GENERAL AGENCY FOR
SPECIALIZED INVESTIGATION
GOVERNMENT REGULATORY AGENCY

In partnership with Canada

MERIT
A CESO AND WUSC PROGRAM

MINE RECLAMATION AND CLOSURE MONITORING

FIELD MANUAL

MONGOLIA: ENHANCING RESOURCE MANAGEMENT THROUGH INSTITUTIONAL TRANSFORMATION (MERIT) PROJECT

Ulaanbaatar
September 2022

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"The Mine Reclamation and Closure Monitoring Field Manual" is published within the implementation framework of the Mongolia: Enhancing Resource Management through Institutional Transformation (MERIT) project, funded by the Government of Canada.

MERIT is an eight-year governance project (2016-2024), implemented through the Canadian Executive Service Organization (CESO) that supports sustainable management of the resource sector. It strengthens the capacity of government and encourages inclusive economic and social development.

OUR VISION is a strengthened and empowered public sector that results in social and economic development that is sustainable and equitable, leading to a better quality of life for Mongolians.

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GLOSSARY

Above-grade landform	Waste rock dumps, tailings storage facilities and overburden stockpiles resulting from mining activities
Below-grade landform	Pits, rock bottom, lake or pond created by mining activities
Best Available Technology (BAT)	The site-specific combination of technologies and techniques that is economically achievable and that most effectively reduces the physical, geochemical, ecological, social, financial, and reputational risks to an acceptable level during all phases of the life cycle, and supports an environmentally, economically and socially viable mining operation.
Best Available/Applicable Practice (BAP)	Management systems, operational procedures, techniques and methodologies that, through experience and demonstrated application, have proven to reliably manage risk and achieve performance objectives in a technically sound and economically efficient manner. BAP is an operating philosophy that embraces continual improvement and operational excellence, and which is applied consistently across the mine lifecycle phases.
Biological rehabilitation	Activity carried out for the purpose of recovering the soil fertility and vegetation of the technically rehabilitated land
Consultant	Green Focus Facilitator NGO
Client	MERIT project
Humus	Organic and mineral components, originated from living organism and accumulated in Layer A of the topsoil that supply plant tissue and organs with nutrients via their roots
Landholder	The owner of freehold land, the holder of leasehold land, or any person or body who occupies or has accrued rights in freehold or leasehold land.
Landform	A single constructed mine facility: dump, mined out pit, stockpile, tailings facility
Landform design	Landform design is the multidisciplinary process that builds mining landforms, landscapes, and regions to meet agreed-upon land use goals and objectives.
Post-mining Land Use	Term used to describe a land use which occurs after the cessation of mining operations.
Reclamation	As for rehabilitation, but specifically refers to the restoration of residual landforms following cessation of mining. A rehabilitation that completely eliminates the residual impact of mining and brings economic, environmental protection, appearance and value to the same level as prior to mining activities

Relinquishment	Formal approval by the relevant regulating authority indicating that the completion criteria for the mine have been met to the satisfaction of the authority.
Rehabilitation	Comprehensive measures to transform the degraded area of the mine into an ecologically sustainable and efficient natural ecosystem that is rehabilitated in accordance with the purpose of post-mining land use
Soil	Fertile surface horizon that develops on geologic materials over time as result of the influence of climate, weathering, geochemistry and flora/fauna.
Standard	A document that prescribes the requirements with which the product, service or function has to conform.
Subsidence	Surficial depression without causing any land surface fracture, due to collapse of underground mining structures, dewatering and settlement of saturated backfill material in open pit mines, or inadequate compaction of backfill material in open pit mines
Tailings facility	The collective engineered structures, components and equipment involved in the management of tailings solids, other mine non-hazardous waste managed with tailings (e.g., waste rock, water treatment residues), and any water managed in tailings facilities, including pore fluid, any pond(s), and surface water and runoff
Tailing	The materials left over after the process of separating the valuable fraction from the uneconomic fraction of an ore. Tailings are the waste rock or other non-hazardous material that overlies an ore or mineral body and is displaced during mining without being processed.
Technical rehabilitation	Preliminary restoration of surface topography and drainage patterns after mining to prepare disturbed land for specific end land use objectives
Temporary Closure	Phase following temporary cessation of operations when infrastructure remains intact and the site continues to be managed.

ACRONYMS

AML	Asid and metalliferous leaching
AMD	Acid and metalliferous drainage
BEIA	Baseline Environmental Impact Assessment
BE	Business entity
CRM	Citizens Representative Meeting
DMCP	Detailed Mine Closure Plan
CSO	Civil Society Organization
DEIA	Detailed Environmental Impact Assessment
EMP	Environmental Management Plan
EMoP	Environmental Monitoring Program
EGAC	Environmental General Assessment Conclusion
FS	Feasibility study
GASI	General Agency for Specialized Inspection
MNS	Mongolian National Standard
MET	Ministry of Environment and Tourism
MERIT	Mongolia: Enhancing Resource Management through Institutional Transformation
MMHI	Ministry of Mining and Heavy Industry
NGO	Non-governmental Organization
PMCP	Preliminary Mine Closure Plan
SGS	South Gobi Sands LLC
RA	Rehabilitated area
RE	Responsible for Environment
RGM	Responsible for Geology and Mining
TSF	Tailings Storage Facility
UNDP	United Nations Development Programme
UR	Undisturbed area

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MERIT Project, funded by the Government of Canada delivers "Mine Reclamation and Closure Monitoring Field Manual" which jointly developed by Canadian Technical Advisors and National consultant team. Thomas Ross Eccles and Gord Mckenna are the Canadian Technical Advisors who led the design, content and editing of the Field Manual on Mine Closure and Reclamation. The National consultants from Green Focus Facilitator NGO who worked on the manual are: Erdene Dorjsuren, (M.A.), Environmental Policy Expert; Ariunbold Dogmidsangi, Environmental Auditor; Dr. Suran Dagdan, Vegetation Expert; Tsetsenbileg Burenbayar, Lawyer; and Erdenechimeg Regjiibuu, MERIT Environmental Specialist.

