

Cross-border watersheds complicate watershed management. Transboundary agreements should be sought and established between countries sharing a watershed, so that common watershed protection goals can be set, monitored, and administered.

Box 5. Case Study: Chile
Watershed-based governance in Antofagasta, Chile

The water management area of Antofagasta, Chile, covers an area of 127,221 km^2 and includes surface waters and groundwater aquifers that require protection. There are multiple demands for water across the region, including from agriculture, mining, hydroelectric, municipal, and industrial sectors (Arrau Ingeniería E.I.R.L., 2012). The Loa River watershed is the main watershed in the Antofagasta water management zone. The water management planning is headed by the Ministry of Public Works, is well developed, and has evolved over the last couple of decades to be more comprehensive and integrated. The strategic plan for water resources included all key components of an integrated and comprehensive water management plan, including:

- Identification of water users and demands
- Characterization of surface and groundwater flows and water quality
- Characterization of capacity and risks of existing infrastructure
- Characterization of environmental resources requiring protection
- Institutional and economic constraints
- Analysis of water management tools
- Conservation requirements of non-economic factors
- Public participation
- Strategic environmental assessment
- Identification of gaps and needs
- Conclusions

The water management program includes a comprehensive environmental assessment and permitting framework and is continually updated with ongoing monitoring and adapted for climate change.

Within this framework, mines like Xtrata Copper's Lomas Bayas can develop their own water management plans that meet the government's clear water protection requirements. Xtrata Copper has also been able to develop its water management plan with community input and has helped improve local water management and agricultural activities (ICMM, 2012).

Box 6. Case Study: Danube River Basin
Watershed-based governance and the International Commission for the Protection of the Danube River

The Danube River is one of the international river basins managed under the EU's Water Framework Directive. The Danube watershed spreads out over 800,000 km^2, extending from the Black Forest in Germany to the Black Sea in Romania. It covers 19 countries, including the EU states of Austria, Bulgaria, Czech Republic, Germany, Croatia, Hungary, Italy, Poland, Romania, Slovenia, and Slovakia; and non-EU states of Albania, Bosnia and Herzegovina, Macedonia, Moldova, Montenegro, Serbia, Switzerland, and Ukraine. The Danube River watershed contains 12 mineral districts and is home to a number of major precious and base metal mines. The river has many effluent discharge points and has been subject to major incidents of contaminants over decades. This historical contamination, combined with current use, has created challenges for these countries' governments.

The Danube River Basin Management Plan (DRBMP) was last updated in 2015 (ICPDR, 2015). The management plan provides a good example of coordinated efforts to effectively manage at a watershed level (Bird et al., 2010). The following are key components of the plan:

- The identification of significant pressures, including pollution, changing flows, invasive species, wetlands, transitional areas of surface water, and groundwater.
- Protected areas.
- Monitoring networks and status—coordinates monitoring efforts for surface and groundwater and identifies gaps and uncertainties.
- Environmental objectives and exemptions.
- Integration issues—coordinates cross-cutting issues such as flood risk management, navigation, water scarcity, and climate change.
- Economic analysis, including options for cost recovery.
- Joint program measures to address surface water, groundwater, climate change, and costs.
- Public information and consultation.

The DRBMP provides a comprehensive example of the breadth of legislation put in place and coordination efforts needed for the governance of a large-scale watershed. These concepts and lessons learned can be applied in developing other watershed management plans at other scales.

Effluent Criteria: Set effluent quality and quantity criteria based on receiving water objectives

Governments must also set mine effluent criteria in consideration of the water quality criteria defined for the watershed. Effluent guidelines for mining are broadly available for governments to draw from, including international guidelines (e.g., IFC EHS Guidelines for Mining, 2007) and jurisdiction-specific guidelines (e.g., Canada Metal and Diamond Mining Effluent Regulations, 2002). These guidelines are usually based on the best available – and economically viable – water treatment technologies.

Water quality criteria in many jurisdictions are set for the intended water use, which is typically drinking water, livestock, agriculture, and the protection of aquatic biodiversity. Extensive work has been conducted to determine acute and chronic toxicity of water quality parameters, and to define water quality guidelines to protect environmental receptors. The US EPA water quality guidelines for aquatic life (US EPA, n.d.a) and for human health (US EPA, n.d.b), for example, incorporate an extensive scientific literature base and are typically set at a level one order of magnitude lower than the chronic toxicity concentration for the most sensitive species. Sometimes criteria are variable based on local conditions and need to be analyzed on a site by site basis. Site-specific limits can sometimes be considered by government if the proponent can prove the effluent discharge will still protect downstream resources and water user requirements.

Any mine authorizations or water licences issued by the government should include mine effluent criteria that not only consider best available treatment technology limits but also protect the downstream water uses. It is up to the mine proponent to provide a water balance and water quality model—and to propose water treatment options—in the ESIA; this will make it their proposed mine effluent criteria clear to ensure that downstream water resources are protected. The associated modelling that is done should be completed by competent professionals, and should predict long-term water quality, incorporate seasonal and chemical complexities, define uncertainties, and identify contingency requirements.

Water treatment systems often need to be developed to meet project-specific requirements. Mine proponents should be required to provide supporting evidence to prove the proposed water treatment plans and technologies will meet the permitted effluent criteria, including bench-scale and pilot-scale studies. Note that samples of mine water are needed for testing, but are not available until after the mine begins operations; therefore, a staged approach should be taken for proving the water treatment flowsheet. In a staged approach, a conceptual treatment process is developed based on detailed water quality predictions based on material sampling and testing, along with known treatment processes for existing mines with similar geology and mineral processing technology. Bench-scale testing may then be completed on samples from the metallurgical and geochemical test work. Depending on the complexity of the process, there may be a need to develop a pilot plant before constructing a full-scale treatment plant. In all cases, where a new treatment method is proposed, sufficient testing and research should be provided, with contingency plans, to prevent the risk of the mine being granted a permit despite having untreatable effluent.

Site-specific effluent quality information may be needed in cases where the background receiving water quality is worse than receiving water quality guidelines. It should be the responsibility of the proponent to provide scientifically defensible studies and modelling to prove that the proposed effluent criteria meet the objectives for protecting downstream water uses.

Note that it is not recommended that mines be permitted as no-discharge facilities. At a minimum, an emergency discharge provision should be included in the permit, with associated conditions regarding allowable quantity and quality measures and special circumstances. Excess water destabilizes earth-filled structures such as waste rock dumps, leach piles, mine workings, tailings dams, and tailings piles; therefore, it is important for mines to have the ability to discharge water to maintain the structural stability of all facilities.

Water Permits: Control water use and discharges through surface water and groundwater permitting

Water rights and use are typically allocated to companies by governments through permits or licences. In addition to the effluent criteria discussed above, mine authorizations and associated water licences should specify the rate of water extraction from surface or groundwater sources and the allowable discharge rates for all potential mine contact water. The flow rates should reflect an allowable volume over a set period of time, and should be compatible with flow rate metrics the government uses to manage the water licence and permit allocations in the watershed.

As with water quality criteria, it should be the proponent’s responsibility to provide a site-wide mine water balance, to detail proposed water extraction requirements, and list all proposed effluent discharges in the ESIA. The water extraction proposal should include details on how the mine’s infrastructure design will prevent aquatic life from getting accidentally captured or harmed in the water intake.

Allowable extraction flow rates are determined based on an assessment of other water users and of environmental flow requirements: the minimum flows needed to support the aquatic life in the watershed. Flow requirements need to consider requirements for all users in all scenarios (annual variation, and drought and flood conditions) over the life of the mine, and they need to account for climate change. Environmental flows should also maintain enough water to support wetland habitats. It should be part of the proponent’s responsibility to do detailed hydrological modelling and the regulator’s responsibility to define recurrence rate requirements for design and management.

Mine authorizations and water licences typically specify conditions for point source effluents from the mine; however, there are other non-point sources that can contribute significant amounts of contaminants to the receiving environment, and these should not be overlooked. The legal frameworks should require non-point sources to be collected and controlled so that the source can be monitored for water quality and quantity. Examples include seepage from mine workings, both underground and open pit, as well as tailings and waste rock dumps.

Box 7. Mine Water Permitting Legislation

Mine water permitting frameworks vary throughout the world. A comparative review of eight jurisdictions with long mining histories (including Australia [Western Australia], Canada [British Columbia], Chile, China, Peru, the Philippines, South Africa, and the United States [Alaska, Arizona, Nevada, and New Mexico]) was completed by Thomashausen et al. (2018). The review identified a variety of approaches that countries have taken to their legal frameworks for mine water permitting:

- Basis of allocation of water: Usually completed through a permit or licence for surface and/or groundwater from the water authority. Chile also has a private market for trading water rights.
- Duration of the water right: Ranges from: a defined 5, 10, 30, or 40 years; to the mine life; in perpetuity provided it is being beneficially used; or simply in perpetuity.
- Basis for regulating a mine discharge: Usually a separate discharge permit administered by the environmental authority.
- Requirement for an impact assessment: Most water permits are linked to the mine development impact assessment.
- Community consultation: Approximately half of the countries surveyed require community consultation on the water permitting and usually as part of the impact assessment process.
- Enforcement: The approach varies from: one authority responsible for enforcement; to water or environment authority can enforce permits; to each authority is responsible for enforcement of their applicable legislation; to public or private enforcement.

Water Management Plans: Review and approve water management plans prior to permitting, and monitor results of implementation throughout all mine phases

Governments need to understand the proposed mine water management plan, check that best practices are employed, and regulate the water discharge quantities to protect the receiving environment.

The water balance and the water quality model, a core component of a water management plan, should be a tool that passes on from the ESIA, is updated over the course of mine operations, and is used to manage and adapt to changes in actual conditions during mining and into closure. Governments should require that water management plans be submitted for review and approval with permit applications. Agencies should review the plans in detail to check that the commitments made in the ESIA and in the project approval are implemented through all mine phases, and that there are sufficient mechanisms to check and adapt to changing conditions.

Mine water management guidance can be prepared and published by the government to define the content and structure of the required management plan. This will allow for submitted plans to be in a similar format so they can be reviewed and approved efficiently. Water management plans should be developed by competent professionals and through an engagement process with local stakeholders. The level of stakeholder engagement should be commensurate with the risks to the stakeholders. Key components of a water management plan include the following:

- The site-wide water balance, including all water sources, management structures, and discharge locations.
- A site hydrological model, including storm and drought events with different recurrence rates.
- Detailed predictions of site water quality, using acid-base accounting, leach tests, and humidity cells.
- The water quality model, including locations for discharge and for downstream receiving waters compliance and monitoring.
- Effluent discharge criteria.
- Receiving water quality objectives.
- Descriptions of water management facilities and operational objectives, which can include minimizing mine contact water volumes and secondary containment features to manage breakages, upsets, or extreme events.
- Water treatment plant designs, with influent and effluent flow and quality specifications.
- Monitoring and reporting requirements.
- Adaptive management plans, including details on triggers and contingency plans.

Box 8. Minimize Long-Term Water Treatment Requirements by Designing for Closure

Water and mine waste management designs and plans should have the fundamental objectives of preventing long-term active treatment and management of water from the mine. The key step in designing for closure is characterizing, segregating, and storing mine waste so it is physically stable and will not leach acid or other harmful constituents to waterways in the future. Designs should also allow for ultimately restoring natural drainages without requiring active pumping or diversions. Constructed wetlands are sometimes planned for long-term passive treatment instead of water treatment plants; however, it should be recognized that constructed wetlands are only semi-passive and will require long-term maintenance.

Monitoring and Evaluation: Allocate financial and human resources for timely and effective reviews of monitoring data

Monitoring and evaluation of the water management plans are key to protecting water resources. In many cases, governments request regular submission of water quality and flow data around the mine site and the receiving environment, but the data are only looked at briefly to see if they comply with permits (or worse, the data simply get filed). The reason for monitoring is not just to check compliance, but to track trends. Since human and financial resources are often limited in governments, permit conditions should require reported data to be presented in such a manner that trends can be easily seen, such as graphs and summary tables of results. Analyzing trends allows government (and proponents) to identify, take proactive mitigation measures, and prevent future non-compliance with permit conditions.

Participatory or community water quality monitoring programs can be implemented and financially supported by the mining proponent. Results from these monitoring programs should also be reviewed and evaluated. A feedback mechanism should be implemented to allow community members to notify government of any observed changes in water quality. This is an opportunity for community members to help the government identify water management issues that require addressing, while also building the community's trust of government.

Governments can also promote improvements to monitoring programs in guidance documents. Technologies such as automated and remote sensing methods can be employed to measure water flows and water quality, and to track trends in a timely and transparent manner. This technology can improve the timeliness of responses to unexpected events and prevent pollutants from being released from the mine. Online tools should also be promoted to share water data, track regional trends, improve regional planning, and more fully engage communities.

Box 9. Using Database Sharing for Better Management and Decisions

Individuals and companies may prefer to keep water quality data confidential. It is the responsibility of government to require all water licence and permit holders to provide baseline and monitoring data in a format that is usable by government and other entities in analyzing trends, and to efficiently model and manage water for each mine and in the watershed as a whole.

Some mine industry initiatives have been undertaken to promote data sharing through a common database; however, the widescale collection of data for a common database has been most effective when these are legal requirements in ESIA submissions and permits.

Real-time water quality and environmental monitoring and data sharing via the Internet and community-level data stations and easily accessible computers can help maximize community engagement and maintain stakeholder trust. Teck Resources, for example, use digital sensors to generate real-time data on water and air quality at its sites at Carmen de Andacollo, Chile, and Elk Valley, Canada. The information generated is shared hourly with government and local communities to help them understand the mine's impact and to feel safe (World Economic Forum, 2017).

Governments can provide an opportunity for database sharing through their permit reporting requirements. Making data available via a government-managed website portal provides transparency and allows data to be available to a broad array of stakeholders to inform watershed management. In addition, SEAs and cumulative effects assessments will become more accurate and better informed by a large, regional database.

Enforcement: Enforce compliance with water permits

Enforcement is a critical component of the legal framework for governance of water management. Appropriate consequences must be included in the legislation to manage situations where non-compliance is discovered from review of the monitoring reports, from inspections, or from upset events. The consequences borne by the proponents should be tied to the level of risk of the non-compliance. It should also be noted that water discharge that is not compliant with the mining authorization or water licence may also be non-compliant with other legislation, such as fish protection and human health protection legislation.

Particularly high risks for non-compliance with mine effluent discharge permits occur during a mine's construction and as new facilities are commissioned, given that the construction of mines involves extensive land clearing over a short period of time. As a result, there is a high risk of sediment release from the erosion of newly exposed soils. Erosion control fences and settling ponds may be in place, but runoff can be challenging to manage, especially during high rainfall events. In addition, commissioning waste management facilities, process plants, and water treatment plants takes time to become fully effective; there is therefore a risk of non-compliance as the systems are brought to full capacity. A robust water management design that includes collection and pump-back systems can help reduce the risk of non-compliant discharges.

Consistent enforcement of minor non-compliances is critical to keeping proponents diligent, to maintaining the trust and authority of regulators, and, most importantly, to preventing larger incidents. Major incidents are often a result of failure of many smaller components. Therefore, catching the failures of minor components early can prevent a major failure.

Chapter 3: Biodiversity

Overview

Activities across the mine life cycle—from exploration through the post-mining transition—can have significant direct and indirect impacts on the natural world. From land-use change and deforestation to pollution, greenhouse gas emissions, and the unintended introduction of invasive species, there are a host of ways in which mining operations can influence local and national biodiversity and ecosystem services. Many of these impacts are unavoidable and must be carefully considered; in some ecologically sensitive areas with rich mineral deposits, the decision may be that these stay in the ground. Examples of these include protected areas, UNESCO World Heritage Sites, and Alliance for Zero Extinction sites. Communities and governments will have to weigh their development priorities with their conservation needs. However, through collaborative planning, implementation, and monitoring and evaluation, these stakeholders can work with mining companies to ensure that economic value is generated with no net loss to biodiversity. In the best-case scenario, when properly planned and implemented, mining activities could even lead to a net gain for nature over the life of the mine.

Governments have a strong role to play here. According to the MPF, governments—through their legal and policy frameworks—should seek to avoid and minimize potentially adverse effects of mining on biodiversity by:

- Requiring that mining entities submit environmental management programs and updates for approval, during the permitting process and whenever there are significant process or operational changes during the operating life of the mine.

- Identifying, monitoring, and addressing potential and actual risks and impacts to biodiversity throughout the mining cycle.
- Requiring that mining entities conduct monitoring on a continuous basis based on national standards and the conditions of the operating permit, compile and submit performance assessments to government, and publish regular reports that are readily accessible to the public.

This chapter provides background information on biodiversity governance in the context of the mine life cycle. It is based on the latest information and trends, and presents internationally accepted benchmarks for how to mitigate the biodiversity risks associated with mining, and how considerations on biodiversity can be integrated into mining policy and law. Improving the protection and management of biodiversity and ecosystems will help with the achievement of a number of SDGs, including SDG 14 (Life Below Water) and SDG 15 (Life on Land). It should be noted that the scope of the chapter has largely been limited to large-scale terrestrial mining, while acknowledging that offshore, deep-sea, and artisanal mining practices can all have significant impacts on biodiversity. For each of these, adhering to the Mitigation Hierarchy (see below) remains a good rule.

