MINING LEARNING SERIES

Environment, Rehabilitation & Communities

A South African learner's guide to responsible mining and lasting value

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LEARNING OUTCOMES

After studying this note, you should be able to identify environmental and social impacts across the mining life cycle, explain the mitigation hierarchy, describe water and rehabilitation controls, distinguish progressive rehabilitation from closure, understand public participation and Social and Labour Plans, and propose responsible monitoring indicators.

How to Use This Study Note

This guide introduces environmental management, mine rehabilitation and relationships with mining-affected communities. It supports learning but does not replace a site's environmental authorisation, environmental management programme, water-use requirements, Social and Labour Plan, legal advice or specialist studies.

A five-question method

Question	What to examine
1. What may change?	Land, water, air, biodiversity, livelihoods, heritage, services and health.
2. Who may be affected?	Workers, land users, households, vulnerable groups, businesses and future generations.
3. Can it be avoided?	Location, design, technology, timing and alternative methods.
4. How will it be managed?	Mitigation, monitoring, responsibilities, budget and response actions.
5. What remains after closure?	Residual risk, maintenance, land use, water, jobs and community resilience.

Good evidence

- Baseline information collected before disturbance.
- Clear impact pathways from activity to consequence.
- Measurable commitments, indicators and thresholds.
- Community knowledge alongside technical studies.
- Transparent reporting of uncertainty, incidents and performance.

LEGAL INFORMATION CHANGES

Environmental and mining laws, regulations and guidance are amended. Use current official government documents and approved project commitments for decisions. This note is educational, not legal advice.

1. Mining, Environment and Society

Mining can provide minerals, employment, infrastructure, taxes and local business opportunities, but it also disturbs land and can affect water, air, ecosystems, heritage, health and livelihoods. Responsible mining plans for these effects before disturbance and continues management after production ends.

Impacts across the mine life cycle

Stage	Typical activities	Potential environmental or social issues
Exploration	Access tracks, mapping, sampling and drilling.	Vegetation disturbance, water, heritage, land access and expectations.
Construction	Clearing, roads, power, plant and accommodation.	Land take, traffic, dust, influx, jobs and pressure on services.
Operation	Extraction, processing, waste storage and transport.	Water, air, noise, biodiversity, safety, livelihoods and cumulative impacts.
Progressive rehabilitation	Reshaping, replacing soil and revegetating completed areas.	Erosion, invasive species, land capability and performance uncertainty.
Closure	Decommissioning, demolition, final landforms and transition.	Job losses, long-term water, residual facilities and economic change.
Post-closure	Monitoring, maintenance and agreed future land use.	Residual pollution, land stability, responsibility and funding.

Direct, indirect and cumulative impacts

Type	Example
Direct	Vegetation removed for a waste-rock facility.
Indirect	New road access increases settlement or pressure on natural resources.
Cumulative	Several mines and towns together reduce catchment water quality or availability.
Positive	Training and procurement strengthen local economic capacity.
Residual	Impact remaining after reasonable mitigation has been applied.

2. South African Legal Framework

South Africa's "One Environmental System" aligns environmental management for mining mainly under the National Environmental Management Act, while mineral rights and social obligations remain linked to the Mineral and Petroleum Resources Development Act. Other laws apply to water, waste, air quality, biodiversity and heritage.

Instrument	Main relevance
National Environmental Management Act (NEMA)	Environmental authorisation, impact assessment, management duties, remediation and financial provision.
MPRDA	Mineral rights, sustainable development duties, Social and Labour Plans and closure responsibilities.
National Water Act	Water use, protection of water resources, licences and pollution prevention.
National Environmental Management: Waste Act	Waste management, contaminated land and listed waste activities.
Air Quality Act	Air emissions, dust and air-quality management.
Biodiversity Act	Protection and management of biodiversity and invasive species.
National Heritage Resources Act	Identification and protection of heritage resources.
Mine Health and Safety Act	Health and safety of employees and other persons at mines.