The field manual was piloted with the guidance of the environmental inspectors in the Tuv province with support from inspectors from Dornod in September 2020 and with the guidance of the environmental inspectors in Sukhbaatar with support from environmental inspectors from Dundgobi in September 2021. Special thanks to the Governors of these provinces for their leadership and to the officials from the General Agency for Specialized Inspection, the Ministry of Environment and Tourism, the Water Agency, the Ministry of Mining and Heavy Industry and the Environmental Research Center who actively informed and strengthened the field manual while contributing to a national level discussion on environmental oversight.

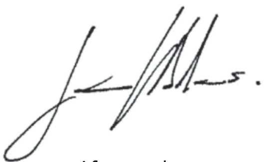
FOREWORD

This field manual on Mine Closure and Reclamation is a practical reference for inspectors containing reliable, objective and timely information to understand and manage mine closure and reclamation in placer gold, open-pit coal, and metal mines. The manual is aligned with the current laws and policies and is informed by international best practice. The aspiration of this field manual is to promote a common understanding and enhance capacity among practitioners and decision-makers in carrying out their assigned duties related to the oversight of mine closure and reclamation.

The MERIT Project, funded by the Government of Canada, supports initiatives and progress in environmental protection. A wealth of practical experience has been gained through the project's capacity building efforts with motivated officials at the central, provincial and district levels.

This manual represents a collaboration between Canadian technical advisors, local consultants and the ministries, agencies and provincial organizations responsible for the oversight of Mongolia's mining and environmental sectors.

The use of this manual will guide the inspectors towards consistency in the scientific methods and procedures used, document those methods and procedures and maintain technical expertise. MERIT is pleased to align our work with the action plans of the Government of Mongolia and the ongoing work of the General Agency for Specialized Inspection (GASI), the Ministry of Environment and Tourism (MET), the Ministry of Mining and Heavy Industry (MMHI) and provincial governments. These partnerships promote a consolidated effort to improve performance and achieve the government's desired results in environmental protection.



Jennifer Adams

Country Director

MERIT

INTRODUCTION

The 'Mongolia: Enhancing Resource Management through Institutional Transformation' Project (MERIT) is funded by Global Affairs Canada and will continue for eight years (2016-2024) to stimulate sustainable economic growth in Mongolia by strengthening the capacity of public institutions to effectively manage the extractive sector.

MERIT is a governance project that promotes responsible mining through capacity-building with central-level ministries and agencies, as well as the provincial and district governments in Dornod, Tuv, Sukhbaatar and Dundgobi. One type of technical assistance provided is to strengthen environmental management and compliance practices within the mining sector. This is achieved through collaborative work with the Ministry of Environment and Tourism (MET), the General Agency for Specialized Inspection (GASI), with their local offices at the provincial level, and the Environmental Departments at the governor's offices to address the concerns of mining-impacted communities in the four provinces. MERIT has worked with GASI to develop technical guidance for practical and affordable field-based monitoring tools and techniques to strengthen mine inspections and to improve the environmental performance of mining operations.

This field manual is intended to provide basic but effective field measurements on mine closure and reclamation in placer gold, open-pit coal, and metal mines. The manual provides STEP-BY-STEP GUIDANCE THAT LOCAL INSPECTORS AND ENVIRONMENTAL OFFICERS CAN UNDERTAKE DURING THEIR MINE SITE INSPECTIONS TO EVALUATE MINE CLOSURE AND RECLAMATION PERFORMANCE.

The purpose of the field manual is to provide consistent and equitable procedures for enforcement officers and technical staff who are responsible for evaluating concurrent reclamation performance against the proposed success criteria, including landform design and stability, soil conservation and reconstruction, and revegetation, erosion, drainage and surface water runoff design. This guidance is primarily targeted for local environmental officers, state inspectors, ecological police officers, and rangers at provincial and district levels. Moreover, the document can be used by wider interested parties such as industry specialists, professional organizations, environmental NGOs and community groups.

The document is structured in the following way: Chapter I summarizes the legal and regulatory frameworks that govern mine closure and reclamation in Mongolia; Chapters II-VI provide an overview of leading practice approaches to achieve successful mine closure and reclamation completion; while Chapters VII-IX provide direction on the practical and applicable field measurements, techniques and tools that could be used by inspectors during their mine site inspection to monitor and evaluate the reclamation and closure performance on mining operations.

The measurement procedures described in field monitoring sections provide valuable guidance for the field officers and inspectors. They recommend success criteria for interim closure and reclamation compliance, including, key monitoring issues; measurable parameters for monitoring compliance; measurement and analytical techniques and tools; sampling locations, intensity and frequency; and standards for evaluating compliance (e.g., government guidelines, etc.). A number of mine case studies are used to illustrate various aspects of mine closure and reclamation in different ecoregions of Mongolia.

RATIONALE/CONTEXT

The minerals sector is the main driver of Mongolia's economic development. Mongolia's long-term development policy, 'Vision-2050' places a strong focus on green development and sustainable mining to foster economic development and promote environmental sustainability. The Government is committed to responsible mining, transparency and accountability while strengthening the sector's competitiveness.

The MET and the Ministry of Mining and Heavy Industry (MMHI) are involved in efforts to update legislation for the mine closure and reclamation aligned with leading practice. The Regulation and Guideline for Development of the Rehabilitation and Closure Management Plan for Mines and Concentration Plants was approved in 2019 as a governance framework for mine closure and reclamation.