In this chapter you will learn why it is important to:

1. Consider biodiversity and ecosystem services when setting the objectives for mine design, establishing an environmental management system, mine closure, and the post-mining transition.
2. Understand the Mitigation Hierarchy and its application by mining companies.
3. Understand how to integrate good practice on biodiversity and mining into relevant mining policies, laws, regulations, and permitting.

Key Issues

Biodiversity and Ecosystem Services

Biodiversity is, most simply, the variety of life on earth, in all its forms and interactions. At the global level, it is governed in part by the UN's CBD, which defines it as: "the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (CBD, 2020).

There are three principal components of biodiversity (CBD, 2008):

- **Genetic diversity:** The variety of genes within a population, species, variety, or breed. Genetic diversity is crucial to maintaining the health of a population in response to environmental changes.
- **Species diversity:** The number of different species that are represented in each community or location. Globally, it has been estimated that there are 8.7 million species, and as of 2011, only a fraction of those—1.2 million—had been described (Mora et al., 2011).

- **Ecosystem diversity:** The variety of ecosystems that occurs within a larger landscape. This ranges from biome, the largest ecological unit, to microhabitat, the smallest.

Biodiversity and ecosystem services are closely related, though important distinctions should be made between the two. Biodiversity can be thought of as the "stock which sustains human life and livelihoods through the ecosystem services that it provides; that is, the processes through which the environment produces benefits useful to human populations (CBD, 2008). These services can include clean water, pollination, soil fertility, carbon sequestration, decomposition of waste, and the control of pests and disease. Ecosystem services are often underpinned by biodiversity, and impacts on the latter will likely affect the delivery of the former (IFC, 2012). This is particularly important in many of the areas home to mining operations, in which adjacent households and communities are typically more dependent on natural resources for their livelihoods.

The ecosystem services provided by biodiversity can be split into four main categories: provisioning, regulating, cultural and supporting (Table 2).

Table 2: Description of the different types of ecosystem services.

Type of ecosystem service	Description	Example
Provisioning	The goods or products obtained from ecosystems	Food, timber, fibre, medicines and fresh water
Regulating	The benefits obtained from an ecosystem's control of natural processes	Climate regulation, disease control, water flow regulation, erosion prevention, nutrient cycling, water cycling and primary production
Cultural	The non-material benefits obtained from ecosystems	Recreation, spiritual attachment and aesthetic enjoyment
Supporting	The natural processes that maintain the other services	Soil formation, nutrient cycling and pollination

Source: TBC, 2018; IFC, 2012

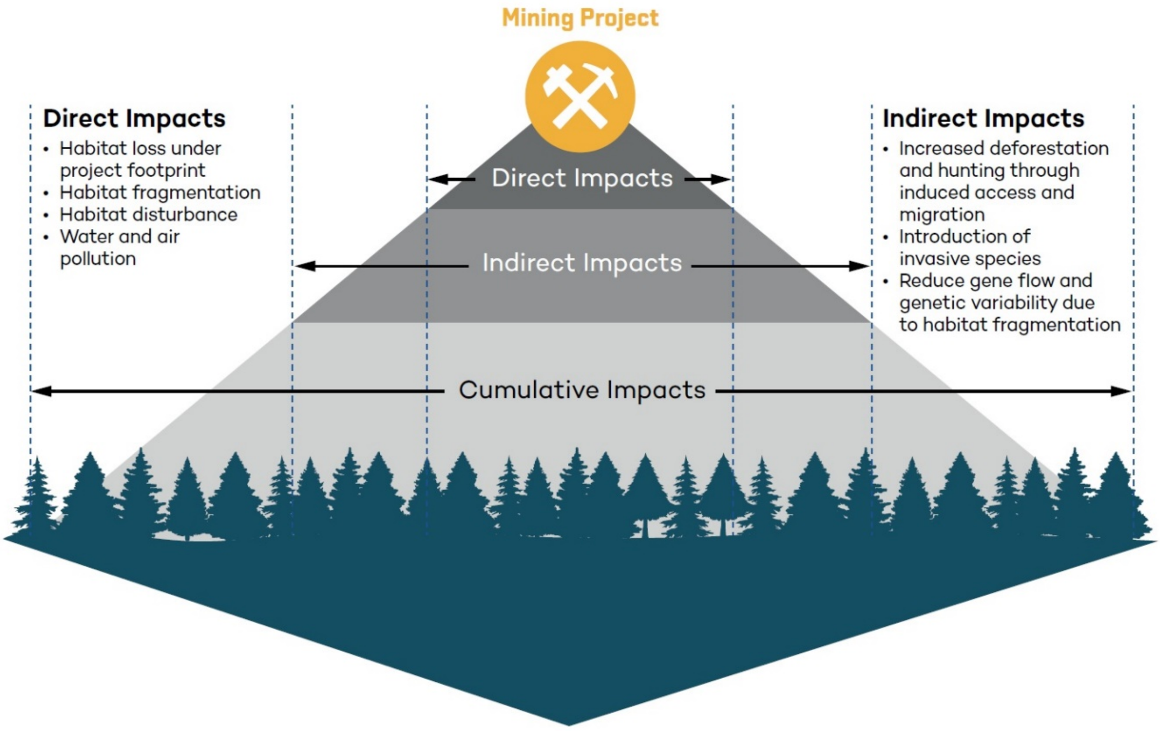
Although societies' appreciation and understanding of the value of biodiversity has improved, globally it continues to decline, and the rates of species extinction and ecosystem deterioration are accelerating (IPBES, 2019). According to the 2019 global assessment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 1 million animal and plant species are now threatened with extinction, many within decades, unless urgent, transformative action is taken (IPBES, 2019). This alarming trend is driven by five key principal anthropogenic factors, each of which is relevant to mining: land and sea use change; direct exploitation of natural resources; climate change; pollution; and invasive species. These drivers, when considered in a context of greater demands on ecosystem services and for natural resources from growing populations, mean that avoiding further degradation or loss of biodiversity and ecosystem services by extractive industries is an increasingly important consideration for both governments committed to supporting the wellbeing of their citizens and companies needing to establish and maintain good relationships with surrounding communities.

Impacts of Mining on Biodiversity

Mining projects have the potential to impact biodiversity and ecosystem services throughout their lifecycle, in a variety of ways. Understanding how development projects can impact biodiversity is vital to the development of appropriate mitigation measures. Impacts can be grouped into three main categories: direct, indirect and cumulative (see Figure 7).

- **Direct Impacts**: These are the biodiversity impacts directly related to a mining project's footprint, activities, and decision making. They include habitat loss, fragmentation, and degradation, as well as water, air, soil, and noise pollution. Most direct impacts occur near project activities, either on site or in a buffer zone; however, some direct impacts—particularly those relating to water pollution—can be felt farther from operations due to downstream transmission. Concrete examples of direct biodiversity impacts include land clearance leading to habitat loss; habitat degradation from acid rock drainage and contamination; species disturbance due to dust, noise, and light pollution; carbon emissions from energy use; and habitat fragmentation resulting from the construction of roads, railways and power lines (TBC, 2018). With adequate baseline knowledge of the ecosystem and the biodiversity present in the project area, these impacts can be largely predicted based on the location, size, and type of planned mining activities.
- **Indirect Impacts**: These impacts can be thought of as the "by-products" of mining activities. In many countries, they are often—though not exclusively—associated with project-induced human migration to and around the project area. This migration can be driven by the increased economic opportunities associated with the project—whether real or perceived—and the expanded access to valuable natural resources that follows the creation or improvement of accessible infrastructure (such as roads) by the project. With this in-migration to a mining area comes the construction of settlements to house the growing population; more hunting, fishing, gathering, and land clearance for agriculture in order to sustain this population; and the unintentional introduction of invasive species to an ecosystem (TBC, 2018). All will affect local biodiversity and ecosystem services. Indirect impacts are much more complex and difficult to predict, and often have more significant negative consequences for biodiversity than the more spatially restricted direct impacts listed above. Compared to direct impacts, they often also have a larger geographic scope, lower levels of predictability and unclear boundaries of responsibility.
- **Cumulative Impacts:** These are the successive, incremental, and combined direct and indirect impacts of a mining project's development and implementation. When considered together, small, non-significant impacts can have a substantial negative effect on the ecological integrity of an area over time. When taken more broadly, consideration of cumulative impacts on biodiversity includes the compounding activities of other past, present, and reasonably foreseeable future projects in the area. These impacts will typically be more significantly cumulative in those areas experiencing rapid development, where those designing and managing mining projects fail to consider the additive effects of other projects in the area (IFC, 2013).

Figure 7. Different types of impacts that mining can have on biodiversity



Continuous and long-term monitoring by stakeholders will help to qualify or quantify actual impacts over time and refine any initial estimates of impacts made as part of ESIAs. The aim of policies on biodiversity—both corporate and governmental—should be no net loss (NNL) to biodiversity or—better still—a net positive impact (NPI) over the life of the project. To achieve this, projects should be designed and implemented in a way that first attempts to avoid any expected impacts from mining operations on biodiversity and ecosystem services (see below). For those impacts that cannot be avoided, minimization must then be pursued. Should impacts still remain, the proponent must address them through rehabilitation and restoration; any impacts remaining after these mitigation efforts are termed "residual impacts." Some of these can be addressed through offsets. These four actions for addressing the direct, indirect and cumulative impacts of a mining project on biodiversity, and achieving NNL or NPI, form the basis of the Mitigation Hierarchy, and will be explored in the next section.

It should be noted that if expected residual impacts cannot be offset—because, for example, the area to be affected is unique and irreplaceable from a biodiversity perspective—governments should investigate the potential need to require the proponent to redesign the project or not permit the project to proceed. This could include projects that could result in extinction-level impacts (mining in an Alliance for Zero Extinction site), or in protected areas where the implementation of the project would run counter to the overall conservation objectives of the area.

International Benchmarks and Standards

The integration of biodiversity and ecosystem service protections into mining policy and legislation is fairly new. It has emerged from an increased and expanding understanding—from the public, from governments, and from corporations—of ecological processes and ecosystem services; of the growing economic importance of nature-based tourism; of the close links between environmental health and community support for mining projects; and of the operational and reputational risks that can derive from destroyed, degraded, or disturbed biodiversity, particularly in an era of increased information flow. Mines have been delayed or even temporarily closed due to community protests linked to the loss of ecosystem services or grievances around inadequate financial compensation received for such losses (TBC, 2018). There is also increasing recognition that a failure from mining operations to address the impacts of their operations on biodiversity can create significant long-term liabilities for developers, can contravene human rights, and can undermine irreplaceable cultural traditions (IAIA, 2018). Finally, financial institutions are an important source of capital for mining companies, and approximately 50 international banks provide the majority of these resources (Arcus Foundation, 2014). Many of these banks have performance standards relating to biodiversity—including the IFC's Performance Standards, the European Bank for Reconstruction and Development's (EBRD's) Performance Requirements and the Equator Principles—which companies must adhere to as part of their lending requirements. The end result of all of this is that integrating biodiversity considerations into mine design, construction, and operations is increasingly good business.

This section will look at the principal benchmarks guiding the interactions between mining operations and biodiversity/ecosystem services, including NNL/NPI, and the Mitigation Hierarchy, as well as standards that have emerged in the industry and in government.

Key Benchmarks

No Net Loss/Net Positive Impact (NNL/NPI)

As mentioned, mining companies—and businesses more broadly—are recognizing the need to manage their operational and reputational risks due to major drivers of environmental change, including biodiversity loss. For the mining industry, this need is often particularly acute because of the frequent overlap of mineral resources and priority biodiversity areas owing to the association between ore bodies and unique environmental conditions. As a result of this close relationship, and in order to maintain good relationships with mine-adjacent communities, companies are starting to think about how they can design, build, operate and close their mines in a way that results in no net loss (NNL) to biodiversity over the life of the mine, or—more positively—strives for a net positive impact (NPI) on biodiversity over time.

NNL/NPI goals are biodiversity targets for development projects (including mining) that call for negative biodiversity impacts caused by the project to be either balanced (for NNL) or outweighed (for NPI) by biodiversity gains through compensation measures implemented in the project region (Alama et al., 2015). To properly measure the success of an NNL/NPI target, a relevant biodiversity baseline must be established prior to the start of a project and any of its impacts. Baselines can consider a number of factors; the European Bank for Reconstruction and Development (EBRD), for example, requires that biodiversity and ecosystem baselines consider loss of habitat, degradation and fragmentation, invasive alien species, overexploitation, migratory corridors, hydrological changes, nutrient loading and pollution, and impacts relevant to climate change and adaptation (EBRD, 2014).

At this stage the biodiversity and ecosystem services are considered priorities from a conservation or community perspective should be identified. Once the baseline has been established and biodiversity priorities identified, the company—working with stakeholders—develops, implements, and monitors the progress of mitigation and compensation measures for priority biodiversity. This is measured against the baseline over the project's life cycle, to ensure that—at the very least—the project has an overall neutral impact on biodiversity, but in a best-case scenario, that biodiversity improves over time.

It is acknowledged that some biodiversity loss is inevitable with development projects such as mining; the nature of the sector guarantees that there will be some disturbance to the natural environment. Committing to NNL/NPI helps companies shift from intending to do less harm to biodiversity to doing overall good for biodiversity. For NPI to be achieved, it is recommended that a systematic approach to biodiversity management is taken, an approach that is normally referred to as the Mitigation Hierarchy (MH).

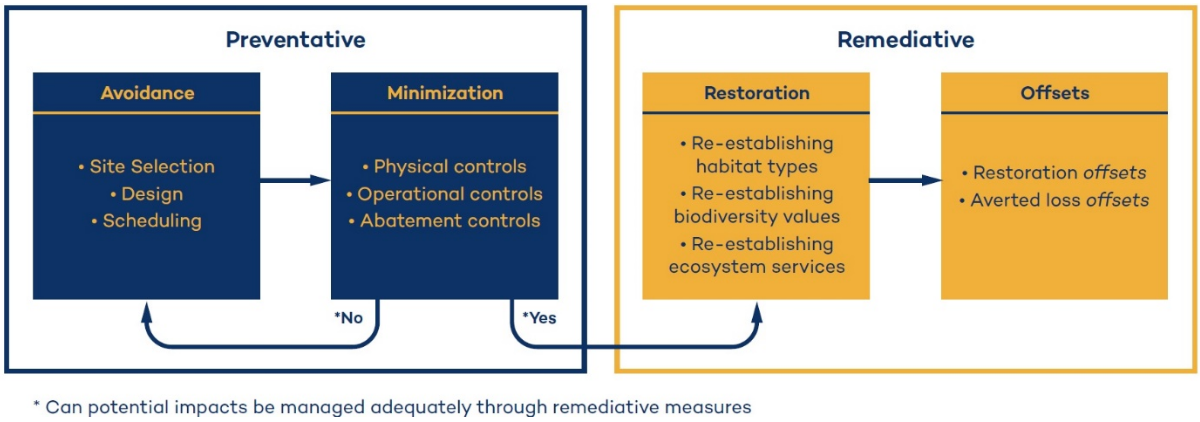
The Mitigation Hierarchy

The mining industry is increasingly using a framework known as the Mitigation Hierarchy (see Figure 8) to guide companies in reducing the negative impacts of operations on priority biodiversity. The focus here is on significant impacts: for example, something threatening, unusual or highly localized, of major economic or cultural value, or where the impacts severely reduce a species' viability.

The MH is an approach to mitigation planning, and is not a standard or goal in and of itself. It has been in use for several years, and is included in the EBRD's Performance Requirement 6 and the IFC's Performance Standard 6 on Biodiversity (see below). Application of the MH can help companies establish and maintain their social licence to operate, reduce their impacts and liabilities, and access funding, among other benefits. It is based on the iterative application throughout the project's life cycle of a series of four sequential steps (see, for example, IFC, 2006; EBRD, 2014; TBC, 2018). These steps are:

1. **Avoidance**: Selecting sites and designing projects that avoid impacts to areas with important biodiversity.
2. **Minimization**: Minimizing unavoidable impacts through micro-siting and operational controls.
3. **Rehabilitation/restoration**: Returning impacted areas to a natural state or to stakeholder-agreed land use.
4. **Offset**: Achieve no net loss or achieve gains for habitats and species that still face significant residual impacts.

Figure 8. The Mitigation Hierarchy



Source: TBC, 2015.

Avoidance and minimization activities are preventive, and typically cheaper, while rehabilitation, restoration, and offsets are focused on remediation, and are usually more costly. The former are preferable for a number of reasons: ecologically, financially, and socially. As such, it is recommended that companies—and governments—place more emphasis on avoidance and minimization activities, which will reduce the scale and cost of any offset actions that may eventually be required. Preventive measures typically occur primarily—though not exclusively—during the planning cycle, while remediation activities occur later in the project, including throughout operations (TBC, 2015).

More detailed descriptions of all four steps in the MH are found below.

