Learning Objectives of the Module

- To introduce a systematic approach to the analysis of risk exposures in mining
- To provide practical advice for developing management programs to protect the environment and efficiently allocate resources

Background to ERM

- Increasing recognition of:
  - Environmental impacts
  - Regulatory requirements to protect the environment
- Increased adoption of:
  - Environmental impact assessment for new facilities
  - Risk-based approaches to control and manage environmental hazards

What is ERM ?

- Environment
- Hazard
- Harm
- Risk
- Consequence(s)
- Likelihood
- Frequency
- Probability
- Risk analysis
- Risk assessment
- Risk management

Everyday Risks
(Source ANSTO 1989)

Risk	Chances of fatality per million person years
Smoking (20 cigarettes a day)	5000
Drinking alcohol	360
Travelling by:	
▪ motor vehicle	145
▪ Train	30
▪ Aeroplane	10
Cancers from all causes	1800
Fires and accidental burns	10
Cataclysmic storms and storm flood	0.2
Lightning strike	0.1
Meteorite	0.001

Typical Environmental Hazards in the Mining Industry

- Clearing vegetation
- Emissions to air and water
- Acid sulphate soils
- Toxic tailings
- Contaminated stormwater runoff
- Storage, transport or handling of fuels (spills, fire, explosions)
- Bushfires
- Inadequate security
- Accidents
- Soil erosion

Principles of ERM

- Uncertainty can be part of any aspect of a system
- Uncertainty can be divided into 3 categories:
  - Uncertainty of *ignorance*
  - Uncertainty of the *unknown*
  - Uncertainty of *unpredictability*

Principles of ERM

- ERM should have two main aims:
  - To eliminate the uncertainty of ignorance
  - To identify and manage the uncertainties of the unknown and unpredictability

ERM is Based on Best Practice Principles

- Commitment and a formalised approach
- All operations and the whole life cycle of the mine must be covered
- Sound risk analysis
- Integration of ERM with overall risk management, overall mine management and environmental management
- An ongoing process

ERM and Mining

- Mining can never have zero environmental impact
- ERM helps ensure that environmental risk is contained to acceptable levels
- A risk-based approach can be a powerful tool in ensuring cost-effectiveness of environmental management
- ERM can help meet regulatory requirements

ERM Methods and Practice

- There are a number of key elements of ERM
- Each element flows into the next and each step is limited by the quality of the work of the step that preceded it
- The process is not always linear
- Effective communication is vital throughout the process

Define the Entity to be Managed

- In an ideal world every aspect of mining-related operations would be subject to ERM
- In reality we need to be more selective and focused
- Depending on the purpose and objectives the ERM exercise may extend across several operations or be limited to a single operation, mining phase or activity

Scoping of the Risk Analysis

- Several studies may be required for an ERM exercise
- Consider time and resource constraints and define boundaries
- Select personnel and methods
- Give personnel opportunity for input into the scope

Risk Analysis

- Components
  - Familiarisation and description
  - Hazard Identification
  - Consequence analysis
  - Likelihood analysis
  - Risk estimation or characterisation
  - Identifying risk contributors
  - Risk reduction
  - Sensitivity analysis

Risk Analysis -
Familiarisation and Description

- All features of the mining operation and its environmental context need to be fully described
- Description and familiarisation are needed to structure the study
- Familiarisation may include a review of existing maps, reports and site inspections

Risk Analysis -
Hazard Identification

- Hazards to all potentially affected aspects of the environment - including perceived hazards
- All types of hazards - continual emissions, accidental releases, wastes and by-products, and natural events
- The whole of the mine life-cycle including exploration and rehabilitation

Hazard Identification Processes

- Audit-type inspections
- Brainstorming sessions with relevant parties
- Reviews of:
  - Community concerns
  - Licence conditions including compliance and breaches
  - Incidents and previous audits
  - Operating, maintenance and emergency procedures

Risk Analysis -
Consequence Analysis

- Examine each part of the event or process that contributes to the environmental outcome, as well as the end outcome itself
- For each element consider:
  - Magnitude
  - Extent
  - Severity
  - Duration

Risk Analysis -
Likelihood Analysis (1)

- Likelihood analysis takes account of the likelihoods of each step in the chain of events. Factors to consider include:
  - Frequency of the initiating event;
  - Probability of safeguards failing;
  - Likelihood of an event causing a primary failure AND a safeguard failure;

Risk Analysis
Likelihood analysis (2)

- The likelihood of events coinciding and causing a different outcome from one event alone;
- Likelihoods for human errors and appropriate and inappropriate responses;
- Likelihoods of certain weather conditions;
- Probablility of fatality or injury (people and other species).

Risk Analysis -
Risk Estimation or Risk Characterisation

- Results of consequence and likelihood analysis are combined to give:
  - Risk estimation (quantitative inputs); or
  - Risk characterisation (qualitative inputs).

Risk Analysis -
Identifying Risk Contributors and Opportunities for Risk Reduction

- Identify the parts of the system that make the largest contribution to risk
- This provides the opportunity to rank matters for action and to identify the opportunities for cost-effective risk management measures

Risk Analysis -
Sensitivity Analysis

- The implications of changes to assumptions and limitations to knowledge should be constantly considered
- Quantitative or qualitative components

Risk Assessment

- Criteria identification
- Assessing risk against criteria
- Developing recommendations for risk management

Risk Treatment

- Accepting risk
  - Requires knowledge and understanding of the risk to allow assessment of the acceptability of the risk by the community
- Risk reduction or minimisation
  - Eliminate the hazard
  - Reduce the consequences
  - Reduce the likelihood

Management and Treatment

- Risk transfer
- Emergency/contingency planning
- Monitoring
- Auditing
- Risk management program or system

Communication and Consultation

- Risk communication is integral to ERM
  - It continues through the entire mining operation
- Communication is a two-way process
  - Listen to what stakeholders have to say
  - Provide clear and accessible information about ERM and risk analysis
  - Communication affects perception of risk

Communication and Consultation

"Effective communication is a two-way process"

- Listening to community concerns is an essential part of risk communication.

Risk = technical (actual) risk + perceived risk

Communication and Consultation

- APELL provides a tool for effective communication about risks and emergency response
- Communication involves three groups of stakeholders:
  - Company
  - Community
  - Local authorities
- The APELL approach should be integrated into the ERM process

ERM and the Mining Cycle

- Planning and concept development
- Exploration
- Approval processes
- Development and construction
- Operations
- Decommissioning, rehabilitation
- Remediating former mining sites

Risk Management and the Future

- ERM will play a bigger role in mine management in the future as environmental management standards develop.
- Why?
  - Growing environmental awareness
  - Regulation requirements
  - Growing global environmental pressures