Reclamation is an integral part of permitting to mitigate the short, mid and long-term environmental and economic impacts. If mine closure and reclamation are not undertaken and reviewed in a planned and effective manner, a site may continue to be hazardous and a source of pollution for many years to come. Local government and affected communities are demanding a voice to have quality reclamation standards and processes. Particular importance is given to safeguard environmental protection and social well-being, balanced with financial performance.

The national program "Rehabilitation 2020-2024" has been implemented to intensify the land reclamation efforts and to safeguard the sustainability of ecosystem services, increase the proper use of natural resources and ensuring environmentally sound extractives operation. This national campaign aims to reclaim a total of 8,000 hectares over 4 years. The total abandoned mining areas is 30,000 hectares.

Ministries, agencies, local government and MERIT are collaborating to strengthen capacity based on leading practices. The training and this guide provide consistency and clarity on performance monitoring requirements for both government and industry.

Although it was mentioned that the mining sector plays a key role in our economy, Mongolia is in the initial phase of development of this sector comparing to other countries. Mine sector development of Mongolia has around 100 years history but the satisfactory rehabilitation experiences are limited. Mine closure and rehabilitation procedures were only approved by the government in 2019. Therefore, none of the mines have been closed according to this procedure so far. Secondly, the size of mine reserves is comparatively small and sparse.

In addition, the manual is the joint product of the Canadian and Mongolian team of consultants together with MERIT staff. Some concepts and best practices developed in Canada are new to Mongolia and may not always be immediately applicable to the economic and environmental setting. However, it is inevitable that Mongolia will, sooner or later, face these issues and will need to be better prepared.

A single environmental inspector in Mongolia is commonly responsible for inspection and monitoring duties over an entire soum territory that covers thousands of hectares. Recognizing the workload pressures being faced by the inspectors, it is the intent of this guidance document to provide inspectors with consistent, repeatable inspection and monitoring procedures that:

- Are understood and accepted by the mining operators;
- Can be practically and efficiently undertaken and completed during a 1-2 day mine site visit; and
- Provide real time, meaningful data on the adequacy of environmental protection measures, and reclamation and closure performance at the mine site.

SECTION I.
SUPPLEMENTAL CONTEXT

GENERAL SUMMARY

This section introduces the fundamental concepts of mine reclamation and closure, including legal and regulatory framework, progressive mine reclamation, mine closure planning and key components of the closure:

- ☑ LEGISLATIVE AND REGULATORY FRAMEWORK
- ☑ PROGRESSIVE MINE RECLAMATION DURING LIFE OF MINE
- ☑ MINE CLOSURE
- ☑ KEY COMPONENTS OF CLOSURE
    1. Sustainable landform design
    2. Soil conservation and reconstruction
    3. Revegetation

There are two case studies selected to illustrate various issues related to mining reclamation and closure:

Case study 1 - Topsoil and subsoil stripping in South Gobi Sands LLC

Case study 2 - Revegetation

1. LEGISLATIVE AND REGULATORY FRAMEWORK

The mining sector plays an important role in the economy of Mongolia. However, the increasing level of mining activities also raises, among others, issues of environmental protection and restoration. Although a comprehensive Mongolian environmental regulatory regime existed, and the Minerals Law covers license holders' obligations towards the environment, the government did not consider it to be adequate in practice. Attempts have been made to resolve this issue on a piecemeal basis by adopting several measures in the last few years, such as increasing water extraction fees, imposing stricter environmental obligations on mining license holders and requiring the deposit of "environmental restoration bonds". For example, in 2019, the government approved "The Regulation on Rehabilitation and Closure of Mines and Concentration Plants".

Given the importance of ecosystem management to any society seeking to achieve a more sustainable development path, Mongolia has been making on-going efforts to modify its legal environment for the mineral sector and to align it more closely with global standards. The list of laws, regulations and national standards is enclosed as Annex 10.1.1-10.1.2 and provides a brief description of the key legislative and regulatory guidance documents and existing mine standards in Mongolia

1.1 MAJOR LAWS

The Law on Minerals (2006/2019)

The key law for the mining sector is the 2006 Law on Mineral, which was amended more than 20 times. This law regulates "the prospecting, exploration and mining of minerals within the territory of Mongolia" and establishes environmental protection and regulations in exploration areas and areas surrounding mines and mining operations.

The most important mine-closure-related amendment to the 2006 Law was adopted in 2014. The Article 10.1.4 requires the Regulation on Rehabilitation and Closure of Mines and Concentration Plants to be jointly approved by the Minister of Mining and Heavy Industry and the Minister of Environment and Tourism.

Law on Environmental Protection (1995/2019)

The 1995 Law on Environmental protection addresses responsibilities of various governmental authorities on environmental protection, environmental assessments, environmental inspections and monitoring, research and information, participation of citizens and NGOs in environmental protection, and economic incentives and fees and payments for the use of natural resources.

In 2012, an amendment to the law introduced the concepts of environmental auditing, biodiversity offsetting and the "polluter pays" principle. Also, the amendment extended the provisions on liability for damages caused to the environment and amended penalties for violation of the law.

Law on Environmental Impact Assessment (2012/2017)

Mongolia has relatively comprehensive regulatory legislation for environmental impact assessments that covers all major mining and petroleum production activities. The Law on Environmental Impact Assessment was first adopted in 1998 and went through a number of amendments during subsequent years, and a revised law was approved in May 2012.

The accompanying regulations were adopted by the Minister of Environment and Tourism (MET) to support and implement the law:

- Regulation of environmental impact assessment Government Resolution 374 (2013);
- Regulation on Environmental Strategic and Cumulative Impact Assessment Government Resolution 374 (2013);
- Regulation on Formulation, Review and Approval and Reporting of Environmental Management Plan A/618 (2019);
- Regulations on Ensuring Public Participation in Environmental Impact Assessment №A/03 (2014); and
- Regulation on monitoring the transaction of special account for environmental protection and rehabilitation guarantee A/04 (2014).