1. **Avoidance**: The first step of the MH is comprised of measures taken to avoid the project having a negative impact on biodiversity from the outset. This can be done through site design and scheduling; while the mineral deposit lies where it is found, proponents can determine a) whether it is viable to develop, based in part on expected biodiversity impacts; and b) whether mine infrastructure can be designed and located, and activities timed, so as to avoid these biodiversity impacts. When choosing a site for project infrastructure, proponents should first undertake a landscape (or seascape) screening of biodiversity risks. With an improved understanding of these risks, the proponent can then design the site accordingly, including the infrastructure it requires, its placement, and its mode of operation. A company may, for example, design the placement of its access roads to avoid rare habitats or a key local species' breeding grounds. Scheduling can also help; certain project activities may be reduced or halted during a critical species' breeding or migratory season, for example, or during seasonal changes in the ecosystem.

- Avoidance is applied most rigorously to the highest-priority biodiversity. It is often the easiest and most effective way of reducing potential negative impacts, but it requires biodiversity to be considered from the design stage of a project onwards, and relies on robust baseline data to be effective. It can be expensive, but these costs are usually upfront, one-off, and typically less than those associated with later steps.

2. **Minimization**: The second step in the MH, minimization, involves those measures taken to reduce the duration, intensity, and/or extent of any impacts on biodiversity that cannot be

completely avoided, and—when effectively applied—can eliminate some negative impacts. Minimization can be used throughout the project life cycle, and can be a core part of ESIA requirements. All mining projects will have some unavoidable impacts on biodiversity; as such, it is recommended that companies get started on minimizing their impacts early in the project life cycle, and that—through risk management, adaptative management, and continuous monitoring—they constantly try to find ways to respond as more data becomes available and baseline conditions change over time (TBC, 2015). In Fiji, during the planning phase of an open-pit/underground mine, processing plant, and waste management facility for copper concentrate, it was found that the project could negatively affect endemic species of flora and fauna in an upland rainforest and cloud forest within the project's area of influence. Application of the MH led to the development of a biodiversity management plan, which included key minimization activities such as restricted access to mine access infrastructure; mine site design around key species to reduce impacts; and buffer zones established around waterways (TBC, 2018).

- There are three main types of minimization actions: physical controls, operational controls, and abatement controls. Physical controls adapt the design of project infrastructure to reduce potential impacts. Operational controls help to manage and regulate the actions of people involved in the project. Abatement controls are those steps taken to reduce the level of pollutants that could have negative impacts on biodiversity and ecosystem services (TBC, 2015). Minimization activities can also support local content policies for companies and governments, as many are labour intensive and can present an opportunity for local jobs and community involvement.

3. **Rehabilitation/restoration**: For those impacts that cannot be avoided or minimized any further, rehabilitation and restoration activities are taken on site to improve degraded ecosystems or re-establish lost ecosystems. There is an important distinction between the two: restoration has specific ecological goals, often aiming to return an area to a state similar to what the ecosystem was before the project activities started, whereas rehabilitation aims only to restore basic ecological functions and/or ecosystem services (e.g., through planting exotic trees to stabilize bare soil, or establishing a lake to provide a recreational facility). Rehabilitation and restoration are frequently needed towards the end of a project's life cycle, but may be possible in some areas during operation (e.g., through progressive rehabilitation, after temporary borrow pits have fulfilled their use). To increase the chance of restoration success and to decrease associated costs, restoration trials will need to be implemented from the early stages of the project onwards.

- Given that the pace of ecological recovery can be slow (restoring an old-growth forest, for example), it is at times hard for proponents to hit their restoration targets within project timescales; typically, these actions are most successful when they use well-tested techniques that have worked in similar contexts, are planned early in the project, and are piloted and implemented as soon as possible (TBC, 2015). Each of these considerations should be integrated into a mine's Environmental Management Plan. Realistic ecological, social, and financial goals should be, too: What is ecologically possible at the site? What is socially acceptable at the site?

What is financially realistic for the proponent? (TBC, 2015). Above all, these actions must work within the broader landscape and must have the buy-in of local communities.

Collectively, avoidance, minimization, and rehabilitation/restoration serve to reduce, as far as possible, the residual impacts that a project has on biodiversity and ecosystem services. Even after their effective application, however, one last additional step will likely be required to achieve NNL or NPI for biodiversity for the project: offsets.

4. **Offset**: These are measures taken off-site to compensate for any residual adverse impacts from mining operations after the previous three steps of the MH have been fully implemented on site. Offsets are almost always related to conservation interventions related to land, freshwater, or sea management, and while typically away from the site of the direct project impacts, they should still be located in areas that deliver benefits to affected communities. It should be noted once more that not all residual impacts can be offset, particularly if the affected area is unique and irreplaceable in terms of its biodiversity and ecosystems (World Bank, 2017). Useful guiding principles governments can consider for how offsets are designed and implemented in their jurisdiction include: equivalence (Is the offset a fair exchange for what is lost?); stakeholder engagement (Are the right stakeholders meaningfully involved in the offset program?); additionality (Will the offset provide real, tangible positive changes on the ground?); and longevity (Will the offset impacts last at least as long as the activity impacts?) (TBC, 2015).

- There are two main types of offsets: “restoration offsets” which aim to rehabilitate or restore degraded habitat, and “averted loss offsets” which aim to reduce or stop biodiversity loss (e.g., future habitat degradation) in areas where this is predicted. Both will have to be diligently monitored over time to ensure that they are having the desired impact. Offsets are often complex and expensive, so mining companies are advised to do all they can to avoid and minimize impacts early and throughout the mine life cycle, and to design restoration and rehabilitation activities that are effective, comprehensive, and—where possible—progressively throughout the mine’s life.

Box 10. Resources on Biodiversity, Mining, and the Mitigation Hierarchy

For further information on the Mitigation Hierarchy, please see the following resources:

Business and Biodiversity Offsets Programme. (2018). *Government planning for biodiversity net gain: A roadmap*. BBOP. https://www.forest-trends.org/wp-content/uploads/2018/11/BBOP-Business-Roadmap-1-11-18.pdf

Cross-Sector Biodiversity Initiative. (2017). *CSBI timeline tool: A tool for aligning timelines for project execution, biodiversity management and financing*. CSBI.

EBRD. (2014). *EBRD performance requirement 6: Biodiversity conservation and sustainable management of living natural resources*. https://www.ebrd.com/who-we-are/our-values/environmental-and-social-policy/performance-requirements.html

ICMM. (2006). *Good practice guidance for mining and biodiversity*. ICMM. https://www.icmm.com/website/publications/pdfs/biodiversity/good-practice-mining-and-biodiversity

IFC. (2012). *Performance standard 6: Biodiversity conservation and sustainable management of living natural resources*. International Finance Corporation. https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/performance-standards/ps6

MAC. (2015). *Towards sustainable mining: Biodiversity conservation management protocol*. https://mining.ca/wp-content/uploads/2019/02/Biodiversity-Conservation-Management-EN.pdf

Southern Africa Development Community (SADC). (2015). *Guidelines for mainstreaming biodiversity and ecosystem services in extractive industry*. Southern African Development Community. https://www.biopama.org/media/SADC%20Extractive%20Industry%20and%20Biodiversity%20Guidelines%20(EN).pdf

TBC. (2015). *A cross-sector guide for implementing the mitigation hierarchy.* http://www.csbi.org.uk/wp-content/uploads/2017/10/CSBI-Mitigation-Hierarchy-Guide.pdf

There are considerable benefits to adopting and using the MH in the mining sector. Ecologically, a company can protect and conserve biodiversity, maintain ecosystem services, and help sustainably manage living natural resources. This in turn reduces the risk of project activities undermining local livelihoods, human health, and the project itself. From an economic perspective, adherence to the MH can help companies reduce risks, costs, and delays, while also helping the company secure easier and less costly access to finance, land, and resources. From a regulatory standpoint, the MH has increasingly been adopted by multilateral and regional development banks, including the IFC, see below), the World Bank, and the EBRD, while governments are now also starting to integrate the MH into laws and directive (see, for example, Australia's Environment Protection and Biodiversity Conservation Act, and the European Union's Birds and Habitat Directive) (TBC, 2015). Finally, from a reputational standpoint, transparent and participatory efforts by companies to eliminate and compensate for biodiversity impacts represent an increasingly important part of establishing and maintaining the support of local communities and the government.

The Conservation Hierarchy

The Conservation Hierarchy (CH) presents a newer approach to biodiversity protection for governments that complements and builds upon the MH. In addition to using the MH, governments can also apply the Conservation Hierarchy to take a broader and more proactive approach to their conservation actions, setting their conservation targets within the four categories of the MH (Sinclair et al., 2019). For example, rather than simply working with mining companies to avoid the impacts of mining to a particular patch of forest, the government can work together with them on actively identifying areas for protected area expansion. Rather than simply trying to reduce pollutant runoff (minimize), governments can use the CH to collectively manage polluters to prevent habitat degradation (Sinclair et al., 2019). Working at the landscape level will help governments not only collectively manage the biodiversity impacts of all industry stakeholders, but will also aid them in meeting their international environmental commitments, including to the CBD and the SDGs (specifically SDG 14: Life Below Water and SDG 15: Life on Land). SDG 15 is particularly relevant, given that it calls on governments to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (UNDESA, 2015).

Key Standards

Many standards relating to biodiversity and ecosystem protection and conservation are linked to project financing from lending institutions and are increasingly converging around similar requirements.

IFC's Performance Standard 6

The IFC's Performance Standard 6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources (PS6) is a key international standard for the management of biodiversity and ecosystem services by the private sector (IFC, 2012c). The IFC, which is part of the World Bank Group, is a large source of multilateral private sector funding, and, as part of its lender requirements, it has developed eight performance standards for borrowers, covering a range of environmental and social impacts including labour, Indigenous people, resettlement, and cultural heritage. The objectives of PS6 are to protect and conserve important biodiversity and habitats, encourage the implementation of the MH, and promote sustainable management of living natural resources. PS6 represents international best practice for biodiversity management and has been widely adopted; for example, the Equator Principles Financial Institutions (which, as of April 2020, comprise 105 of the world's major finance institutions) all are signatory to applying PS6, and PS6 requirements feature in many leading government and corporate biodiversity mitigation policies. IFC clients must meet the requirements of PS6 while also complying with international and national laws.

By using the MH, governments can require companies to address a number of key threats across the landscape or seascape, including: habitat loss, degradation, and fragmentation; invasive species; overexploitation; hydrological changes; nutrient loading; and pollution. The basic targets for PS6 are a net gain for critical habitat (areas of the highest importance for biodiversity conservation) and no net loss for natural habitat (areas of natural ecosystems). Achieving these targets requires an assessment of the habitat at the beginning of the project and evaluating the presence of critical habitats.[2] Specific requirements are also in place for projects located in internationally recognized and legally protected areas.

In areas that have been defined as critical habitats, projects can still go ahead under PS6 if the following are demonstrated:

- No other viable alternatives exist.
- There are no measurable adverse impacts on the biodiversity values for which the critical habitat was designated.
- No net reduction in global, national or regional populations of Critically Endangered or Endangered species.
- Inclusion of a biodiversity monitoring and evaluation plan (BMEP) in developer's management plan.

When these criteria are met, the project's mitigation strategy will need to be described in a Biodiversity Action Plan (BAP). In order to demonstrate the NNL/NPI has been achieved, long-term monitoring and evaluation of the critical or natural habitat are required, and the approach should be detailed in the BMEP.

EBRD's Performance Requirement 6

EBRD's Performance Requirement 6 on Biodiversity Conservation and the Sustainable Management of Living Natural Resources (PR6) is one of 10 performance requirements, covering key environmental and social issues, that the bank requires the projects it finances to comply with. PR6 recognizes the importance of maintaining the core ecological functions of ecosystems and their biodiversity, and requires that projects protect and conserve biodiversity in part through the adoption of the MH (EBRD, 2014). As described above, this is grounded in risk and impact assessment, and the proponent characterizing baseline conditions and assessing the project's anticipated risks and impacts. How it will address these risks and impacts is then described in the project's overall environmental and social management system and project-specific ESMPs, including biodiversity management plans, or where appropriate, a specific BAP (EBRD, 2014). The management of risks through the application of the MH should happen across the project life cycle, which requires that proponents adopt adaptive management practices to ensure that what they are doing responds to changing conditions over time (EBRD, 2014).

Equator Principles

The Equator Principles (EPs) is a risk management framework designed to help financial institutions determine, assess, and manage environmental and social risks in projects (Equator Principles, 2020). 108 financial institutions in 38 countries have officially adopted the EPs, covering the majority of international project finance debt in developing and emerging markets (Equator Principles, 2020). In

[2] Critical habitats are areas with high biodiversity value, including (i) habitat of significant importance to critically endangered and/or endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes (IFC, 2012). Further guidance on how to proceed with a Critical Habitat Assessment, including how to define an area of analysis and assess biodiversity features against thresholds for qualifying as a critical habitat, can be found in the IFC's associated guidance note (see Further Resources box above).

adopting the principles, financial institutions must assess the potential environmental and social risks associated with a proposed project seeking financing—risks described in the ESIA and including those relating to biodiversity. This due diligence from financial institutions, and the ways in which the proponent plans to address and manage these risks and impacts through its ESMP, will in turn affect lending decisions. Financial institutions should also encourage their clients to share commercially non-sensitive, project-specific biodiversity data with the Global Biodiversity Information Facility, as well as relevant national and global data repositories (Equator Principles, 2020).

Other Standards

The multilateral and regional development banks—from EBRD to the Asian Infrastructure Investment Bank to the Inter-American Development Bank to the Asian Development Bank—have now largely adopted NNL/NPI principles, and the requirements are now globally adopted. In addition to the above, there are several other lenders who have performance standards that also provide a good benchmark. The World Bank's "Environmental and Social Standard 6" relates to biodiversity conservation and the sustainable management of living natural resources (World Bank, 2017). This standard follows a similar, but less detailed framework for biodiversity which encourages the use of the Mitigation Hierarchy and has an NNL target for Natural Habitat and an NPI target for Critical Habitat. The Inter-American Development Bank also has guidance for assessing and managing biodiversity impact and risks (Watkins et al., 2015), a detailed document that promotes the use of the Mitigation Hierarchy, and also outlines approaches relating to baseline studies, BAPs, and monitoring biodiversity.

On the industry side, ICMM published good practice guidance for mining and biodiversity for its members in 2006. The guidance was developed to help members achieve Principle 7 of ICMM's Sustainable Development Framework, in which they have committed to "contribute to the conservation of biodiversity and integrated approaches to land use planning" (ICMM, 2006). It focused on the integration of biodiversity considerations into: all phases of mining (project development, operations, and closure planning and implementation); into ESIAs and ESMPs; and into stakeholder consultation and engagement. Finally, it offers guidance on mitigation, rehabilitation, and offsets (ICMM, 2006). Biodiversity has also been integrated into the Mining Association of Canada's (MAC's) Towards Sustainable Mining program, with MAC offering both a protocol and framework for biodiversity conservation to its members, most recently updated in 2020 (MAC, 2015). The protocol outlines three indicators that have been established for MAC members to guide their actions with regards to biodiversity conservation. These are: establishment of a corporate commitment to biodiversity conservation, with accountability and communications; facility-level biodiversity conservation planning and implementation; and biodiversity conservation reporting (MAC, 2015).

Role of Government

Governments, when considering the merits of a proposed mining project, will have to weigh the economic and development needs of the country and the local community against its conservation and environmental goals. However, active collaboration on biodiversity management and protection among governments, companies, and local communities is increasingly seen as a win–win, for many of the reasons already mentioned. For governments specifically, working with mining companies to protect biodiversity and ecosystem services can help them achieve their commitments under multilateral environmental agreements, including SDGs 14 and 15, the Aichi Targets of the Convention of Biological Diversity, the Convention on Migratory Species, the Ramsar Convention on Wetlands, and the UN Framework Convention on Climate Change. In addition, biodiversity management activities can provide livelihood options for local communities, improve land-use planning, and can support both mitigation and adaptation to climate change.

The draft text of the post-2020 global biodiversity framework produced by the CBD has presented an ambitious global target for biodiversity of NNL by 2030 and NPI by 2050 (CBD 2020). These targets will almost certainly necessitate the adoption of new national-level legislation on biodiversity for many of the 196 Parties to the convention. As of 2019, more than 100 countries have developed—or are in the process of developing—policies for biodiversity offsets, 37 of which require biodiversity compensation as a prerequisite to project permitting, and 64 of which enable voluntary offsetting (GIBOP, 2019). A large majority of the global offsets legislation (85%) is embedded in national ESIA frameworks, though there is only a weak link to the Mitigation Hierarchy in much of this legislation (Global Inventory of Biodiversity Offset Policies [GIBOP], 2019). According to GIBOP, as of 2019 only 10 countries globally required a robust application of the Mitigation Hierarchy and guidance according to best practice principles.

This represents a major weakness in the current national legislative frameworks because, by focusing only on offsets and not the entire Mitigation Hierarchy, the cost for companies to comply with the regulation is likely to be higher, given that this last-step remediation option is typically far costlier than avoidance, minimization, rehabilitation, and restoration. This may discourage or delay investment, and, for those projects going ahead, the risk of a net loss of biodiversity is higher.