Project instruments

- Environmental impact assessment and environmental authorisation.
- Environmental management programme and specialist plans.
- Water-use authorisation and water-management measures.
- Social and Labour Plan and stakeholder commitments.
- Annual rehabilitation plan, closure plan and financial provision.
- Monitoring, audits, incident reporting and compliance inspections.

APPROVAL IS NOT THE FINISH

An authorisation permits activities under conditions. The mine must implement, monitor, audit and update commitments throughout the life cycle.

3. Impact Assessment and Mitigation

Assessment sequence

Step	Purpose
Screen and scope	Identify activities, sensitive receptors, legal triggers and reasonable alternatives.
Baseline studies	Describe conditions before development, including natural and social systems.
Predict impacts	Estimate nature, extent, duration, intensity, probability and significance.
Evaluate alternatives	Compare locations, technologies, layouts, timing and the no-go option.
Design mitigation	Apply the mitigation hierarchy and define management actions.
Engage stakeholders	Share understandable information, record concerns and include relevant knowledge.
Monitor and adapt	Measure outcomes, compare with commitments and correct underperformance.

The mitigation hierarchy

Priority	Meaning	Example
1. Avoid	Prevent the impact entirely.	Move infrastructure away from a wetland or heritage site.
2. Minimise	Reduce scale, duration or intensity.	Use smaller disturbance footprints and water-efficient technology.
3. Restore / rehabilitate	Repair affected land or ecosystem function.	Replace topsoil and establish suitable vegetation.
4. Offset	Address significant residual impacts elsewhere under strict requirements.	Protect or restore comparable biodiversity when residual loss remains.

Significance is not only a score

USE JUDGMENT TRANSPARENTLY

A matrix supports comparison, but decisions must explain assumptions, uncertainty, vulnerable groups, legal limits, cumulative effects and whether mitigation is proven and enforceable.

4. Water Stewardship

Mining water management considers quantity, quality, timing and shared catchment needs. Water may enter through rainfall, runoff, groundwater and purchased supply, while losses occur through evaporation, product moisture, seepage and discharge.

Water risks and controls

Risk	Control direction
Dirty and clean water mix	Separate catchments, divert clean runoff and contain affected water.
Acid or metalliferous drainage	Characterise materials, limit oxygen/water contact, collect and treat seepage.
Salinity or chemical contamination	Source control, lined containment, recycling, treatment and monitoring.
Groundwater drawdown	Hydrogeological modelling, abstraction control, monitoring and mitigation.
Competition for water	Efficient use, alternative supplies, transparent allocation and catchment engagement.
Flood or drought	Climate-informed design, storage, freeboard, emergency plans and adaptive triggers.

Simple site water balance

Opening storage = 120 ML; rainfall/runoff = 35 ML; purchased water = 20 ML; recycled return = 60 ML; plant use = 70 ML; evaporation = 18 ML; controlled discharge = 10 ML.

Calculation	Result
Total inflow = 35 + 20 + 60	115 ML
Total outflow = 70 + 18 + 10	98 ML
Closing storage = 120 + 115 - 98	137 ML
Change in storage = 137 - 120	+17 ML

Monitoring network

- Upstream and downstream surface-water points.
- Background and potentially affected groundwater boreholes.
- Flow, level, rainfall and storage measurements.
- Field parameters plus accredited laboratory analyses.
- Trigger levels linked to defined investigation and response actions.

5. Land, Soil and Biodiversity

Resource	Before disturbance	During operation	Rehabilitation objective
Landform	Survey slopes, drainage and erosion risk.	Control footprint and maintain stable drainage.	Create safe, stable landforms integrated with surroundings.
Topsoil	Map depth, quality, weeds and contamination.	Strip selectively; avoid mixing and compaction.	Replace suitable soil at planned depth and condition.
Vegetation	Survey habitats, species and ecological condition.	Avoid sensitive areas; control fire and invasive species.	Establish suitable native or agreed land-use vegetation.
Fauna	Identify habitat, movement and threatened species.	Manage traffic, lighting, noise and rescue procedures.	Restore habitat connectivity and monitor recovery.
Land capability	Assess grazing, cropping, conservation or other use.	Prevent unnecessary loss and contamination.	Achieve agreed post-mining capability where feasible.