Under the EIA law, a detailed environmental impact assessment (DEIA) is to be developed for all major extractive projects by a MET-accredited assessor company that is retained by the license holder. The DEIA is a key planning tool that identifies particular project risks and impacts, and must include an Environmental Management Plan (EMP) that "translates strategic goals of the DEIA into concrete, budgeted, scheduled activities to mitigate and monitor identified environmental risks".

The license holder is required to provide an updated EMP every year to clearly document proposed environmental protection activities for the coming year. The license holder is also required to submit to MET an annual EMP Report, which reports on the company's performance at meeting EMP commitments for that year. Progress reports on rehabilitation/reclamation, offsets, and hazardous material disposal for the year and any independent third-party audit reports must also be provided by the company for review.

Other relevant laws are described in Annex 10.1.1 Laws and Legislative Acts.

1.2 MAJOR REGULATIONS AND METHODOLOGY

Regulation on rehabilitation and closure of mines and concentration plants A/181 (2019)

The Regulation on Rehabilitation and Closure of Mines and Concentration Plants was approved by the Ministry of Environment and Ministry of Environment and Tourism through their joint decree numbered A/181 and A/458 dated 28th of August, 2019. The purpose of this regulation is to set out closure requirements and relations relating to the content, requirements, processing, delivery and control of these documents, in accordance with inter alia Mongolian Minerals Law, Environmental Impact Assessment Law and other applicable laws.

In compliance with this regulation, three types of mine closure plans must be developed by the project proponents and three new documents as follows.

- Preliminary mine closure plan shall be included in the Feasibility study;
- Detailed mine closure plan shall be developed and approved at least three years prior to commencement of mining closure activity.

If it was confirmed by state integrated resources registration that the ore resources cannot be extracted by industrial methods and become economically inefficient due to the technical and economic basis of using the deposit or the lack of reserves, project implementor shall submit a request about the complete closure of mine to MMHI minimum an year prior to implementing mine closure.

The accompanying document, the Guideline for the Development of the Rehabilitation and Closure Management Plan for Mines and Concentration Plants is developed and approved in compliance with the Articles 2.1 and 2.2 of the Mine Closure Regulation. The guideline provides a framework that leads toward successful mine closure and relinquishment of mine lands, and defined the needs and contents of mine closure planning. *Please refer to more detailed information about the regulation in The Annex 10.1.3*

Regulation on monitoring the transaction of special account for environmental protection and rehabilitation guarantee A-04 (2014)

In accordance with the Articles 9.9 and 9.10 of the Law on Environmental Impact Assessment, "Regulation on Monitoring the Transaction of Special Account for Environmental Protection And Rehabilitation Guarantee" was approved through the Decree No. A-04 (2014) of the Minister of Nature, Environment and Green Development. It regulates the control of income and expenditure transactions of the special fund ("special account"), and where the project implementer shall place the guarantee funds to fulfill its obligations on environmental protection and rehabilitation. Mining entities are required to report on reclamation progress in line with approval conditions, usually on an annual basis, that include careful estimates of reclamation costs. These are reviewed and approved by MET in line with changes in the mine plan.

- Mineral exploration - shall deposit 50% of the guarantee fund to Local Government for the implementation of the annual EMP; and
- Mineral extraction, processing and chemical plant - shall deposit 50% of the guarantee fund to the MET for the implementation of the annual EMP.

Mining entities need to demonstrate to regulators that reclamation objectives have been met before the bond is returned.

Methodology for Technical and Biological Rehabilitation of Land Affected by Mining Activities A-138 (2015)

Methodological guidance for technical and biological reclamation of mined land Regulation was approved by the Minister of Environment, Green Development and Tourism in 2015. This methodology covers the important aspects of the rehabilitation. The first, technical rehabilitation of the disturbed land, must be consistent with and supportive of the end land-use objectives agreed to by affected stakeholders. Final decisions on the backfilling of pits and the recontouring of waste rock and overburden will also be dependent on the type of materials encountered at the mine and extraction techniques used during mine operations.

Moreover, soil salvage, storage and replacement methods for land rehabilitation must be defined by the mining company along with available materials like dung, manure, dust straw, etc., to be used for soil improvement.

- Biological rehabilitation will depend on the type of ecological zone, and is to be implemented after technical rehabilitation is completed. In addition, topsoil redistribution, selection of species, timing to plant, set norms and normative, after-planting care, monitoring of vegetation growth and germination rate are also included in this methodology; and
- Policy and measures to be implemented by mine project proponent regarding the contribution to and management of costs required to implement the mine reclamation and closure plan is also described by the methodology.

1.3 MONGOLIAN STANDARDS

Mongolia has several national standards related to the rehabilitation of disturbed land, the preservation of topsoil, and the technical and biological rehabilitation of land and subsoil. The most directly involved standards are described below:

- *MNS 5914:2008 Environment. Reclamation of disturbed land. Terms and definitions* -Determines terms and definitions related to the issue of reclamation of land disturbed by industrial activities.
- *MNS 5916:2008 Environment. Fertile soil /top soil/ removing and its temporary storage during the earth excavation* - Sets out general requirements for topsoil stripping and stockpiling in mine operations;
- *MNS 5917:2008 Environment. Reclamation of land destroyed due to mining activities. General technical requirements* - Sets out general requirements for mine rehabilitated land;
- *MNS 5918:2008 Environment. Revegetation of destroyed land. General technical requirements* - Defines the general requirements for revegetation of disturbed land;
- *MNS B: 2013 Environment. General requirement of tailings storage and re-use facility of wet mineral processing plant* - Specifies guidelines and principles for the safety management of dams of wet mineral processing to manage the risks associated with these structures; and
- *MNS C: 2013 Environment. General requirement of tailings storage and re-use facility of dry mineral processing plant* - Specifies guidelines and principles for the safety management of dams of dry mineral processing to manage the risks associated with these structures.