There is no one way to integrate biodiversity and ecosystem services considerations into legal and regulatory frameworks; each country has its own economic, social, environmental, legal, and institutional context, and there is no one-size-fits-all solution to balancing national and local development and conservation needs. There are, however, certain good practices that governments can follow as they move toward improving the protection of biodiversity and ecosystem services.

Policy Development: Develop and adopt a national policy on biodiversity

The MPF recommends that governments develop, adopt, and implement laws, policies and regulations to protect biodiversity and ecosystem services (IGF, 2013). The first step for a government aiming to improve biodiversity protection in the mining sector—and across all industries—is to set an explicit policy goal for biodiversity. This might mean stating that the government intends to move from cumulative loss of biodiversity to NNL to NPI by a set future date. The policy should also include a commitment to the entire Mitigation Hierarchy and not just offsets. When setting the national objective on biodiversity, it is important to be realistic; it is better to achieve a lesser but viable target in the short term than to commit to an ambitious but unrealistic goal (BBOP, 2018).

With a policy goal established, the government can move toward implementation. This might entail the development of a new policy on biodiversity or the improved integration of biodiversity considerations into existing sectoral policies (including mining) through the country's National Biodiversity Strategies and Action Plans under the CBD. Either way, the approach taken must be aligned with the country's development path and priorities as well as its international commitments (including the CBD and SDGs). The work on biodiversity policy should be consultative, involving relevant government departments and agencies, the private sector, and civil society, in order to ensure inclusivity and broad support.

Legal Frameworks: Integrate the mitigation hierarchy into national legislation and regulations

Once the biodiversity policy, policy modifications, or national action plans or strategies are in place, the government must work to complete the roadmap: developing, for example, the necessary laws, rules, regulations, and standards required to implement the policy; establishing the institutions required to carry out the policy; securing and allocating the resources needed to implement and enforce the policy; and developing the guidelines that spell out the policy and its regulations to relevant stakeholders.

Robust laws, regulations, and guidelines covering the entire Mitigation Hierarchy are essential for the implementation of biodiversity best practice relating to NNL/NPI targets. Governments must first review and, as appropriate, revise their legal frameworks to include the protection of biodiversity and ecosystem services. National legislation needs to be clear on the scope, permitting requirements, and processes to be followed and the objectives that need to be met. Legislation or guidance that is not consistent across different sectors, and could give rise to conflict, should be aligned (SADC, 2015).

Some key considerations for the integration of biodiversity in national legal frameworks, as aligned with the MPF, include:

- Requirement that proponents conduct a systematic review with affected communities to identify priority ecosystem services (for both the operations and for affected stakeholders), and take into account the differing values assigned to biodiversity and ecosystem services by affected communities and other stakeholders where appropriate.
- Provide guidance on acceptable metrics for measuring biodiversity loss and gain.
- Require that mining entities identify potential and actual risks and impacts to biodiversity before, during, and after mining, as part of the ESIA process and based on national standards and the conditions of the operating permit.
- Explore opportunities for integrating biodiversity management plans, biodiversity monitoring and evaluation plans, and BAPs into ESMPs, and that these are updated whenever there are significant process or operational changes during the operating life of the mine, and that they compile and submit performance assessments to government and publish regular reports that are readily accessible to the public.
- Clarity on no-go scenarios, locations, and situations in which negative biodiversity impacts are not permitted in the most sensitive areas, including protected areas, UNESCO World Heritage Sites (Natural and Mixed), and Alliance for Zero Extinction sites; and
- Develop and distribute guidance on the set of activities that can deliver the secure and additional long-term gains needed to offset any residual impacts, the exchange rules outlining

which types of impacts on biodiversity can be offset by which type of gains (for example, like for like or better), and the areas suitable for offsets (and those to be avoided).

As noted above, the Mitigation Hierarchy can usefully be integrated as a risk assessment and management tool in the ESIA process or regulations and into ESMPs. By integrating the MH into the ESIA process, governments can help ensure that biodiversity considerations are included in the permitting and licensing system for major projects involving significant land-use decisions, including mining projects. As part of the screening or scoping phase of the project, and prior to the ESIA, the MH can be used to assess the magnitude of biodiversity and ecosystem services risks: for example, the feasibility of mitigating impacts at the site, or whether the site can be restored (CSBI, 2015). During the ESIA process, the MH can serve as the principal organizing framework for biodiversity and ecosystem services considerations within the process, guiding associated planning and communications. Finally, once the ESIA has been submitted and construction and operations are underway at the mine site, the MH can be used as an adaptive management framework for practitioners, an audit tool for regulators and financial institutions, and a tool for offset design (CSBI, 2015). Governments will have to set and communicate approval conditions for the biodiversity components of ESIAs and ESMPs.

Box 11. Case Study: Ecuador – Community access to clean water and biodiversity conservation is enshrined in the constitution

The 2008 Constitution of the Republic of Ecuador, as amended at the Referendum of February 4, 2018, states that basic principles of the State include, “Planning national development, eliminating poverty, and promoting sustainable development and the equitable redistribution of resources and wealth to enable the realization of good living” (Art. 3(5)). The literal term for “good living” is “*sumak kawsay,”* an Indigenous term that refers to living in harmony with community and the environment (Berros, 2015).

The constitution assures that, in order to protect and manage biodiversity and the natural environment, “[t]he State shall establish and implement programs with the participation of the community to ensure the conservation and sustainable use of biodiversity” (Article 57(8)). In particular, the constitution aims to protect “the biodiversity of the Amazon ecosystem,” requiring the central government and decentralized governments to adopt sustainable development practices (Article 259).

The constitution further aims “to foster participation and social monitoring, acknowledging the diverse identities and promoting their equitable representation, at all stages of governance,” and “to restore and conserve nature and maintain a healthy and sustainable environment ensuring for persons and communities equitable, permanent and quality access to water, air and land, and to the benefits of natural resources and natural assets” (Article 315).

Institutional Arrangements: Establish and maintain adequate institutions for biodiversity protection

Governments must also ensure that the institutional arrangements required to implement and enforce its policies and regulations on biodiversity protection are in place to ensure strong and transparent governance of MH-related activities. Assigning a lead department or agency, or task force within that department or agency, will help ensure that there is ownership for the policy's implementation, and that there is a clear structure in place for communication, monitoring, evaluation, and adaptive management. Building and maintaining high-level, cross-ministerial support for the policy will be important for its successful implementation, recognizing that this can be difficult to achieve given the competing priorities across ministries.

One early task for such a group will be to establish a coordination mechanism for different relevant branches of government, and to review relevant ministerial policies on biodiversity to ensure that it can identify and remove any contradicting policy signals coming from the government. This could include integrating biodiversity considerations—and NNL or NPI objectives—into land- and sea-use planning; clarifying which institutions will play a role in the generation and communication of environmental data and information; assigning roles in the review of biodiversity assessments and management plans; and assessing how individual projects and their cumulative progress are helping the government achieve its overall biodiversity goals. While coordination is required across ministries, departments, and agencies, the lead agency must also define and communicate the role of subnational and local levels of government in the delivery of national biodiversity targets. The government must also clearly outline who is responsible for enforcement, and ensure that the institutional arrangements are in place to follow up on any breaches or non-compliance.

Guidelines: Establish clear guidelines on biodiversity offsets

The government will have to ensure that clear, consistent guidance is developed for the use of biodiversity offsets, that it is available to potential buyers and sellers, and that these stakeholders are connected. These guidelines should be developed in consultation with mining companies, but also with conservation organizations to ensure that they result in meaningful, effective offsets. For situations in which larger offsets are required, governments can consider making allowances for larger, aggregated offsets with multiple mine developers in a mining district or establishing new reserves or protected areas in the portion of a large mining concession not needed for mining. Governments will need to provide mechanisms for big offset options for mining if they are to meet their biodiversity conservation and protection goals.

Collaboration: Establish mechanisms and requirements for information sharing and reporting

Companies and local communities will need reliable, timely, and robust data, maps, and information on local development and local biodiversity and ecosystem services to establish baselines and metrics, and design effective and realistic biodiversity and ecosystem management systems for their mine plans. The government, working with communities and civil society, should establish mechanisms that allow them to provide this information in an open and accessible way, and in a standardized format easily understood and used by stakeholders. This information can then form the basis for landscape-level planning, baselines, and metrics to calculate the impacts of the mining operation and the potential gains associated with the mining company's biodiversity and ecosystem conservation activities. One existing external source of such information is the Global Biodiversity Information Facility, which is an international network and research infrastructure that aims to provide open access to data about all types of life on the planet. Once provided, the information should be regularly updated to reflect changing ecological conditions and—hopefully—the positive results of the company's conservation activities at the project and landscape levels.

Once the mine's conservation activities are developed and planned with inputs from all stakeholders, but before they are underway, proponents should be obliged to publicly disclose how they were developed, and their progress on the implementation of these measures with indicators (originally outlined in the monitoring plans). The same transparency should be required of offset providers and managers; they should also publicly disclose how offsets are designed and how they are being implemented. This will allow the public, and particularly the affected local community, to monitor progress over time, and for the government to assess broader progress toward its biodiversity policy goals.

Enforcement: Allocate adequate funding to support implementation and enforcement

Finally, adequate resources will need to be allocated to the protection and strengthening of biodiversity and ecosystems. This includes funding to cover the monitoring and enforcement of the biodiversity components of the legal framework for mining, including those activities that take place after mine closure; the government must require that sufficient financial assurance is in place for long-term risks to ecosystem restoration success, and that sustainable financing is in place if needed to meet the long-term requirements of NNL and NPI.

Governments can also consider engaging independent panels of experts or review boards for those complex projects with significant impacts on biodiversity. This could include formal review boards like the Mackenzie Valley Review Board, which was established to conduct fair and timely environmental impact assessments in the Mackenzie Valley of the Northwest Territories in Canada. It can also include more project- or topic-specific panels, such as the one set up by the International Union for Conservation of Nature (IUCN) to provide objective guidance on the environmental and socioeconomic restoration efforts that are underway in the Rio Doce watershed in Brazil, following the Fundão tailings dam breach at the Samarco mine in 2015 (IUCN, 2017).

Beyond the mining sector specifically, this includes not only sufficient funding for a country's protected areas, but also ensuring that relevant government staff have the time, skills, and resources needed to work on the implementation of the country's biodiversity policy and enforcement of its regulations. This will require adequate training for staff in biodiversity and ecosystem services impacts, in the concepts of NNL and NPI, and in the application of the Mitigation Hierarchy. Government staff will also have to be capacitated to review and approve ESIA and biodiversity management plans.

Capacities must extend beyond government staff to independent external experts with strong regional experience; these individuals can assist in the development of a mitigation hierarchy for a proposed project (SADC, 2015). Local knowledge is important here; identifying the beneficiaries of ecosystem services requires sociological and anthropological expertise and stakeholder consultation. These independent experts can also assist in the preparation of conservation plans, baseline studies, impact assessments, loss–gain calculations, and the design of feasible offset activities and management plans (BBOP, 2018). Domestic capacities should also be built for offset providers and brokers to generate and maintain long-term gains in biodiversity and ecosystem services.

Chapter 4: Mine Waste Management

Overview

Mining typically moves and processes large amounts of materials to extract the target commodity. The excess, non-marketable material is known as mine waste. Mine wastes typically have some mineralization that may be reactive or that could be released from the rock when it is mined, crushed, and exposed to air and water. As a result of having large amounts of waste material coming out of their operations, mining companies need to spend a lot of time and energy on managing these wastes effectively.

Given the potentially significant impact that poorly managed mine waste can have on operations, communities, and ecosystems, governments have a central role to play in ensuring that these by-products of the mining sector are managed in an effective way. According to the MPF, to achieve this governments need to:

- Ensure that structures such as waste dumps and tailing storage facilities are planned, designed, and operated such that geotechnical risks and environmental impacts are appropriately assessed and managed throughout the entire mine life cycle and after mine closure.
- Require that mining entities design, operate, and maintain mine waste structures according to internationally recognized standards.
- Require that mining entities commission independent expert reviews and report to governments prior to development approval, when changes in design are proposed, and at regular intervals during the operating phase.

This chapter provides an overview of critical mine waste management issues and applicable international standards and best practices. It then provides more detailed guidance on the role of government in supporting sound mine waste management. Mine waste in this chapter includes waste rock, tailings, spent leach pads, mine water treatment sludges, and dust. For the purposes of this report, mine waste does not include general industrial and municipal wastes such as hazardous materials, non-hazardous materials, recyclables, hydrocarbons, sewage, and putrescible wastes. There is already guidance in place for governance of these general wastes, and controls for these wastes are typically integrated into permit conditions.

The overall objective of mine waste management is to ensure the long-term physical and chemical stability of all mine waste management facilities. This objective supports the UN SDGs in that stable mine waste facilities will protect water resources, life below water, and life on land, while still supporting the mining needed in many areas for local economic prosperity.

As with many aspects of environmental management in mining, waste management should follow a risk-based framework to determine priorities. Waste management in mining is complex and incorporates a range of disciplines, including geology, geochemistry, hydrology, hydrogeology, civil engineering, and geotechnical engineering. In addition, engineered facilities need to incorporate site-specific design criteria for seismic conditions, for local climate, and to accommodate climate change scenarios. It is important for governments to have an overall understanding of the potential issues and what affects them and to obtain expert advice and assistance where and as needed for effective control and governance through all mine phases. This includes once mining has finished and the mine has been closed, when responsibility for long-term management of facilities reverts to government. For example, a national seismic risk map should be used as a guide for foundation design and slope stability, but detailed assessment and modelling are required using the dam design and specific bedrock and hydraulic conditions. Similarly, climatic conditions and the impact of climate change on engineered structures and their systems are required in consideration of various operating and post-mining transition and closure conditions.

In this chapter you will learn why it is important to:

1. Set clear standards and codes for good mine waste management.
2. Set quality standards for tailings dam stability and establish requirements for independent tailings review panels.
3. Review mine waste management designs, risk assessments, and plans prior to project approvals and permitting.
4. Consider financial guarantees to manage facility risk.
5. Allocate financial and human resources for timely and effective reviews of monitoring data.
6. Enforce compliance with mine permits.

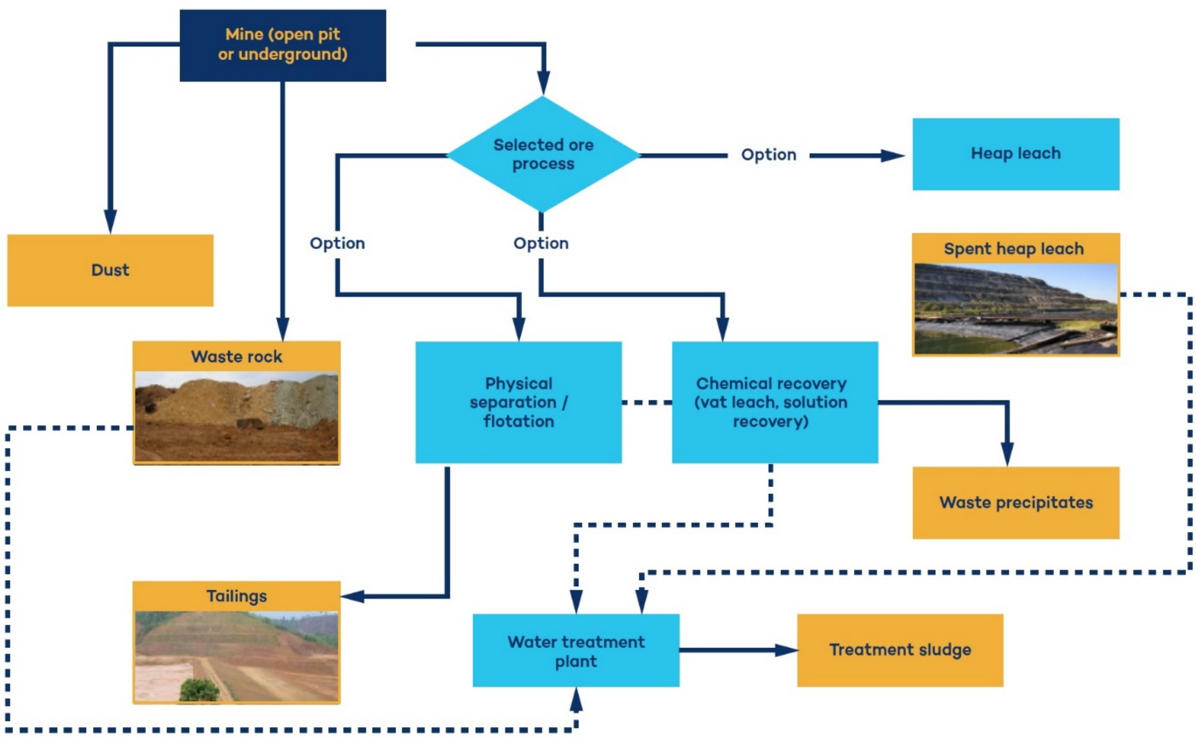
Key Issues

Typically, the extraction of mineral-bearing ore requires the mine operator to first remove low-grade waste rock surrounding the ore body. The ore is then processed to recover the economic minerals.