Topsoil calculation

Area to strip = 12 ha. Planned topsoil depth = 0.25 m. Since 1 ha = 10 000 m^2: area = 120 000 m^2. Topsoil volume = 120 000 × 0.25 = 30 000 m^3. If bulking factor is 1.15, loose stockpile volume = 30 000 × 1.15 = 34 500 m^3.

Good soil management

- Strip only when the receiving or storage area is ready.
- Keep suitable topsoil separate from subsoil and contaminated material.
- Limit stockpile height and storage time where practical.
- Control erosion, compaction, weeds and unauthorised traffic.
- Record volumes, source locations and final placement.



Progressive rehabilitation rebuilds stable landforms, soil function and vegetation while mining continues. | Source: Rio Tinto - Richards Bay Minerals

6. Waste, Tailings, Air and Noise

Aspect	Main concerns	Control themes
Waste rock	Acid generation, metal leaching, dust, instability and footprint.	Characterisation, selective placement, covers, drainage and monitoring.
Tailings	Structural failure, seepage, dust, water loss and long-term liability.	Safe design, governance, monitoring, water balance and emergency readiness.
Hazardous waste	Fire, toxicity, incompatible storage and contamination.	Minimise, label, segregate, contain, track and use authorised facilities.
Dust	Respirable particles, nuisance deposition and reduced visibility.	Source suppression, enclosure, speed control, vegetation and monitoring.
Gaseous emissions	Combustion products, process gases and greenhouse gases.	Cleaner energy, capture, treatment, maintenance and measurement.
Noise and vibration	Health, disturbance, wildlife effects and structural concerns.	Equipment selection, barriers, timing, maintenance and monitoring.
Light	Community disturbance and ecological effects.	Directional lighting, shielding, colour and operating-hour controls.

Tailings management principles

- Understand material behaviour and water balance.
- Use competent design, independent review and accountable governance.
- Operate within defined limits and verify critical controls.
- Monitor deformation, seepage, water levels and performance trends.
- Prepare emergency response and downstream communication arrangements.
- Plan closure configuration and long-term maintenance from the beginning.

WASTE HIERARCHY

Prevent and reduce waste first, then reuse or recycle where safe, recover value where practical, and dispose responsibly as the final option.

7. Progressive Rehabilitation

Progressive rehabilitation is completed during the operating life as areas become available. It reduces the final closure workload, tests methods, controls erosion and demonstrates whether the planned land use can be achieved.

Rehabilitation sequence

Stage	Typical work
1. Plan and characterise	Confirm final land use, material properties, drainage, soil and completion criteria.
2. Make safe	Remove hazards, isolate contamination and control unstable features.
3. Shape landforms	Construct stable slopes, drainage paths and erosion controls.
4. Place growth medium	Rip compacted surfaces and replace suitable soil or cover material.
5. Revegetate	Use appropriate species, seeding/planting methods and seasonal timing.
6. Maintain	Repair erosion, control weeds, manage grazing/fire and replant failures.
7. Monitor and improve	Compare results with completion criteria and adapt methods.

Completion criteria

Theme	Example measurable indicator
Safety and stability	No uncontrolled subsidence; slopes and drainage remain stable.
Soil	Required cover depth, chemistry and erosion performance achieved.
Vegetation	Target cover, diversity, density and sustainable recruitment reached.
Water	Runoff and seepage meet agreed quality and quantity criteria.
Land use	Demonstrated capability for the agreed grazing, conservation or other use.
Maintenance	No unreasonable continuing intervention needed beyond agreed post-closure care.

Progress calculation

If 45 ha are available for rehabilitation and 27 ha meet the defined completion stage: progress = 27 / 45 × 100 = 60%. Report the stage clearly; “reshaped” is not the same as “successfully closed.”

REHABILITATION IS AN OUTCOME

Moving soil and planting grass are activities. Success is demonstrated by stable, functioning land that meets agreed criteria over sufficient time.