Other relevant standards are listed in Annex 10.1.2.

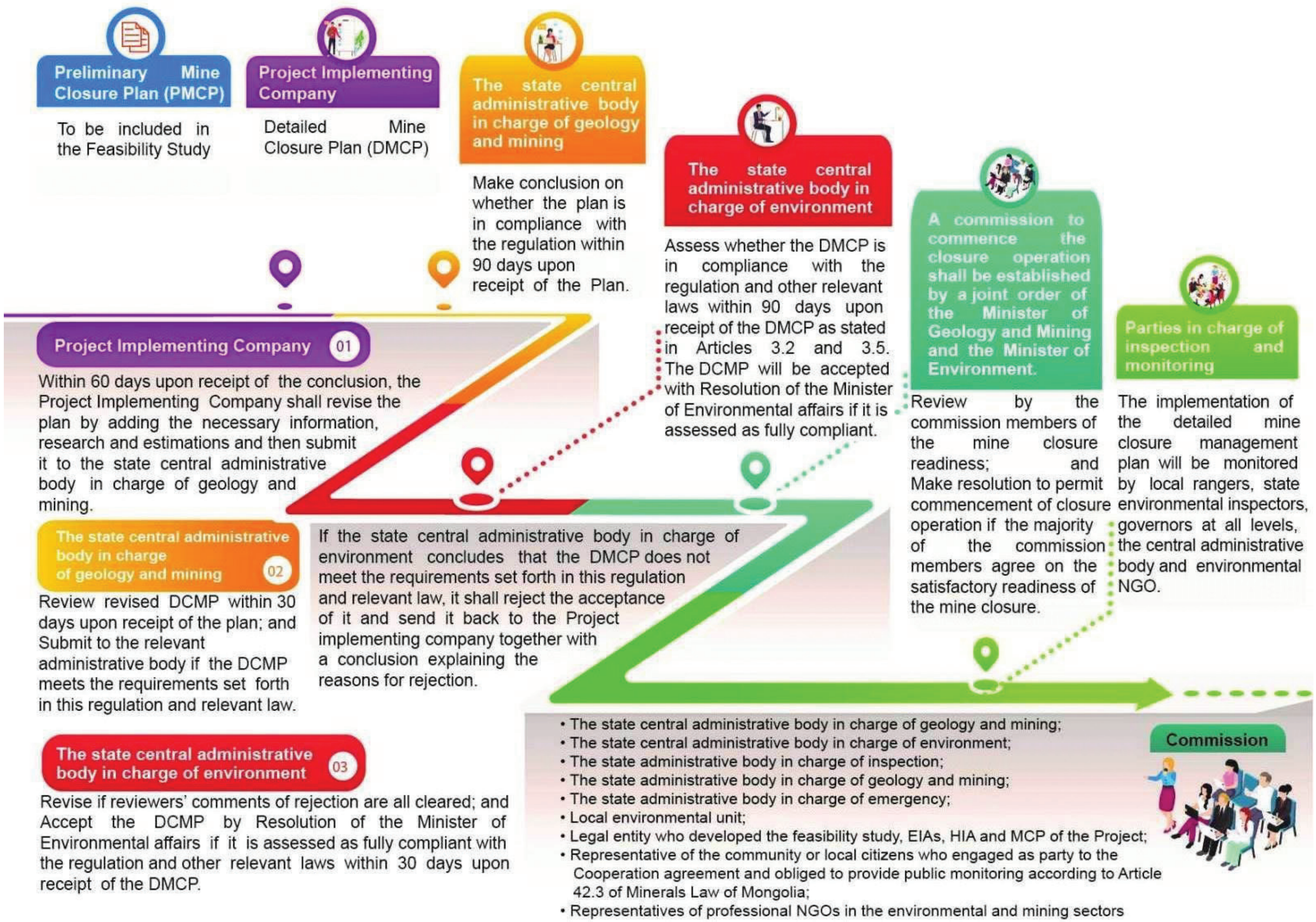


Diagram 1. Map for approval of mine closure management plan (detailed steps)

Diagram 2. Approval process of the Closure management plan

2. PROGRESSIVE MINE RECLAMATION DURING THE LIFE OF A MINE

2.1 DEFINITIONS

Modern mining practices generally encourage forward thinking through the whole process to ensure minimum disturbance and maximum efficiency in land use. For this reason, the mines of today prepare for a rehabilitated landscape right from the beginning in a process known as "**progressive reclamation**". The progressive reclamation involves the staged treatment of disturbed areas during exploration, construction, development and mining operations as soon as these areas become available, rather than undertaking large scale rehabilitation works at the end of planned exploration and/or mining activities.

Progressive mine reclamation is defined differently across the mining industry, yet the consensus is that it represents "best available technology" for reducing environmental risks at closure and optimizing closure costs.

Canadian and Australian definitions of progressive reclamation are illustrated below:

> *"The process of restoring land that has been mined to a natural or economic usable state in an ongoing manner over the life of mine." (British Columbia, Canada); and*
>
> *"A life of mine process that produces benefits that enable post-mining land-use objectives to be achieved." (Australia)*

As a critical part of mine design and operational procedures, progressive land reclamation plans for the reclamation and closure of available portions of the mine footprint during active mine life. It reduces net land disturbance from the active mine footprint during operations and minimizes reclamation and closure requirements at the end of the mine life. Progressive reclamation also allows users back on the land progressively where practical, reducing the socioeconomic impact of the mine and allowing users to personally judge the performance of the reclaimed land.

2.2 MITIGATION HIERARCHY FOR REDUCING LAND DISTURBANCE DURING MINE OPERATIONS

The mitigation hierarchy is an iterative best-practice approach to limiting and managing negative impacts of mining projects, helping to balance environmental and social needs with mine development priorities.