An exception is *in situ* leaching or solution mining where solutions are pumped into an orebody that break down the economic minerals into solution, which are then extracted in liquid form and further processed (e.g., some gold, copper, and uranium mining). Managing these waste materials safely and effectively will be critical to ensuring the safety of staff, of the surrounding communities, of the broader ecosystem, and of the continuing operation.

Mine wastes comprise a major proportion of the total material managed in mining—typically much larger by volume than the ore. The strip ratio defines how much waste rock there is compared to ore and can range from less than one-part waste to one-part ore to more than 10 parts waste to one-part ore. From 1 tonne of ore, the amount of economic mineral is recorded in grams per tonne for precious metals or in small percentages for other ores, leaving the remaining waste rock to be managed and stored. In addition, as the rock is blasted and removed from the ground, it becomes bulkier (less dense) than when it was intact in the ground, which is often termed as the "swell factor." Figure 9 illustrates the sources of mine waste from mine operations, each of which is discussed below.

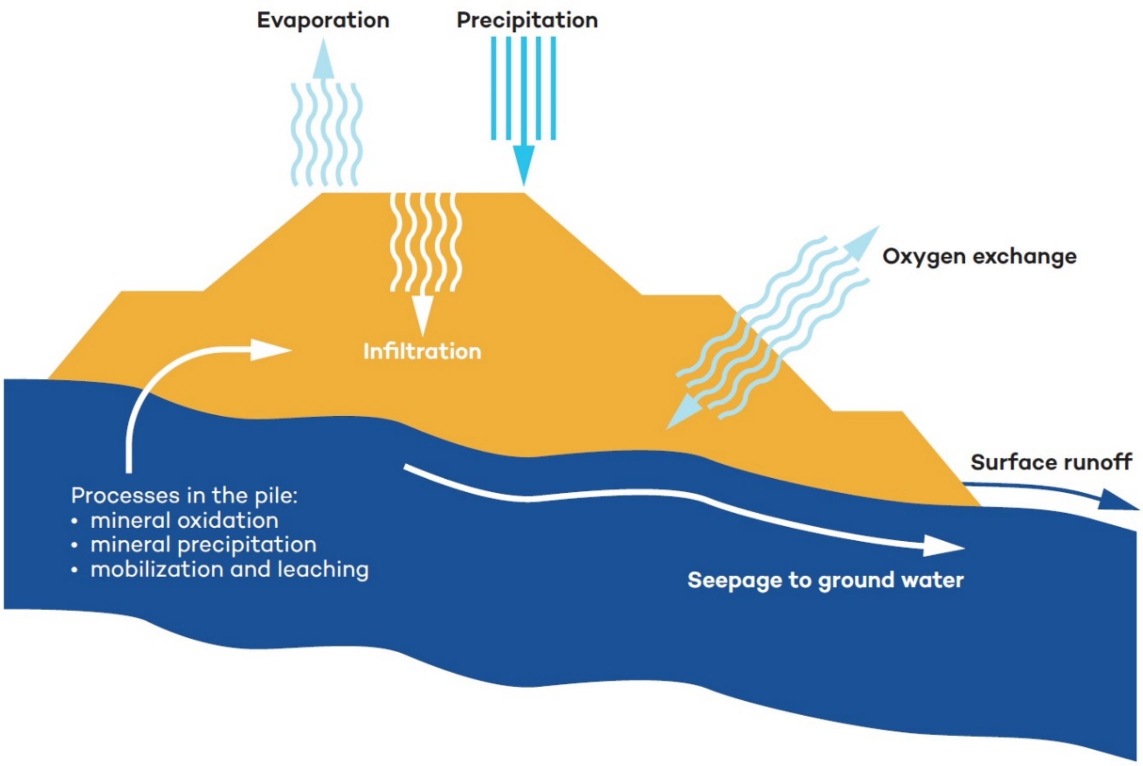
Figure 9. Sources of mine wastes from the main mine components



Waste Rock

Waste rock storage facilities, leach pads, and tailings storage facilities are large structures that must be carefully engineered to ensure they are geotechnically stable in the long term. These structures must be designed to be physically stable to ensure the safety of workers and the public given characteristics of the stored material, and the climatic, geotechnical foundations, and seismic characteristics of the mine site. The design must also account for how these factors might change over time. The chemical stability of these facilities is also critical since they can be the source of long-term pollutants leaching into the receiving environment. For example, waste rock can be the source of acid generation and/or metal leaching for centuries if not stored correctly. Special considerations will be required for radioactive mine wastes from uranium and rare earth mining, due to the inclusion of uranium and thorium in the waste rock. Conversely, in some deposits, some waste rock does not contain harmful minerals, is considered "clean," and can be used for construction. For example, the uranium mining company Cameco uses clean waste rock as aggregate for maintaining site roads and in concrete mixtures at most of its mines (Cameco, 2016). Many mines, including the Kumtor gold mine in Kyrgyzstan, use their clean waste rock for downstream tailings dam and buttress construction. Figure 10 illustrates the geochemical and hydrometeorological processes in a typical waste rock facility.

Figure 10. Waste rock storage facility processes

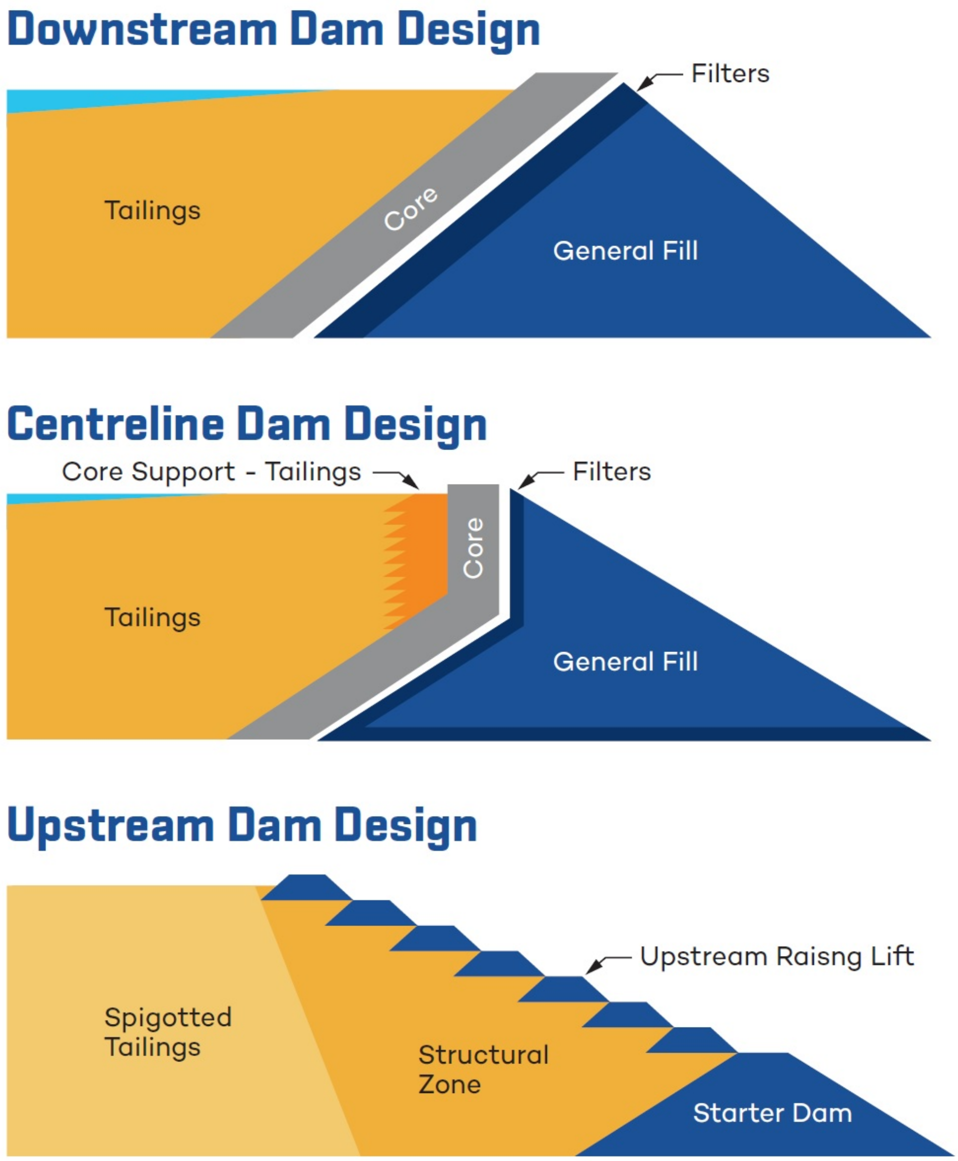


Source: Adapted from Garbarino et al., 2018.

Tailings Management

Tailings are a residual material from mineral processing, and can include fine material such as sand, silt, and clay-sized materials. A process flowsheet, developed to recover the minerals for a specific mine, is needed to determine the types of tailings that will be produced and managed by the mine. Tailings will vary depending on site-specific conditions, as will the optimal tailings facility designs. They can be chemically benign, potentially acid generating, and/or metal leaching. They are typically in a slurry form at the end of mineral processing, at which point they can then be dried, thickened, or left in slurry form. Once ready, they may be stored on site in water-retaining dammed facilities, dry stacked, in open pits, backfilled underground, or occasionally disposed of in lakes or the ocean. Tailings storage needs to be carefully planned, designed, and managed to ensure that the foundations and dam slopes are geotechnically stable, that any dams will remain in perpetuity, and that the tailings are chemically stable for the long term. Liquefaction of the tailings dam during a potential dam breach is a critical risk, and must be considered in the design, construction, operation, and maintenance of the tailings impoundment; the same is true of how the dam withstands potential flooding events. Figure 11 illustrates three approaches to conventional tailings dam design (downstream, centreline, and upstream). The upstream configuration uses the least fill material, is a higher-risk design, and—considering the recent Brumadinho tailings dam failure—is no longer a permittable design in some jurisdictions, including Brazil (National Mining Agency of Brazil [ANM], 2019).

Figure 11. Tailings dam design types



Source: McLeod & Bjelkevik, 2017.

Spent Heap Leach Closure

Heap leach facilities recover metals through leaching: running a dissolving solution through the heaped pile of ore. The dissolving solution will differ according to the ore: a cyanide solution is used to recover gold and precious metals, for example, and a sulphuric acid solution is used to recover copper, nickel, and uranium. Once the available metals are recovered, the leach pad must be rinsed during decommissioning to remove residual cyanide or acid to levels that are not harmful in the long-term. Heap rinsing can take considerable time and must be accounted for in closure planning.

A key design feature of heap leach facilities is the foundation liner and leachate collection system, which protects the surrounding ecosystem and water sources from contamination. The liner system is a feature in the waste management design that is linked to water management, illustrating the importance of an integrated approach to mine waste and water management and governance.

Precipitates From Water Treatment and Chemical Recovery Processes

Mine water treatment and chemical recovery processes also produce residual wastes such as metal sludges that need to be managed in a manner that ensures the long-term stability of wastes and prevents future mobilization of contaminants. Generally, there are only small quantities of residuals; however, prediction of future potential volumes and disposal plans need to be made, especially if the closure plan includes water treatment in perpetuity.

Dust

Dust can be generated from blasting, waste rock, tailings, and heap leach piles, as well as mine site roads and cleared areas. As a result, the dust may contain constituents from the mined materials that are potentially harmful to humans (through respiratory diseases, for example), plants, and wildlife. These dusts can also contain sulphides or metals that can leach out and impact the surface water or groundwater. Dust minimization is best achieved through inclusion of dust containment structures at ore transport and transfer points in project design (e.g., baghouses), progressive reclamation to minimize exposed materials, and dust-suppression measures including the use of watering or non-toxic dust-suppression chemicals.

International Standards and Best Practices

Many international standards and best practice guidelines are available for governments to draw from when designing their requirements for mine waste management. As outlined below, most of these standards and best practices are technical in nature and share the underlying goal of managing mine wastes to prevent pollution in the long term.

IFC Performance Standards and Environmental, Health, and Safety Guidelines

The IFC Environmental and Social Performance Standards provide guidance on waste management in Performance Standard 3: Resource Efficiency and Pollution Prevention. The requirement is to minimize the waste generated during mining and to dispose of the waste that is generated in a manner that does not harm people or the environment (IFC, 2012).

The IFC's Environmental Health and Safety Guidelines for Mining also provide recommendations on how mines should manage waste rock, tailings, and leach pad waste (IFC, 2007a). The guidelines require the geochemical characterization of ore and waste, and the development of appropriate segregation and storage plans to minimize the threats of acid rock drainage and metal leaching.

Geochemical Characterization of Mine Wastes

Geochemical characterization of all mine wastes prior to construction and ongoing through operations is best practice. This type of analysis provides an understanding of the geochemical characteristics of all materials that will be mined and processed, allowing for a more accurate prediction of how the materials will perform in the conditions where they are stored (i.e., taking into consideration climate, any material blending, water covers, and air circulation). The GARD guide provides international best practices for sampling, analyzing, and predicting acid generation, and determining metal leaching potential of mine waste materials (INAP, 2014).

Mine Waste Planning and Design

The Mine Environment Neutral Drainage program has supported extensive research and provided guidance on mine waste management, from prediction through prevention and controls, treatment, and monitoring. It also publishes research on the newest innovations and technologies in mine waste management.

The European Commission's *Best Available Techniques Reference Document for the Management of Waste from Extractive Industries* and the guidance on *Extractive Waste Management Plans: Circular Economy Action* both provide best practice guidance on how to characterize materials and plan mine material management from exploration through design and closure (Garbarino et al., 2018; Eco Efficiency Consulting and Engineering Ltd., 2019).

Tailings Management

Tailings dams have been given special attention in setting standards for mine waste management. Many tailings dams have failed over the years, with a range of consequences, and tailings dams are typically one of the highest-risk facilities on a mine site. As a result, tailings management and standards have developed and strengthened over time.

The Global Industry Standard on Tailings Management by ICMM, UNEP, and PRI was released in August 2020. The latest standards present clear principles and requirements for strict controls in tailings management and address six key areas: knowledge base; affected communities; design, construction, operations, and monitoring; management and governance; emergency response and long-term recovery; and public disclosure and access to information. A requirement for an independent tailings review board is becoming a new international standard. This provides for a multidisciplinary team of experts to further check the design, construction, operation, and closure of each tailings facility.

In addition, a new World Declaration on Dam Safety was published in 2019 that outlines the key principles and requirements for dam safety – including tailings dams (ICOLD, 2019). The member countries of the International Commission on Large Dams, or ICOLD, (101 by the end of 2019) were consulted on the Declaration. The Declaration is discussed further in the section on the role of government.

Several other tailings dam guidelines have been published across key mining jurisdictions. The following are some key examples:

- Australian National Committee on Large Dams. (2012). *Guidelines on tailings dams, planning, design, construction, operation, and closure.*
- Canadian Dam Association. (2007). *Dam safety guidelines.*
- ICOLD. (2020). *Bulletin 181 on tailings dam design – Technology update.*
- Mining Association of Canada's Towards Sustainable Mining: (2019a). *A guide to the management of tailings facilities; (2019b). Tailings management protocol*; (2019c). *Developing an operation, maintenance and surveillance manual for tailings and water management facilities (2019).*

Role of Government

Given the key issues related to mine waste presented above, and the international standards and best practices that are being used across the sector, there are key actions that governments should take to ensure the effective and safe management of mine waste. The key actions are broadly aligned with the MPF and are presented in a sequence related to policy development and the mine life cycle. Specifically, governments should:

1. Prior to mine permitting, develop mine waste management standards.
2. Prior to mine permitting, set specific standards for tailings dams.
3. Through the ESIA review and mine permitting process, review and approve the mine waste management plans.
4. Through the ESIA review and mine permitting process, require financial sureties for waste management facilities to manage government risks if the mining company cannot meet its obligations.
5. During construction, operation, and closure, monitor and evaluate mine waste management performance.
6. During construction, operation, and closure, enforce compliance to protect land and water resources, as well as worker and community safety.

Mine Waste Management Standards: Set clear standards and codes for good mine waste management

Standards for mine waste management should be set clearly by governments in their legal framework. In many jurisdictions, legislation has been developed and revised as a result of mine waste facility failures. For example, the European Union's Mine Waste Directive 2006/21/EC was developed recognizing dam and heap failures at Aberfan (UK, 1966), and Stava (Italy, 1985), and as a result of dam failures near Aznalcōllar (Spain, 1998), and at Baia More and Baia Borsa (Romania, 2000).[3] British Columbia, Canada now has the most comprehensive regulations for tailings storage facilities in the world as a result of the Mount Polley tailings dam failure in 2014.

Based on various legal frameworks and industry experience, mine waste management standards should consider covering the following:

- Overarching objectives of sound mine waste management
- Any unacceptable or banned mine waste designs or management practices
- Requirements for third-party and independent reviews of designs and plans
- Required analyses to manage risk, such as:
    - Alternatives analysis
    - Slope stability
    - Waste characterization
    - Foundation studies
    - Groundwater and seepage analysis
    - Failure modes effects analysis
    - Dam breach and inundation analysis
- Engineered designs, including specified design criteria
- Management and monitoring plan requirements, such as:
    - Construction quality assurance and quality control plan
    - Waste segregation plan
    - Operation and surveillance plan
    - Reclamation and closure plan
    - Community emergency response plan
- Closure plans

In addition, governments should set mandatory standards for minimum design criteria such as slopes, factors of safety, hydrometeorological events, and seismic events within development or mining policy and in mining legislation. Legal standards for mine waste facilities should be set, taking into consideration local conditions, such as existing facilities, meteorological conditions, engineering capacity, and emergency response capacity in the country within regulations or legislated guidelines.