8. Mine Closure and Post-Closure

Closure planning begins before construction and becomes more detailed as knowledge improves. It integrates physical works, environmental risks, financial provision, workforce transition, community development and future land use.

Closure domain	Questions to resolve
Physical	Which shafts, pits, buildings, dumps, roads and services remain, change or are removed?
Chemical	Could waste, water, soil or structures release pollutants over time?
Biological	Will ecosystems and vegetation be stable and resilient?
Social	How will jobs, local procurement, housing, services and vulnerable groups be affected?
Economic	What post-mining activities are viable without permanent mine subsidy?
Legal and institutional	Who owns, monitors, maintains and reports on residual features?
Financial	Are rehabilitation, decommissioning and post-closure costs adequately provided for?

Closure cost components

- Demolition and removal of infrastructure.
- Earthworks, covers, drainage and contaminated-land remediation.
- Revegetation and maintenance.
- Water treatment, monitoring and long-term management.
- Professional services, contractor costs, contingency and escalation.
- Social transition commitments where applicable.

Financial provision

PURPOSE

Financial provision protects rehabilitation, decommissioning, closure and post-closure work if the holder cannot perform it. Estimates must be reviewed against current disturbance, methods, rates, residual risk and legal requirements.

Closure certificate does not erase risk

Residual environmental effects may require long-term monitoring and maintenance. Clear responsibility, funding, land ownership and access arrangements are essential.

9. Community Engagement and Participation

Public participation gives interested and affected parties a meaningful opportunity to understand a proposal, raise concerns, contribute knowledge and comment on alternatives and mitigation. Engagement should continue throughout the mine life, not end when authorisation is issued.

Principle	Good practice
Inclusive	Identify landowners, occupiers, traditional structures, municipalities, workers, women, youth, businesses and vulnerable groups.
Accessible	Use appropriate languages, venues, formats, transport arrangements and notice periods.
Timely	Engage before key decisions are fixed and allow enough time for response.
Transparent	Explain benefits, impacts, uncertainty, rights, constraints and what can or cannot change.
Traceable	Record issues, responses, commitments, owners and deadlines.
Respectful	Protect dignity, cultural practices, privacy and freedom from intimidation.
Feedback	Report what was decided, why, and how comments influenced the outcome.

Engagement is not consent or agreement

Stakeholders may disagree even after a fair process. The quality test is whether participation was meaningful, information was understandable, concerns were considered honestly and lawful rights were respected.



Public participation should create genuine dialogue and a traceable response to community concerns. | Source: Canyon Coal - Bekezela public meeting

10. Social Value, SLPs and Grievances

Social and Labour Plans are required under South Africa's mineral law and include commitments linked to human-resource development, local economic development and management of downscaling and retrenchment. They should be evidence-based, aligned with local planning and monitored transparently.

Area	Questions for a strong commitment
Needs and baseline	Is the problem supported by reliable community and municipal information?
Participation	Were affected people involved in defining priorities and design?
Responsibility	What is the mine's role, and what belongs to government or partners?
Outcome	What change should the project achieve, beyond completing construction?
Sustainability	Who will staff, fund, maintain and govern the project after handover?
Measurement	Which indicators, evidence, deadlines and public reports will show progress?
Closure resilience	Will the benefit continue after production and mine funding decline?

Local procurement and employment

- Publish clear, realistic requirements and opportunities.
- Build supplier capability without promising contracts unfairly.
- Use transparent recruitment and prevent gatekeeping or payment scams.
- Track who benefits, contract value, job quality and business survival.
- Avoid dependence on one mine by supporting transferable skills and markets.

Grievance mechanism

Step	Action
Receive	Provide safe, free and accessible channels; allow confidential reporting where suitable.
Record	Assign a reference, classify the issue and protect personal information.
Acknowledge	Confirm receipt and explain the process and expected timing.
Investigate	Gather evidence fairly and avoid retaliation.
Respond	Explain findings, remedy, responsibility and appeal options.
Track and learn	Verify closure, analyse trends and improve systems.