Planning future activity should consider the aspects such as impact avoidance, operational mitigation, reducing damage footprint, reducing double handling of materials and maximizing reclamation outcome.

The mitigation hierarchy consists of four steps:

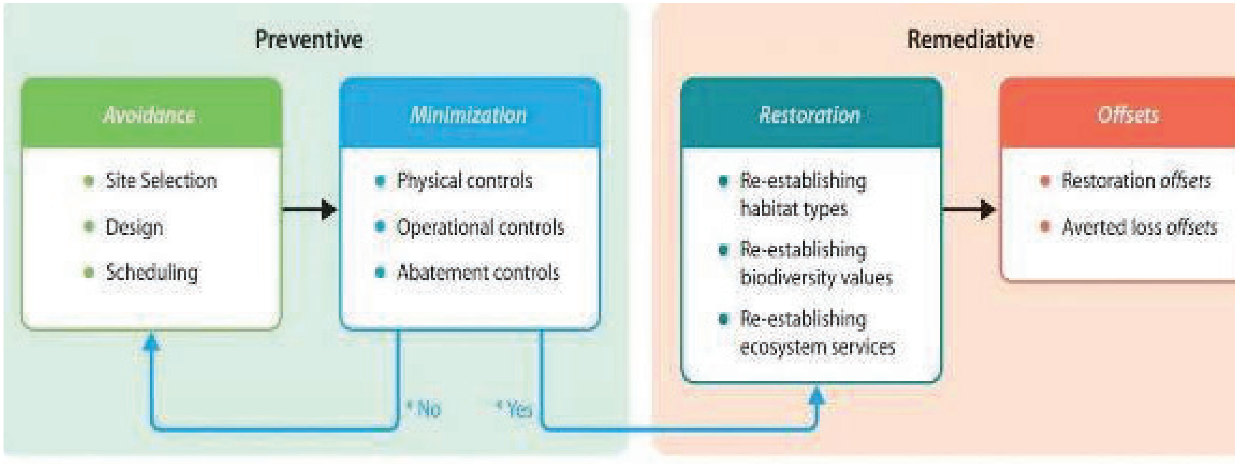


Diagram 3. Potential impact management through mitigation measures

These four steps must be followed in order – **Avoid, minimize,** and **restore** impacted areas and finally **Offset** any impacts that remain. Preventing impacts (steps 1 and 2) is most effective. Restoring or offsetting impacts is usually costly and has a higher risk of failure. In practice, applying the mitigation hierarchy is not a linear process: projects will often need to go through a series of iterations to ensure that they have prevented impacts as much as possible. The diagram above shows a simple illustration of this iterative process.[1]

- **Avoidance:** The first step of the mitigation hierarchy comprises measures taken to avoid creating environmental impacts on biodiversity, such as screening potential risks prior to project design and selecting an alternate development site and avoid from the outset;
- **Minimization:** The second step of the hierarchy requires that before and during development, impacts are minimized, such as by using more environmentally friendly technologies. It consists of measures to reduce the duration, intensity and/or extent of impacts that cannot be completely avoided;
- **Restoration/Rehabilitation:** The third step requires that biodiversity loss is then restored within the footprint of the development and includes measures taken to improve degraded or removed ecosystems following exposure to impacts that cannot be completely avoided or minimized, which could entail actions such as reseeding affected land or developing a breeding program for affected species during and after project completion; and
- **Offset:** The fourth and final step requires that any residual impacts not captured by the first three steps of the hierarchy are offset elsewhere, such as through wetland restoration or the removal of invasive species from ecologically important areas and measures taken to compensate for any residual, adverse impacts after full implementation of the previous three steps of the mitigation hierarchy.

[1] https://www.sprep.org/attachments/VirLib/Regional/gn-mh-general.pdf

As the world's population and economy grow, the use of resources such as food, water, energy, and minerals is increasing. Addressing this growing global need with environmental protection and sustainable development goals is one of the challenges. Countries around the world are focusing on reducing the impact of projects and developing and implementing policies to reduce habitat loss and maintain or restore biodiversity. The measure is defined as "biodiversity offset" and is translated into Mongolian as "биологийн олон янз байдлын дүйцүүлэн хамгаалал".

Offsetting measures shall not be a ground for relieving the project implementer from the obligation to rehabilitate (Environmental Impact Assessment Procedure: 5.2.3). In some cases, there are misconceptions, such as the implementation of offset at the project closure stage after reclamation. Along with avoiding the impact by implementing possible mitigation measures, offsetting measures for the unavoidable impacts will begin as the project begins. At the beginning of reclamation, the reclaimed impact can be excluded from the offset protection requirement.

Guide to Planning and Implementation of Offsetting Measures 2018,

MET, UNDP, and TNC

2.3 INTEGRATING PROGRESSIVE RECLAMATION INTO MINE PLANNING

Mine reclamation involves design, planning, operations, and monitoring/maintenance. Effective early planning will minimize reclamation costs. Taking a more integrated and progressive approach to mine planning and engineering decision-making processes should optimize opportunities for progressive rehabilitation consistent with the post-mining land use(s) and closure objectives.

A progressive (staged) reclamation plan needs to be developed according to the site-specific objectives for mine closure, and it should be undertaken over the mine life cycle.

The progressive reclamation plan addresses below aspects:

- Design of final landforms and drainage structures;
- Estimating, reconciling and scheduling reclamation material inventories;
- Staged construction and earthworks (including regrading of temporary mine-waste slopes and construction of surface-water drainage channels);
- Landform surface treatments (ripping, selective application of topsoil, placement of materials);
- Revegetation research and trials;
- Reclamation performance monitoring; and
- Ongoing improvement and refinement of reclamation techniques.