Jurisdictions where uranium and rare earth deposits occur typically have additional legislation specific to these mines. Residual wastes from uranium and rare earth mining contain radioactive material, which requires additional controls such as ventilation, respirators, gamma radiation monitors, and material-specific training. Therefore, worker and public health and safety must be considered in the characterization of the waste, as well as the design, operation, and closure of waste storage facilities. For example, a process-hazard analysis is a required component for uranium mining in Canada (Government of Canada, 2000). Process-hazard analysis is typically required by safety authorities "for any industrial process that makes use of hazardous chemicals. It identifies and analyzes data to provide information that will assist employers and employees in making decisions

[3] European Commission. (n.d.). *Extractive waste*. https://ec.europa.eu/environment/waste/mining/index.htm.

for improving safety and reducing the consequences of unwanted or unplanned releases of hazardous chemicals” (Occupational Health and Safety Academy Training, n.d.).

Mine waste management legislation may overlap with other pieces of legislation such as those governing contaminated sites, air quality, and hazardous materials. It is important to ensure that legislation is consistent and aligned, and guidance materials should be published to provide clarity for any overlaps.

Case study: Sullivan mine and lessons learned from a reactive waste rock facility

The Sullivan mine is a closed lead, zinc, and silver underground mine in British Columbia, western Canada that closed in 2001. The waste rock facility contained an estimated one million cubic metres of acid-generating rock. Acidic runoff from the waste rock pile was collected from a toe drain at the facility and treated with lime. The chemical oxidation of sulphides in the waste rock consumes oxygen, resulting in anoxic conditions within the toe drain. Tragically, four fatalities occurred in 2006 as a result of anoxic conditions in the confined sampling housing at the toe drain. Investigations arising from the facilities led to a greater understanding of airflow patterns within chemically reactive waste rock dumps. With daily temperature variations outside the dump, and heat-generating chemical reactions in the dump, large air flows result through the entire dump. The airflows continue to replenish the sulphides with oxygen resulting in continued chemical reactions and production of acid mine drainage.

This case study illustrates the importance of investigative testing and modelling to predict the physical and chemical behaviour of waste rock facilities. It is important that this information is used to improve waste rock facility design (Sullivan Mine Incident Technical Panel, 2010). To assist companies and mines in conducting risk assessments specifically for this type of risk, the British Columbia Workers’ Compensation Board, with WorkSafe BC and the Workers’ Compensation Board of Nova Scotia, funded the development of an atmospheric conditions risk assessment tool for companies in 2011.

Tailings Dam Requirements: Set quality standards for tailings dam stability, and establish requirements for independent tailings review boards

A government’s legal framework on mine waste management should include standards for tailings dams design, construction, and management that are consistent with international standards and best practices. For consistency with current international best practice, an independent tailings review board should be legally required to periodically review the design, construction, operation, and closure of high-risk tailings storage facilities. High-risk tailings storage facilities include, but may not be limited to, facilities with a large dam which is defined by ICOLD as greater than 15 metres or a dam between 5 metres and 15 metres impounding more than 3 million cubic metres of material.[4]

The over-riding objectives in legislation regarding tailings dam stability should be ensuring the long-term physical and chemical stability of the tailings dam. The legal framework should also include:

[4] ICOLD definition of a large dam, https://www.icold-cigb.org/GB/dams/definition_of_a_large_dam.asp

- Requirements for the design and study details, including emergency response and closure plans, to be included and reviewed by government and stakeholders in the ESIA
- Inclusion of community engagement in the development of tailings management plans and emergency response planning and implementation
- Engineer and proponent responsibilities defined for the life of the facility
- Monitoring and reporting requirements during construction and operation
- Inspection requirements by government and independent experts
- Closure and long-term post-closure monitoring and reporting requirements.

Tailings facility design depends on the geophysical and geochemical properties of the tailings, and the meteorological, hydrological, physiographic, social, and environmental context. Extensive testing on the tailings and surficial geology of the foundation conditions are needed, combined with designs by experienced geotechnical engineers. A comprehensive alternatives assessment is usually completed for tailings facilities to assess alternative technologies, locations, and designs. A risk-based analysis, such as a Failures Modes Effects Analysis, is also usually completed for a comprehensive design.

Example: Standards Resulting from the Mount Polley Tailings Dam Failure

The Mount Polley tailings dam failed on August 4, 2014, in British Columbia, Canada releasing millions of cubic metres of tailings and water to downstream Polley Lake, Hazeltine Creek, and Quesnel Lake. Several standards were written into the Health, Safety and Reclamation Code of British Columbia[5] as a result of the Independent Review Panel Report[6]. Some key changes to the code included the following:

- An independent tailings review board and an engineer of record must be designated for all tailings facilities.
- The Mine Manager is responsible for the safety of all tailings facilities on the site and for designating a Qualified Person for the tailings storage facility.
- Physical stability is included in the code as the primary objective, all available technologies (such as dry-capped tailings) should be considered in the designing phase, and water should be removed from tailings. The alternatives assessment needs to include environmental, societal, and economic considerations in addition to technical considerations.
- Risk assessments and a breach and inundation study must be completed for proposed tailings storage facilities.

[5] BC Ministry of Energy and Mines (2017).
[6] Independent Expert Engineering Investigation and Review Panel (2015).

Mine Waste Management Plans: Review mine waste management designs and plans prior to project approvals and permitting

Mine waste management facility designs and plans should be scoped into and defined in the terms of reference in the ESIA review phase for a proposed mine development. The level of design required to be presented for review in the ESIA should be commensurate with the level of risk for the proposed facilities, with engineered designs required to be submitted for the environmental assessment and for permitting. In general, a pre-feasibility-level design should be expected for the ESIA and feasibility-level design for permits.

The ESIA legal framework should include stakeholder consultation. Stakeholder consultation is imperative if the mine plan includes any high-risk mine waste storage facilities that have the potential to directly impact communities or to impact any water and land resources used by the community. Community members downstream of any mine waste storage facilities must be involved in the development of community emergency response plans.

Detailed engineering designs for high-risk structures should be required to be submitted to the mining and environmental authorities and inspectors in advance of construction and with enough time for the relevant authorities and inspectors (or their designated technical expert) to review and approve plans prior to construction. Designs should also be required to be submitted for review and approval prior to any significant new phases to be constructed and prior to any significant changes in the facility. Design changes may require permit amendments. And a new ESIA review process may be triggered if the facility design changes would alter the footprint, waste and water management plans to a point where there are potentially significant new impacts.

The legal framework should require that all engineered designs be signed off by qualified and competent professional engineers, and legislation should be in place to register and ensure the competencies of these professional engineers. Alternatively, the legal framework should define the competencies and acceptable professional engineer qualifications, responsibilities, and obligations for mine facility designs.

The Mining Act of the Philippines, for example, requires every contractor to undertake an environmental protection and enhancement program covering the period of the mineral agreement or permit (Section 69). This program must be incorporated into the work program the contractor or permittee submits when applying for a mineral agreement or permit. The work program must include not only plans relative to mining operations but also to “rehabilitation, regeneration, revegetation and reforestation of mineralized areas, slope stabilization of mined-out and tailings covered areas, aquaculture, watershed development and water conservation; and socioeconomic development” (Mining Act, Section 69).

Box 12. New Technologies: Assess research and evidence prior to accepting new technologies

New technologies are needed to address the long-standing challenges of physical stability, acid mine drainage, and metal leaching of mine waste storage. Considerable research has been completed and continues to be needed to better minimize the long-term risks of mine wastes. The International Network for Acid Prevention[7] is a global alliance of groups conducting this research and sharing knowledge for better mine waste management. Examples of technologies that have been researched include the following:

- Cyclone sand – a method to separate coarse material from tailings that can be used for structural earthworks where borrow materials are limited or can be used to minimize the disturbance footprint.
- High Density Thickened / Paste tailings – a tailings dewatering method that reduces the water management requirements at the storage facility.
- Dry stack tailings – a tailings dewatering and storage method that reduces the volume of tailings and reduces or, in some cases, eliminates dam requirements.
- Waste rock dry covers – a method to reduce water infiltration into potentially acid-generating waste rock or tailings. Research has looked at cover thickness, permeability, and effects on performance with vegetation, with varying degrees of success in application.
- Co-placement – a method where tailings are thickened or filtered and blended (mixed) with waste rock, at an appropriate ratio, to maintain the geotechnical safety of the waste rock dump and potentially mitigate acid generation.
- Blending – a method where acid-generating and acid-neutralizing waste rock are blended before placement in the storage facility to neutralize any acidic drainage generated. Research and application have had varying levels of success.
- Segregation and encapsulation – a storage method where acid-generating mine waste is separated from non-acid-generating waste and stored within a specified zone in the storage facility where air and/or water flow through are minimized to prevent acid drainage release. The success of application depends on the site and the design.
- Air reduction in waste rock storage facilities using bottom-up construction in small lifts with fine compacted material between lifts. This design limits liberation of contaminants from the waste rock by limiting oxidation. The design also improves the opportunity for progressive reclamation as the facility is constructed (Meiers et al., 2018).

Governments should require proponents to provide the research and evidence to support any proposed new technologies. Site-specific bench-scale or pilot-scale studies should also be provided that prove that the proposed technology will work for the proposed project, since each mine has unique characteristics of mineralization and site conditions.

[7] See the INAP website and access its partners' websites via https://www.inap.com.au/.

Financial Surety for Waste Management: Consider financial guarantees to manage facility risk

Financial sureties should be required for closure and reclamation of the entire mine project, and these should be based on detailed cost estimates. Within the closure and reclamation cost estimate, mine waste facilities costs should include (as applicable):

- Rinsing of heap leach pads
- Construction of closure features, such as a final spillway
- Re-contouring
- Capping and revegetation
- Instrumentation and long-term geotechnical monitoring
- Associated hydrogeological, hydrological, and water quality monitoring along with water treatment costs

Note that costs should include mobilization, demobilization, equipment, and contractor costs to account for a scenario when the mine proponent is bankrupt and government becomes responsible for closure and reclamation.

Financial sureties (or a portion of the sureties) are returned to the proponent following the end of the post-closure period. An appropriate final financial surety should be retained after post-closure and structured into a sustainable finance mechanism to pay for the long-term monitoring and management of any high-risk mine waste facilities in perpetuity. As recommended in the World Bank mine financial surety guidance, there are many ways to structure financial surety regulations; however, the best structures are led by one agency, are simple and clear, and take into account the jurisdiction's structure and capacity (Sassoon, 2009).

Monitoring and Evaluation: Allocate financial and human resources for timely and effective reviews of monitoring data

Monitoring and evaluation of mine waste management facilities have similar requirements as those discussed for water management in Chapter 2. Monitoring and reporting requirements for mine waste management should be specified in permit conditions, and guidance and standard templates (or tables of contents) should be provided to mining proponents so that the information submitted is in a standard format that allows for efficient review.

Regular inspections of mine waste storage facilities should also be conducted. Inspections should be followed up with a report of any non-compliances and work to be completed, plus a required timeframe for the mine proponent to report on follow-up. Follow-up inspections may need to be conducted for any major non-compliance that cannot wait until the next government inspection.

Government staff completing the inspections should have the necessary technical competencies for the type of facilities and for conducting inspections. It is preferable that the staff reviewing the monitoring reports be the same people conducting inspections. Government might need to contract inspection services to external experts if their staff do not have the key competencies required to adequately complete the task.

Finally, government should plan and allocate appropriate financial and human resources to complete monitoring report reviews, inspections, follow-up, staff training, and enforcement.

Enforcement: Enforce compliance with mine permits

A key component of the legal framework for the governance of mine waste management is enforcement. Appropriate consequences must be included in the legislation to manage situations where there are instances of non-compliance discovered from reviews of the monitoring reports, from inspections, or in response to incidents. The consequences should be tied to the level of risk of the non-compliance.

Failure of mine waste management facilities may result in non-compliance with other legislation. For example, an incident with the tailings impoundment may be non-compliant with the approved design in the mining permit, but may also result in the release of tailings material that could result in a non-compliance with water or fish legislation, and could even result in criminal charges if the release harms people and communities.

Major incidents are often a result of the failure of many smaller components, and therefore the consistent enforcement of minor non-compliances is critical to keep proponents diligent, maintain the trust and authority of regulators and communities, and—most importantly—to prevent larger incidents. Catching failures of minor components early can help prevent a major failure.

Box 13. Case Study: Consequences of dam failures in Brazil

The most recent catastrophic dam failures in Brazil include BHP Billiton and Vale's Fundão tailings dam in 2015 that killed 17 people and polluted 663 km of the Rio Doce, and Vale's Corrego do Feijão mine tailings dam on January 25, 2019, that resulted in 259 deaths.

Following the Fundão tailings dam failure, criminal charges were laid by the Brazil government against 22 people, and a civil claim settlement of USD 5 billion was made for environmental remediation. Another claim for USD 5 billion was filed against BHP in May 2019 in England on behalf of 235,000 Brazilian individuals, companies, and Indigenous tribes (Ridley & Lewis, 2019).

Following the Corrego do Feijão tailings dam failure, murder charges were laid against 16 people, including company executives and engineering consultants (Phillips, 2020).

Vale and BHP are working to compensate for social impacts and repair environmental damages. The work being completed is communicated through the Vale's company website and BHP's Renova Foundation website.[8]

As a result of these incidents, Brazil revised its legislation to prohibit tailings dams using an upstream construction method (ANM, 2019). In addition, Brazil's National Mining Agency ordered stability reviews of all tailings dams in Brazil and stopped 47 mine operations in April 2020 where dam stability could not be certified (Reuters, 2020). The outcomes of these tragedies are still being realized. The Brazilian government must ensure the enforcement measures are appropriate for the damages and also need to work with the companies to support their efforts to compensate for and repair damages.

Internationally, tailings dam standards have become more stringent as a result of these incidents, and the mining industry and governments need to continue to improve governance of mine waste management to ensure a sustainable future for mining.

[8] Vale's repair and development website is http://www.vale.com/brasil/EN/aboutvale/reports/atualizacoes_brumadinho/Pages/default.aspx, and BHP's Renova Foundation website, http://www.vale.com/brasil/EN/aboutvale/reports/atualizacoes_brumadinho/Pages/default.aspx.

Chapter 5: Emergency Preparedness and Response

Overview

Emergency preparedness, management, communications, response, and recovery are increasingly important in the mining sector. Emergencies, including both internal mine site accidents and external natural and social hazards, can affect operations, workers, and communities, and the impacts can extend well beyond the boundaries of a mine, to the communities, rivers, wetlands, farms, and infrastructure that surround the site. Emergency events can also affect operations and communities across the mine life cycle, with the risks extending from construction and operations through mine closure to the post-mining phase. National governments, working with companies, communities, and all levels of relevant authorities, must ensure that all potentially affected stakeholders identify and understand potential risks and that they are well prepared to address and respond to them. This extends beyond those crises that may impact operating mines to the accidents and emergencies that can equally affect the closed facilities and waste storage infrastructure that are left to the community after mining ceases.

A strong culture of safety starts from the top down of an organization, whether it be a government or a mining company. For a country, a safe culture starts with the government setting a strong example of safe practices and establishing expectations for safety throughout its legal framework. Emergency preparedness and response for mining are not just about what the mining companies put in place; they must be an extension of the regional and national emergency preparedness and response network. Putting in place a strong national culture of safety will not only support community health and well-being (SDG 3) but will help to attract mining companies and investors, as it reduces their risks and liabilities and helps protects their staff and assets.

Preparing for emergencies through formal programs—whether within a mining company, government, or community—is above all else about prevention and working to protect populations and ecosystems. A series of high-profile accidents in the sector, including the Brumadinho tailings dam failure in Brazil and the jade mine collapse in Myanmar, combined with the increasing impacts of a changing climate, have underscored the need for national and local governments, mining companies, workers, and communities to work together to identify possible risks and develop, test, implement, and improve emergency preparedness before, during, and after mining.

To this end, the MPF recommends that governments require that mining companies operating in their jurisdiction develop and implement an emergency preparedness program. This should include (IGF, 2013):

- Requiring all mining operations to have an emergency preparedness and response program in place prior to commencement of operations, and ensuring that the program is comprehensive, meets current best practice standards, and is reviewed, tested, and updated on a regular basis.
- Basing all elements of the emergency preparedness program on ongoing consultation and cooperation with local communities, government, and other relevant stakeholders.
- Ensuring that monitoring of the effectiveness and responsiveness of the emergency preparedness program is conducted by companies in cooperation with communities and all levels of government.