DO NOT BUY SILENCE

Community investment must not replace impact mitigation, compensation where legally required, honest disclosure or the right to raise concerns.

11. Careers and Study Pathways

Career	Main contribution
Environmental scientist / officer	Coordinates impact management, monitoring, reporting and compliance.
Rehabilitation specialist	Plans landforms, soils, vegetation and completion criteria.
Hydrogeologist / water specialist	Studies groundwater, surface water, water balance and pollution pathways.
Ecologist / biodiversity specialist	Assesses habitats, species, ecosystem services and restoration.
Geochemist	Evaluates acid generation, metal leaching and material behaviour.
Tailings / geotechnical engineer	Supports safe residue design, operation, closure and monitoring.
Community-relations practitioner	Manages engagement, commitments, grievances and partnerships.
Social-performance specialist	Assesses social impacts, human rights, livelihoods and closure transition.
GIS and monitoring specialist	Manages spatial data, remote sensing, dashboards and evidence.

Study routes

- BSc in Environmental Science, Geology, Geography, Ecology or Hydrology.
- Engineering degrees or diplomas in mining, civil, chemical, geotechnical or environmental fields.
- Qualifications in community development, sociology, economics, public management or social science.
- Specialised postgraduate study in rehabilitation, water, biodiversity, environmental law or social performance.
- Technical routes in sampling, laboratory work, GIS, surveying, water treatment and land-care operations.

Skills that connect the disciplines

Skill	Why it matters
Science and data	Supports defensible baselines, monitoring and interpretation.
Law and governance	Connects actions to duties, approvals and accountability.
Communication	Translates technical information and supports respectful dialogue.
Systems thinking	Links land, water, ecology, economics and communities over time.
Ethics	Protects evidence, fairness, rights and future generations.

12. Key Terms and Revision

Quick glossary

Term	Meaning
Baseline	Conditions measured before a proposed activity or change.
Completion criteria	Measurable standards used to judge rehabilitation or closure success.
Cumulative impact	Combined effect of past, present and reasonably foreseeable activities.
Environmental authorisation	Official approval setting conditions for listed activities.
Financial provision	Funds or instruments set aside for rehabilitation and closure obligations.
Mitigation hierarchy	Avoid, minimise, restore/rehabilitate and, where appropriate, offset residual impacts.
Progressive rehabilitation	Rehabilitation completed while mining continues.
Residual impact	Impact remaining after mitigation.
Social and Labour Plan	Required plan addressing defined human-resource and socio-economic commitments.
Stakeholder	Person or group interested in, affected by or able to influence an activity.

Revision questions

- 1. Identify impacts at exploration, construction, operation and closure.
- 2. Name the main South African laws relevant to mining and environment.
- 3. Explain the mitigation hierarchy using one mining example.
- 4. Prepare a simple mine-site water balance.
- 5. Calculate topsoil volume for a selected area and depth.
- 6. Explain progressive rehabilitation and completion criteria.
- 7. List seven domains that must be considered in closure planning.
- 8. Describe meaningful public participation.
- 9. Explain why an SLP project needs an operating and maintenance plan.
- 10. Design a grievance process and five performance indicators.

COMMUNITY ACTIVITY

Choose a fictional mine near a river and village. Identify five stakeholders, five possible impacts, one avoidance measure, three monitoring indicators and a fair way to communicate results.

13. References

Sources were checked on 17 August 2026. Legal requirements and project approvals change; always use current official legislation and site-specific authorised documents.

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Image credit - Rio Tinto. Richards Bay Minerals dune-rehabilitation photograph used in Section 5. https://www.riotinto.com/en/Operations/south-africa/richards-bay-minerals

Image credit - Canyon Coal. Bekezela public-participation photograph used in Section 9. https://www.canyoncoal.com/latest-news-and-announcements/bekezela-public-participation-meeting-attended-by-ward-12-community

FUNDAWAY

Learn Today, Achieve Tomorrow. Responsible mining plans for closure from the beginning, uses evidence, rehabilitates progressively and treats communities as rights-holders and partners in decisions that affect them.