2.4 BENEFITS OF PROGRESSIVE RECLAMATION

Progressive reclamation can provide an early indication as to whether the Mine Closure Plan needs to change to meet closure objectives proposed by the proponent and whether closure objectives are realistic and achievable. Furthermore, progressive reclamation enables contamination issues to be adequately managed in an appropriate manner and within an appropriate timeframe based on the risk posed. Not managing contamination issues in a timely manner can result in an increase of the extent of that contamination and represent an exponentially greater cost of remediation at mine closure. There is a large overall benefit, not only in cost, to dealing with contamination through a progressive process, rather than leaving such actions to the point of closure, which can be many years (or decades) in some cases.

As a key component of mine closure implementation, progressive reclamation has many benefits, including:

- Reduced financial liability under the Mining Rehabilitation Fund as reclamation progresses;
- Showing responsible closure commitment to the community and regulators by reducing the un-rehabilitated "footprint" of the mine; and
- Costs of reclamation are managed throughout the life of the mine.

In addition, if it is properly conducted, progressive reclamation will have a number of advantages:

i) Early revegetation reduces dust and improves visual surroundings; improves runoff water quality by minimizing silt loads;

ii) Increased efficiency through reduction of double handling of waste rock and reclamation materials;

iii) Reduced future reclamation costs, minimized duration of environmental exposure, and enhanced environmental protection;

iv) Ongoing feedback by key stakeholders through monitoring of the effectiveness of reclamation designs;

v) Shortened time for achieving closure objectives and valuable experience provided on the effectiveness of certain measures that might be implemented during permanent closure;

vi) Facilitation of timely bond recovery and tenement relinquishment;

vii) Lower risk of regulatory non-compliances and less regulatory interest. Anticipated closure outcomes are more reliable as they are the product of considered decisions, scientific trials and investigation; and

vii) Tension of the local community and other relevant stakeholders will be minimized.

Photo 1. Progressive reclamation

Although the progressive mining reclamation process brings up a number of benefits, it can be also complicated in terms of technical and technological perspectives. In some cases, next stages of the active mine operations could harm or disturb the previously rehabilitated land.

Progressive reclamation approaches for placer gold mining

The planning and implementation of progressive reclamation measures should include consideration of:

- Grade or re-contour overburden piles and steep excavated slopes to stable configurations as they become inactive;
- Direct place topsoil from active topsoil stripping areas onto backfilled and contoured landforms ready for biological reclamation to conserve native seed bank;
- Revegetate reclaimed landforms as they become available;
- Establish a dynamic, operational surface drainage system to minimize fresh water contact with mine operations; and
- Minimize disturbances of surface and ground water systems through earth dam construction for process-affected water impoundment, water recycling, and water quality management.

Progressive reclamation approaches for open pit coal and metal mining

The open pit involves the operators making significant structural changes to the land to allow the physical removal of minerals and to allow access of vehicles and workforce to the mine during operation. Following cessation of mining, the land must be made structurally sound. The mine site must also have some defined shape to it and this will require the design of terrain to recreate an appropriate landscape and provide a basis for the returning ecosystem.

Progressive reclamation options for open pit mine workings may include, but are not limited to, the following:

- If multiple pits are excavated, sequentially backfill pits with waste rock and/or tailings as operations proceed;
- Alternatively, create pit lakes to treat mine site water if backfilling is not feasible;
- Map exposures of mineralized rock in high walls as they become apparent and conduct ARD/ML assessments;
- Identify and monitor seepage locations and water quality from high walls during operations;
- Waste dump construction and reclamation should, where practicable, start on the outer dump perimeter with later dumps inside the rehabilitated perimeter dumps;
- Final pit walls and pit floors to be progressively rehabilitated;
- Implement best available practices to select the most appropriate technology for tailing facilities to manage risks on a site-specific basis, and establish an ongoing risk assessment and control program;
- Contain and encapsulate the tailings to prevent their escape to the environment
- Minimize seepage of contaminated water from the TSF to surface waters and ground waters; and
- Provide a stabilized surface cover to prevent erosion from the tailing facilities.

For large-scale hard rock mines, proponents should consider using pits for backfilling waste (particularly where there are multiple pits) and progressively rehabilitate areas where possible, e.g. linear and supporting infrastructure areas.

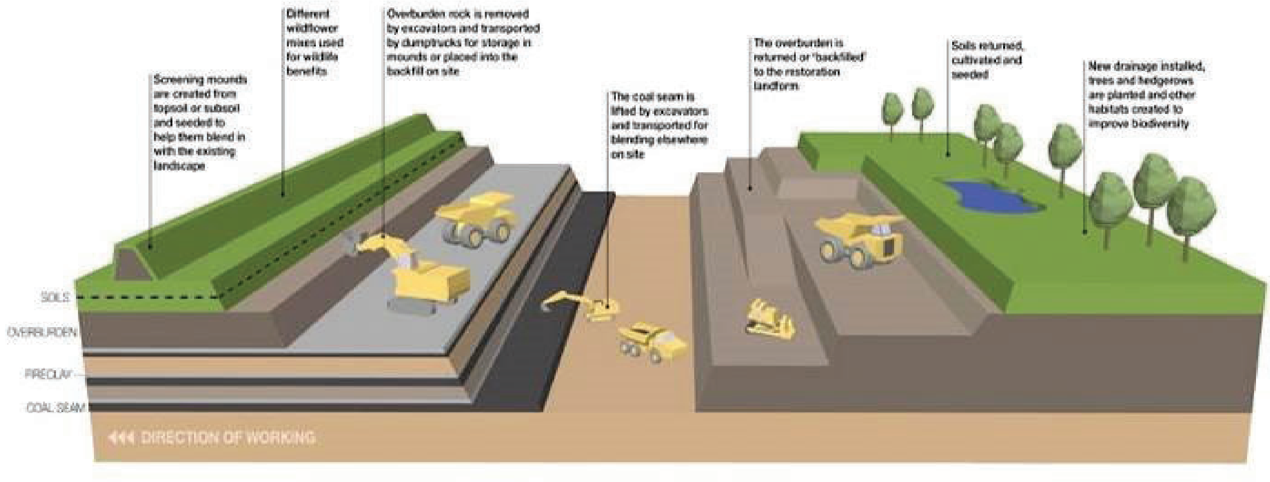


Diagram 4. Open pit mine progressive reclamation

3. MINE CLOSURE

3.1 DEFINITIONS AND PRINCIPLES

After mining activities are completed, the areas are considerably altered in comparison with their original state which, in many cases, is considered degradation or at least deformation of the environment.