The following chapter outlines key concepts in emergency preparedness, the benchmarks and standards most commonly applied in the sector, and the role of governments in ensuring that mining companies, staff, and communities are fully prepared for emergency situations. Please note that the chapter will primarily focus on emergencies at large-scale underground and open-pit mines, and not offshore or small and artisanal operations; however, many of the concepts can be adapted to other environments and scales.

In this chapter, you will learn why it is important to:

1. Ensure companies develop comprehensive emergency preparedness and response plans, grounded in risk assessment, prior to the granting of mining permits.
2. Require that the development, implementation, testing, and monitoring of emergency preparedness and response plans are consultative and inclusive.
3. Mandate that emergency preparedness and response plans cover the entire mine life cycle.
4. Regularly test, review, and update emergency preparedness and response plans to reflect the changing context.

Key Issues

Emergency preparedness and response require understanding exposure and vulnerability to potential **emergencies** through a **risk assessment**, designing **response measures** that aim to prevent and minimize vulnerabilities to the greatest extent possible through **consultation** with relevant stakeholders in planning, training, and response, effectively **communicating** preparedness and response to and with partners, and continuously **testing, training, and improving** the plan based on experience, changing contexts, and evolving best practice.

An **emergency**, in the context of mining, is a sudden event that can significantly affect the ability of a mining company to carry out its business (MAC, 2018a). As mentioned, emergencies can happen across the mine life cycle, including—where applicable—the post-mining transition. Emergencies can include (MAC, 2018a):

- Industrial emergencies, including those involving critical injuries, property damage, fire, building collapse, vehicle and aircraft accidents, derailment, mine structural failures, flooding, explosions, power failure, freeze-up, and loss of water.
- Natural and climate-related disasters that jeopardize staff, community safety and commercial operations, including flooding, mud slides and landslides, tsunamis, tornadoes, hurricanes, earthquakes, wildfires, and volcanic eruptions.
- Health emergencies, including an epidemic, a pandemic, or medical emergencies on sites where access to quality medical care is limited or lacking.
- The accidental release of materials into the environment, such as through tailings dam failures or major chemical spills.
- Missing persons relating to criminal or non-criminal circumstances.
- Political and security risks, such as kidnapping, extortion, bomb threats, bombings, political or civil unrest, illegal detention, and insurgent or guerrilla activities.

Emergencies and hazards such as those listed above can have a number of consequences and impacts for staff and operations, for the health and well-being of local and regional communities, for biodiversity and ecosystems, for critical infrastructure, and for critical economic sectors like water, agriculture, transport, forestry, and tourism. These consequences can be expressed in several ways: according to their social or human impacts, in operational or technical terms, or in terms of their monetary implications.

Emergency Preparedness

Emergency preparedness and response programs should cover all foreseeable emergency scenarios. As a first step, this will require looking at historical hazards and emergency events in a given area, as well as future climate projections, to assess what risk scenarios might exist for a site, and the possible scale and duration of these events. This kind of **risk assessment** should form the basis of emergency preparedness plans.

Risk assessments should be performed before mining starts, preferably as part of the ESIA process, and then across the mine life cycle at any time substantial changes are made to the operation (DMIRS, 2018). In a risk assessment, the risk level of an event is determined by the likelihood of occurrence multiplied by the potential consequences. Site-wide risk assessments should identify all major foreseeable emergency events that could affect a mining operation and its personnel. Those conducting the assessment need to perform a detailed analysis and answer many questions, including the following (DMIRS, 2018):

- What emergencies could happen at the site?
- How could these emergencies occur?
- When, where, and why could it happen, and to whom?
- What is the likelihood of occurrence?
- What are the potential consequences?

Once the company, working with other affected parties, has answered these questions and completed its risk assessment, it can think about the actions (or controls) that are available to it to reduce risk and prevent emergencies and their consequences, and to identify any possible hazards that might be associated with the proposed responses.

Emergency Response

For identified risks, companies—working with their community and government partners—should then develop a list of appropriate **response measures** for each possible emergency. Within large mining companies, site-specific emergency preparedness and response programs are prepared and aligned with a company's overall risk management approach across its operations. Site-specific response measures to be adopted should be considered from most reliable and protective to least. The Government of Western Australia, for example, asks that these control measures be presented in a hierarchy, from the most appealing option to the least: elimination of the risk; substitution of the risk; isolation or segregation of the risk; development of engineering solutions to the risk; development of administrative procedures for handling the risk; and the use of personal protective equipment (DMIRS, 2018). Response measures will form the basis of the emergency preparedness and response programs, but these programs should be robust and adaptable enough to respond to unforeseen events. Response planning should also not detract from the preeminent goal of accident prevention, and should not focus solely on operating mines, given the permanent nature of many sites and the potential for post-closure accidents (UNEP, 2001).

Companies should try to implement response measures that avoid emergency risks by: deciding not to start or continue with the activity (for example, shutting down operations due to a storm or increase in seismic activity); removing the source of the risk if possible (a hazardous chemical, for example); changing the likelihood of the risk occurring; or changing the consequences (DMIRS, 2018). Mines in Chile, for example, are built to withstand large earthquakes, a response to the high frequency and scale of seismic activity in that country. As a result, large lithium and copper mines in the north of the country were unaffected in June 2020 by a magnitude 6.8 earthquake that struck nearby San Pedro de Atacama (Patnaik & Cambero, 2020).

Consultation

To be effective, emergency preparedness and response activities—from risk assessment through planning and design to testing, implementation, and monitoring and evaluation—should be inclusive, involving not just mine managers but also staff, communities, local authorities, and national governments. **Consultation** should be a formalized process that includes open and transparent dialogue among stakeholders about possible hazards and emergency response procedures, and how responses will be sequenced and organized to optimize their effectiveness. Stakeholder input can help inform response procedures that consider the local culture and tie into existing community communication, notification, and response networks. This will serve to not only increase the effectiveness of planning and response actions, but can increase community awareness of mining operations and emergency risks, as well as build trust among stakeholder groups.

Consultation and coordination are particularly important given that a key challenge in emergency response for mines is that the effectiveness of responses is often predicated on the availability and quality of regional and national emergency response infrastructure and resources. For example, response to a serious medical emergency at a mine may require evacuation to a local hospital if facilities are available, or it may require evacuation to a hospital in a nearby country if local facilities are not available. The time required to get medical attention increases the risk. The consequences of an emergency can be reduced if the government has strong fire, medical, and response equipment, services, and facilities along with a well-established communication network.

Communications

Crisis communications are also important. Effective, structured crisis communications—and the systems and institutions required to support them—will help a company and community, working together, to reduce confusion with the onset of an emergency and resolve an issue more quickly (UNEP, 2001; MAC, 2018a). Companies—through one-on-one discussions, group meetings, workshops, or other means—should provide information to local authorities and community members on the hazards involved in the mining operation, and on the measures the company is taking to reduce these risks. They must also communicate continuously during a crisis on how the company is managing and resolving the situation, to coordinate actions and so that messaging to responders and communities from the company and government is consistent to avoid confusion. Strong, coordinated communications will also help maintain and build confidence in the company and government during a critical time (MAC, 2018a). Doing this effectively takes considerable planning, organization, and practice long before an unwanted event occurs.

Monitoring

The finalization of the emergency preparedness and response plan is not the end of this process: the plans must be **continuously tested and improved** across the life of the mine, to ensure that it reflects the operating realities and footprint of the mine site, that it integrates changes in the broader operating context (including regulatory changes), that it reflects the mining company's organizational approach to emergencies, that it integrates evolving best practice, and that it incorporates experiences and lessons learned from its application over time. Staff and partner **training** must also be continuous, to ensure that capacities to respond are in place and not lost to time or staff turnover.

A well-planned and coordinated approach to emergency preparedness and response—based on risk assessment and supported by open and effective communications, rigorous testing, continuous improvement, and comprehensive training for staff and outside partners—will ensure that an organized and sequential set of response activities is in place to guide responders should an emergency occur. This will strengthen a mining company's capacity to prevent, protect against, respond to, and recover from incidents and emergencies during and after mining, and to avoid the cascading losses that can occur. Good planning also allows for fast, effective response, and organizations have recognized that rapid assessment and notification in the initial moments of an adverse event can make a significant difference in the mitigation of the situation.

Box 14. Mining During a Cyclone

The Moma titanium project, located near the Mozambican coast, is prone to severe weather damage. The mine is operated by Kenmare, and the approach of Cyclone Idai in March 2019 triggered the on-site emergency management team to activate the mine's cyclone preparedness plan. This was done to protect the company's staff and assets, and included the suspension of product-loading activities and shipping (due to rough seas). The storm eventually made landfall to the southwest of Moma, near the town of Beira, and caused untold suffering and damage to those living in the region. The mine's distance from the storm's path saved it from the cyclone's worst impacts; however, the initiation of preplanned mitigation measures prior to landfall ensured that mine managers could reduce the threat to both personnel and operations (Mining Review Africa, 2019).

International Benchmarks and Standards

Comprehensive emergency preparedness planning begins at the outset of mine design and planning, and should continue throughout the mine life cycle. The focus within these plans should be on prevention above all else, but mitigation and recovery must also be addressed in the event of an emergency. Mining companies, governments, and communities can draw on several international, regional, and corporate benchmarks and standards in the development of their emergency preparedness and response plans. These benchmarks and standards cover several of the key issues outlined above, and they overlap in a number of ways. Complementary aspects of each are highlighted below.

International Guidelines

International guidelines on emergency preparedness and response have been developed by several organizations, including UNEP, the World Bank/IFC, and the European Union. These guidelines collectively stress that the process of planning for and responding to emergencies should be initiated prior to permitting, applied throughout the mine life cycle, be inclusive and consultative, and be grounded in risk assessment.

UNEP's Awareness and Preparedness for Emergencies at the Local Level (APELL)

UNEP's APELL guidelines were developed for the mining sector in 2001, in collaboration with ICMM. The guidance takes users through the steps they must follow **from the outset** to ensure that their operations reduce emergency risks, to prepare and plan for unwanted emergency situations, and to have the systems, procedures, and mechanisms in place to ensure that a company can manage, communicate and recover from emergency situations (UNEP, 2001). The overall goal of applying the guidance is to prevent loss of life or damage to health and social well-being, to avoid property damage, and to ensure environmental safety at the site, in the local community and—where relevant—in the broader environment. It **applies across the mine life cycle**, including in the post-mining phase. The APELL guidelines, while nearly 20 years old, are still referred to in guidance on emergency preparedness by MAC and ICMM.

UNEP outlines 10 key steps for achieving emergency preparedness (see Box 15). In addition to adhering to these steps, the APELL guidance also recommends that stakeholders developing emergency preparedness and response efforts consider integrating the mine's emergency preparedness plans into broader plans in the area: those for local communities and those for other businesses operating nearby. This will allow all stakeholders to consolidate their plans into an overall emergency preparedness plan for the region, and to coordinate planning, testing, implementation, and response actions. Such cooperation will serve to strengthen the ability of all stakeholders to respond to and recover from emergency situations.

Box 15. The 10 steps of APELL

Step 1	Identify the emergency response participants and establish their roles, resources, and concerns.
Step 2	Evaluate the risks and hazards that may result in emergency situations in the community and define options for risk reduction.
Step 3	Have participants review their own emergency plan for adequacy relative to a coordinated response, including the adequacy of communication plans.
Step 4	Identify the required response tasks not covered by the existing plans.
Step 5	Match these tasks to the resources available from the identified participants.
Step 6	Make the changes necessary to improve existing plans, integrate them into an overall emergency response and communication plan and gain agreement.
Step 7	Commit the integrated plan to writing and obtain approvals from local governments.
Step 8	Communicate the integrated plan to participating groups and ensure that all emergency responders are trained.
Step 9	Establish procedures for periodic testing, review, and updating of the plan.
Step 10	Communicate the integrated plan to the general community.

Source: UNEP, 2001.

IFC Performance Standard 4: Community Health, Safety, and Security

Emergency preparedness is covered under the IFC's Performance Standards 1 (PS1: Assessment and Management of Environmental and Social Risks and Impacts) and 4 (PS4: Community Health, Safety, and Security) (IFC, 2012b). Clients of the IFC are required to apply these performance standards in order to manage and mitigate the environmental and social risks and impacts of their operations, to ensure that they contribute positively to sustainable development. PS4, which builds on the World Bank's Environmental, Health and Safety Guidelines, recognizes that project activities can increase community exposure to risks and impacts, and that companies have a significant role to play in preventing or minimizing these threats to health, safety, and security (IFC, 2012b). Measures that are proposed to mitigate emergency risks should favour avoidance over minimization. Risks and impacts should first be identified early in the mine life cycle (and prior to permitting) during the ESIA process, and with initial preparedness plans then included as a central component to a company's environmental and social management system (IFC, 2012b). This **risk assessment**, covered in Performance Standard 1, along with the identification of mitigation measures, should be done in close collaboration with affected communities, local authorities and other relevant parties, and preparedness plans should be documented and shared with all relevant stakeholders. Preparing for emergencies should include identifying: mine site areas where emergency situations may occur; communities and individuals that may be affected; response procedures; required equipment and resources to implement the preparedness plan; roles and responsibilities for staff; communications procedures; and periodic training to ensure effective response (IFC, 2012a).

European Union

The EU issued guidance on major accident prevention and information in 2006, as part of its directive on the management of waste from extractive industries (Directive 2006/21/EC). The directive notes that Member States must ensure that major accident hazards are identified and incorporated into the design, construction, operation, and maintenance of waste facilities, including through closure and the post-mining transition. Operators are required to prepare a major accident prevention policy, specifically for extractive wastes, and put into effect a safety management system to implement it, under the guidance of a safety manager. Plans should cover both on-site and off-site responses to any accident, including rehabilitation, restoration, and clean-up of the environment, and must be developed prior to the granting of a permit. As with other jurisdictions, the development of **emergency plans must be consultative**, involving the potentially affected public in both the development of the plan and its review prior to finalization. Once an acceptable plan is approved and in place, the directive requires that it be made public, free of charge, and that it be reviewed every three years for updates, as necessary (EU, 2006).

Governmental Guidelines

Subnational governments in both Australia and Canada have developed regulations and codes of practice on emergency preparedness for those mining companies operating within their state or provincial borders. While echoing much of what appears in the international guidance listed above, these subnational governments also stress the importance of carefully considered response measures, as well as regular testing and review.

Government of Western Australia

In Western Australia, mining companies are required by the government to have three kinds of plans in place to prepare for, manage, and recover from emergency situations: an emergency plan, a crisis management plan, and an emergency response plan (DMIRS, 2018). An **emergency plan** is an overall preparedness plan for the site, which includes the identification of hazards and risk assessment. A **crisis management plan** is designed for the overall management of an emergency, and is designed for managing external stakeholders in an emergency situation and not for managing the company's response activities. Finally, **emergency response plans** are procedures that assign responsibility and tasks for responding to a specific event and implementing specific contingency plans (DMIRS, 2018).

Government of British Columbia

In the Canadian province of British Columbia (BC), regulations require that companies develop a Mine Emergency Response Plan and—as in many jurisdictions—that the plan outline the response procedures and preventive measures that are essential for effective and timely management of an emergency (British Columbia Ministry of Energy Mines and Petroleum Resources [MEMPR], 2017). For BC, **regular reviews and revisions** of plans are required, as they are seen as necessary to assessing a company's level of readiness for emergencies, by identifying how conditions have changed over time, and where areas of improvement lie. Based on these regular reviews, it is expected that the emergency management team can adapt the plan over time to reflect changing risks and circumstances.

Industry

Finally, international and national mining associations have also developed principles and protocols for their members to follow, in order to ensure that operations, personnel, and communities are prepared for and can safely respond to emergencies and crises. While similarly echoing the benchmarks and standards outlined by the international and governmental sources listed above, both ICMM and MAC reiterate the importance of collaboration and consultation with affected stakeholders, and the crucial role that effective communications can play in the speed and efficacy of emergency response measures.

International Council on Mining and Metals

ICMM members have committed themselves to implementing 10 Mining Principles and measuring their performance against them. Emergency Preparedness is covered by a few of these principles, which stress the importance of **collaboration and consultation**. The fourth principle, on risk management, refers to the need to "inform potentially affected parties of significant risks from mining, minerals and metals operations and of the measures that will be taken to manage the potential risks effectively" and to "develop, maintain and test effective emergency response procedures in collaboration with potentially affected parties" (ICMM, n.d.b.). Where the risks to external stakeholders are significant, the Principles note that the development, implementation, and testing of plans should take place in collaboration with potentially affected stakeholders and be consistent with established industry good practice. Other supporting principles include the fifth, on Health and Safety, which requires a commitment to "seek continual improvement of our health and safety performance," and the tenth, on stakeholder engagement, which includes a commitment to "engage with and respond to stakeholders through open consultation processes."

Mining Association of Canada

MAC provides protocols to its members on **emergency communications**, as part of its Toward Sustainable Mining initiative. MAC recognizes that for a mining company to successfully resolve a crisis and limit long-term reputational damage, structures and protocols must be in place internally to ensure proactive crisis management and clear, effective communication with affected stakeholders (MAC, 2018a). Members are asked to carefully develop a crisis management and communications plan, and continuously scrutinize and modify the plan over the mine life cycle. This communications plan should be in place before an emergency occurs, and it should be updated with lessons learned after each crisis. As part of a company's pre-incident preparation, the plan should identify, prioritize, and prepare contact sheets for key stakeholders, to ensure that in the event of an emergency no one is missed. The company's emergency response team should also meet regularly or annually with their counterparts within the local authority. Finally, the protocols point out that—as part of preparedness testing—crisis simulation exercises should be carried out regularly by the company. These can include: management training exercises, table-top discussions, semi-active sessions, and full crisis simulation. The various types of simulation provide users with information about the planned response activities, allow key stakeholders to practice procedures and decision making during an event, and bring together the key participants to establish and maintain engagement and teamwork (MAC, 2018a).

Role of Government

National governments have a major role to play in emergency preparedness and in ensuring that, should a crisis occur, responses are swift, organized, and coordinated, and that all relevant stakeholders, from local communities to staff, are safe and protected.

Through legislative, policy, and regulatory frameworks and instruments, governments should mandate that emergency preparedness and response plans cover the entire mine life cycle, and should:

1. Ensure companies develop comprehensive emergency preparedness and response plans, grounded in risk assessment, prior to the granting of mining permits.
2. Require that the development, implementation, testing, and monitoring of emergency preparedness and response plans are consultative and inclusive.
3. Necessitate that companies regularly test, review, and update emergency preparedness and response plans to reflect the changing context.

Planning: Ensure companies develop comprehensive emergency preparedness and response plans, grounded in risk assessment, prior to the granting of mining permits

First, governments should require all mining operations to have a formal and written emergency preparedness and response program in place prior to the granting of permits or licences and the start of operations. These programs should be formally documented, should accurately and comprehensively reflect the risks associated with the company's operations and the mine's location, should be publicly accessible, and should meet current best practice standards. They should form part of a mine's ESMP. Emergency preparedness and response plans should include five principal components: risk assessment, prevention and preparedness, response, recovery, and crisis communications.

Risk assessment should serve as the foundation of the plan: an identification of possible crises that could occur at the site before, during, and after mining, and the potential severity of the associated impacts.

Prevention and preparedness: Once major foreseeable emergency events and their impacts have been identified, preparedness plans can outline the control measures that will be implemented to prevent, minimize, and mitigate these risks as well as any hazards that might be associated with these responses (DMIRS, 2018). As mentioned throughout this guidance note, a mine life cycle approach should be taken to emergency preparedness, including the closure and post-closure phases, and control measures should be developed in collaboration with affected stakeholders.

Response plans include plans for the overall management of an emergency, including the management of external stakeholders in an emergency situation, and plans for managing the company's response activities, which outline the procedures that assign responsibility and tasks for responding to a specific event and implementing specific contingency plans (DMIRS, 2018).

Recovery plans detail those activities that will commence or continue beyond the emergency in order to restore community safety, ecosystem health, and mining operations.

Crises communication plans include protocols for both internal and external communications of the preparedness and response plan, to ensure that affected staff and stakeholders are aware of risks and response measures, and of the lines of communication in the event of an emergency, to ensure that emergency response and recovery actions are clear and coordinated.

These plans should be developed and submitted before mining starts to ensure that they are in place should an emergency occur.

Governments can formalize these requirements in legislation, such as a Mine Safety and Inspection Act or Emergency Management Act (as in Western Australia, for example). They can also regulate it: given the strong focus of emergency preparedness on risk assessment, it makes sense for governments to integrate emergency preparedness into the ESIA process, and to require that these plans be included as part of the conditions for the granting of mine leases and permits. These conditions should include not only that the preparedness plan be established prior to the granting of a permit, but also that the plans are developed collaboratively with potentially affected stakeholders and that they are periodically reviewed and adjusted over time to reflect changes in the mine's operations or context.

In order to support mining companies and communities in their efforts to plan for emergencies, national and subnational governments can consider endorsing and promoting international best practices in this area, such as UNEP's APELL process. Application of these kinds of guidelines will help to better coordinate emergency preparedness between mining entities, local authorities, and local populations. To complement international best practice, governments can also develop a national code of practice around emergency management for surface and underground mining and quarries, which could include both mandatory and voluntary actions. Mandatory actions could include the establishment, training, and resourcing of a site-specific crisis management team; the launch of a well-equipped crisis control centre; and the hiring and training of crisis communications specialists.

Governments can also develop codes and standards for mining companies that consider country-specific risks; these risks can be identified through a national or regional risk assessment process. For example, codes and standards might focus on emergency preparedness and response for cyanide spills if there is gold mining in the country, security requirements if there is potential for local civil unrest, and building standards and underground support guidance in areas with high seismic risks.

Collaboration: Require that the development, implementation, testing, and monitoring of emergency preparedness and response plans are consultative and inclusive

Promoting and facilitating collaboration and cooperation on emergency preparedness among key stakeholder groups is another central function of the national government.

First, mining ministries should work to ensure that all appropriate government ministries, departments, and agencies, at the national, district, and local levels, are aware of emergency risks and of planning processes, and are ready to cooperate with mining companies, both during the planning phase and—crucially—in response to a crisis occurring. The Pilbara Ports Authority in north-west Australia, for example, worked with mining companies to shut down the region's ports in advance of Cyclone Veronica in March 2019, to minimize the category five storm's threat to mining assets and infrastructure (Mining Technology, 2019). Throughout the mine life cycle, mining ministries should also transmit to stakeholder groups information and data on potential natural and social risks for the mine site and surrounding communities, including seismic, climatic, and topographical information. Some of these risks will change over time, and governments should establish appropriate channels or platforms for knowledge exchange to make sure the information gets to those that need it during mining and that it arrives in a format they can understand and use.

During the planning phase, companies should be required by government to consult and cooperate with local, district, national and—as appropriate—transboundary stakeholders in the development of emergency preparedness programs. This includes jointly conducting risk assessments, developing site-specific response measures, and specifying communication systems and chains of command. A consultative process will help to ensure the plans are comprehensive, that they reflect local needs and perceptions of risk, and that response strategies are widely understood, locally appropriate, feasible, and effective. Beyond the planning phase, communications and consultation must continue; this can take the form of regular meetings between the mine's crisis management team and the local emergency response authorities, organizing and delivering training programs together, and cooperating on both testing and auditing.

One particular form of coordination that can be promoted by governments is the alignment and integration of company preparedness plans into local emergency response plans, resulting in one overall plan for the community—including the mine—to use in the event of a crisis (UNEP, 2001). Having an integrated plan prior to mining will allow for the development of formalized processes within the program that will facilitate communications between communities and the mine's crisis management team, and improve—through coordination—the efficiency and feasibility of both preventive and response measures. Further, the collaborative and transparent development of integrated preparedness plans will help to establish and foster trust among stakeholders, while all parties will be able to leverage the knowledge, capacities, and resources of their partners for gains that would not be achieved were they acting alone.

Monitoring and Evaluation: Necessitate that companies regularly test, review, and update emergency preparedness and response plans to reflect the changing context

A mining company's exposure to emergency hazards and risks will change over time, both as the operation progresses through the mine life cycle and as the wider context within which the mine is located—including local demographics, politics, and climate change. Governments have to ensure that emergency preparedness programs are reviewed, tested, and updated on a regular basis during mining, to ensure that these programs remain feasible, effective, and responsive in light of the current context. The regular monitoring and evaluating of preparedness plans should be done by companies in cooperation with communities, local authorities, and the national government.

The periodic review of emergency preparedness and response plans will help to make sure that the plans reflect not only the changing risks faced by a company's operations, but also that they consider changes in the company's needs, in the operational realities of the mine (e.g., current staff numbers, the footprint of the mine, the technologies employed at the mine site, and so on), and in international best practices. These international best practices can be drawn from national and international mining industry associations, though the best practices of industries where similar hazards and emergency situations can arise—such as the petroleum sector—should also be reviewed.

A comprehensive review and evaluation of preparedness plans and response procedures should look at:

- Hazard identification and scenario analysis procedures
- Preparedness plans and contingency plans
- Organizational structure, roles, and responsibilities for preventive and response activities
- Training and competency of those involved in the response activities
- Equipment and resourcing
- Internal and external communication structures and procedures.

External audits of emergency preparedness and response plans can provide a strong mechanism for evaluating the adequacy and effectiveness of company plans, and of identifying and implementing any needed corrective actions. Audits are typically undertaken by people that are not involved in the activity or program being audited; this independence can help provide assurance on the adequacy and effectiveness of the review. Based on the results of audits and reviews, the company's crisis management team can then develop specific goals to improve the program or adapt it to the changed circumstances (MEMPR, 2017).

In addition to periodic reviews during mining, governments can also require that companies undertake regular testing of their plans to gauge their effectiveness and to ensure that all staff understand their role in both emergency prevention and response. Testing can take a number of forms across the mine life cycle (from management training exercises and table-top discussions to semi-active sessions and full crisis simulations (MAC, 2018a)), and will help to ensure that, despite the staff turnover that mining companies habitually deal with, staff knowledge and capacities are continually in place to implement the plan.

Should an emergency occur and the company's response plan be implemented, companies should work with responders and affected stakeholders to document any lessons learned from the experience and to integrate these into emergency preparedness going forward. In addition to reviewing the overall response, this exercise should include identifying what worked well and what did not with regards to: internal and external communications; notification activities; equipment and capacity constraints; roles and responsibilities; response sequencing; and coordination among affected stakeholders. The organization needs to perform this lessons learned analysis with responders, stakeholders, and staff to scrutinize, update, and strengthen the plans with a focus on improvement, and not blame or fault.

Testing, reviewing and updating emergency preparedness and response plans will require resources, and companies must allocate adequate funding to the implementation and upkeep of these plans. That extends beyond the mine's closure; for the long-term risks that a company cannot eliminate, governments should require that sufficient financial assurances are in place to respond to future risks.

Box 16. Case Study: Testing emergency preparedness in Queensland, Australia

In response to an explosion at the Moura 2 mine in 1994, the state government of Queensland in Australia launched an inquiry that, when completed, recommended that exercises testing emergency procedures should be carried out at all mines on an annual basis (DMIRS, 2018). The government followed this up with standards on running emergency procedures exercises in 1996, and further updated in 2009. As part of the standard, mines are required to test their emergency procedures on an annual basis.

For the emergency simulation exercise conducted at Grosvenor coal mine in July 2018, a broad team of assessors were involved, including representatives from Grosvenor, from the union, from other mines in the state, and from across the government: from inspections and health and safety to the mine rescue services. The simulation exercise tested the protocols and procedures that would be used in the event of an explosion at the mine, and the need to ensure the explosion was contained and that staff were safely evacuated from the site.

This exercise points to a strong standard for emergency preparedness and response planning, in which legislative requirements mean that annual testing of emergency plans is mandatory, and that these tests are undertaken with government oversight and with the participation of government assessors. The government also writes the report evaluating the exercise and the mine's ability to plan for and respond to an emergency (DMIRS, 2018).

Chapter 6: Environmental Management Gap Analysis

The guidance presented in the previous chapters of this document describes good international practices and key government actions for environmental management of the mining sector. But how does your government begin to assess what changes are needed, given your current legal and regulatory framework? Where do you begin to actually incorporate this guidance to make sure that your policies and legal frameworks protect the environment while optimizing the social and economic benefits of the mining sector?

There are several things that governments must do before, during, and after mining to ensure that those operating in their mining sectors effectively manage water resources, protect biodiversity and ecosystems, properly store and dispose of waste materials, and prepare for and respond to emergencies. Using the legislative, regulatory, and policy tools at their disposal, governments can design, implement, and enforce a regulatory framework that supports responsible and effective environmental management in mining that protects communities, supports the private sector, and helps with the achievement of national environmental objectives and the SDGs. Conducting a gap analysis, based on the information presented in this guidance document, is an effective way for governments to identify their strengths, gaps, and opportunities in environmental management for mining and to develop a path forward for achieving their environmental objectives.

1. Review the Existing Legal and Regulatory Frameworks

As a first step, governments should conduct a review of their existing legal and regulatory frameworks to understand what they are currently doing or requiring on all four aspects of environmental management across the mine life cycle, including in their ESIAs and ESMPs requirements. This information can be presented in a table listing, for example, everything that the government requires of proponents on water management before, during, and after mining, and so on.

2. Assess Strengths, Gaps, and Opportunities

The table prepared by the government in the previous step can then be compared with Table 3. This comparison will help the government see how their legal frameworks on water, waste, biodiversity, and emergency preparedness compare to international standards and benchmarks. This will help them to identify an initial list of their strengths, gaps, and opportunities for improving legal frameworks on environmental management; it may be, for example, that their requirements on water management before mining commences are largely in line with international standards, but that there are opportunities for further strengthening the laws, policies, and regulations that govern water during mining and after mine closure.

Table 3. Environmental management across the mine life cycle

		Before mining	During mining	After mining
Water		Ensure the legal framework has clear requirements for water protection and process for water allocation Develop water management policies and programs at the watershed level Develop guidance materials for mine water management, permitting, and reporting Set effluent criteria and receiving water objectives Review the ESIA and water management plans to set permit conditions for water use and discharges (if approved)	Monitor and evaluate mine water management performance Enforce compliance with permit conditions Review applications and make permit amendments for mine changes Ensure sufficient financial assurance is left in place to manage any post-mining water treatment requirements and risks	Monitor and evaluate post-closure mine water management performance Enforce compliance with closure requirements
Biodiversity		Ensure legal framework includes protection of biodiversity and alignment with the international Convention on Biological Diversity Develop policies and programs for biodiversity conservation including	Monitor and evaluate biodiversity management plan and progressive restoration performance Enforce compliance with project approval	Monitor and evaluate mine restoration performance Enforce compliance with closure requirements

		processes for biodiversity banking and offsetting Develop biodiversity protection guidance including following the mitigation hierarchy and no net loss/net positive impact Review the ESIA and biodiversity management plans and set approval conditions	conditions pertaining to biodiversity	pertaining to biodiversity Ensure sufficient financial assurance is left in place for long-term risks to restoration success, and any sustainable finance mechanisms are in place if needed to meet long-term requirements of no net loss/net positive impact
Mine waste		Ensure legal framework includes environmental protection provisions specific to mine wastes Develop policies and programs for mine waste management Prepare guidance on mine waste management in alignment with international best practice Review the ESIA and mine waste management plans and set approval and permit conditions Require independent tailings review panels if applicable	Monitor and evaluate mine waste management performance If applicable, review independent tailings review panel reports and follow up on implementation of recommendations Enforce compliance with permit conditions Review application and revise permits for mine waste facility changes or if required based on independent report recommendations	Monitor and evaluate mine waste facilities closure performance Enforce compliance with mine waste closure requirements Ensure sufficient financial assurance is left in place to manage any post-mining management or risks associated with mine waste facilities
Emergency preparedness and response		Ensure national emergency response infrastructure and system is in place and is harmonized with the mine emergency preparedness and response plan Ensure legal framework includes requirements for mine emergency preparedness and response Review the emergency preparedness and response plans prior to granting mining permits and ensure they are based on assessment of risks Require that implementation, testing, and monitoring of the emergency preparedness and response plan has been consultative with government and communities	Require and monitor and evaluate testing, review, and updates of the emergency preparedness and response plan (including testing with communities and the national system as appropriate)	Require mine closure to eliminate long-term mine risks If not all risk can be eliminated, ensure sufficient financial assurances are in place to respond to future risks

3. Identify Priorities for Reform and the Risks of Inaction

Looking at gaps and opportunities, the government can next identify the risks associated with inaction and the benefits of reform, and subsequently prioritize those actions it must take to minimize any risks, maximize any benefits, and strengthen its legal frameworks for environmental management. If, for example, the gap analysis reveals that there is a significant risk to local communities as a result of inadequate requirements for developing emergency preparedness and response plans prior to permitting, governments may prioritize addressing this in the legal framework reform process.

4. Develop a Roadmap

With a list of priorities in hand, the government can develop a roadmap for how it will adjust or reform its legal and regulatory frameworks on environmental management to achieve its policy objectives and meet its international commitments. In this roadmap, the government will outline where changes in policy, law, institutions, capacities, and resourcing will be needed; the best legal instruments for making positive change; the steps that the government will follow to revise the legal framework; and a timeframe for the process (changes to be made in the next 5 to 10 years, for example). This roadmap will help the government articulate how they will get from where they currently are to where they need to be. This roadmap should be developed in a participative way to ensure that it reflects a variety of stakeholder perspectives and has their support. The roadmap should reflect the roles and responsibilities of those that will implement it. It should also be feasible; the roadmap should adequately and realistically reflect the time, resources, and capacities needed from the government for this work and not be so ambitious that the roadmap ceases to be implementable.

5. Implement the Roadmap

Once a realistic roadmap has been developed and adopted, the relevant parties can set about implementing it. This will likely require considerable resources and the participation of several different ministries, departments, and agencies, as well as the participation of outside, relevant stakeholders.

6. Continuous Improvement

The government should establish systems and capacities to continuously monitor and evaluate its legal and regulatory frameworks on environmental management, to ensure that it continues to meet international standards and benchmarks. Ongoing monitoring and evaluation efforts will allow the government to manage change and adjust frameworks as needed over time to reflect changing best practices and evolving knowledge.

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