Mine closure is the process of transforming an active mine into a set of safe and stable landforms that are non-polluting and provide habitat and ecosystem services and/or support economic activities by the new land users. The principal closure objectives are for rehabilitated mines to be (physically) safe to humans and animals, geotechnically and geochemically stable, non-polluting/non-contaminating, and capable of sustaining an agreed-to post-mining land use.

3.2 HIERARCHY OF MINE CLOSURE NEEDS

Mine closure plan provides frameworks that leads to closure and relinquishment of mine lands, addressing the key aspects of physical and chemical stability, as well as successful socio-economic transition and beneficial use.

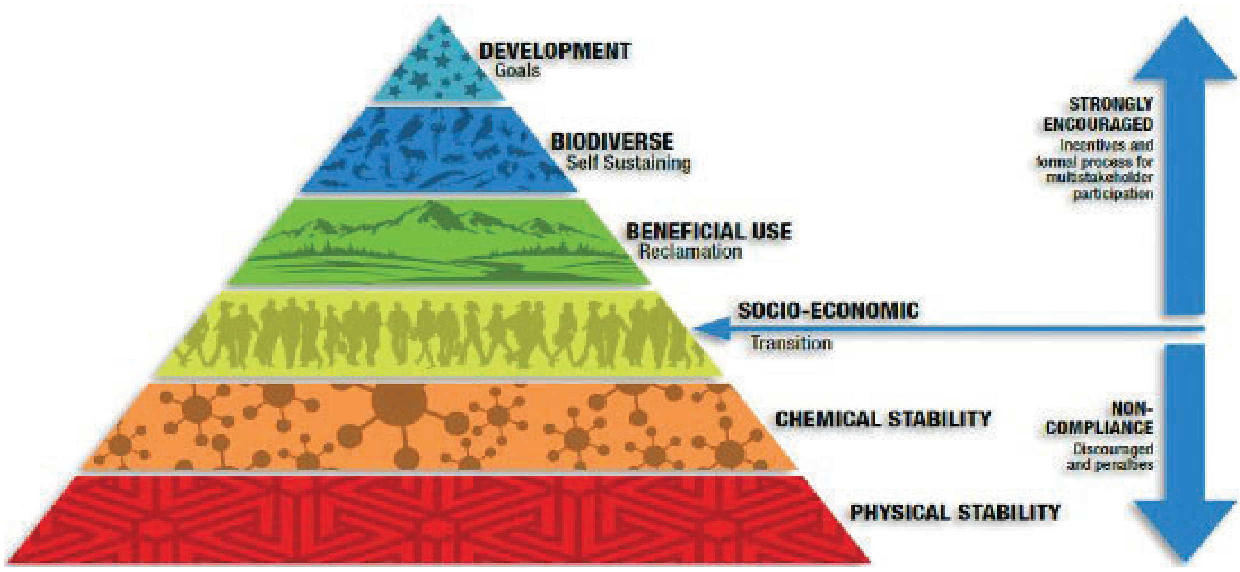


Diagram 5. Hierarchy of mine closure (Source: Mine Closure Checklist for Governments, Asia Pacific Economic and Technical Cooperation, Feb. 2018)

I. Physical Stability-At the most fundamental, rebuilt landforms must be geotechnically stable and resist the risks of significant failures, either under normal operation or under the influence of infrequent events such as earthquakes and floods.

II. Chemical Stability – Geochemical safety should address the risk of any solute concentrations being too high or too low (e.g. acid rock drainage or metal leaching). Wastes may be very reactive and prone to generating impact on contact water.

III. Socio-economic Transition- When the mine life comes to an end, the transition can result in job loss, loss of social programs, and loss of taxes can have lasting negative impacts, especially in areas where the mine was the main employer.

IV. Beneficial Use – Reclamation - Considerable emphasis shall be placed on reclamation activities, designed to either restore the mined landscape to its pre-mining use or ensure that some other beneficial use of the land is possible following closure.

V. Biodiverse – Self-Sustaining - Seeks to attain a post-closure landscape that has a biodiversity equal to (or even greater than) the pre-mining conditions, with self-sustaining ecosystems attained.

VI. Development Goals – When properly managed, the complete mine life cycle, from planning and development through to operations, closure, and post closure, can provide a net development benefit to the country, providing a long-lasting positive impact in terms of community development, education, and economic diversification. Hence, careful planning for closure from the earliest stages of operation can result in a legacy that is overall positive.

3.3 END LAND USE OBJECTIVES AS A GUIDE FOR CLOSURE

Selecting post-closure land use is the single most important decision in developing a mine closure plan, as all closure and reclamation activities will be defined based on the next use of the land. With the evolution of modern concepts around sustainable development, it may not be sufficient to simply attempt to return the land to the pre-mining conditions, nor is that always the most practical goal. Therefore, care should be taken to avoid simplistic policy that simply advocates (or prescribes) a return to pre-mining land use.

> ***Post mining land use shall be technically achievable, economically practical, and widely accepted by all the parties***

Policy should promote a focus on post-closure land use that starts in the early planning stage of the mine and continues through operation as part of a dynamic and evolving closure plan that captures regulatory constraints, community input, economic aspects, and needs for post-mining stewardship.

Post closure land use types

Defining post-mining land uses is an essential part of mine closure. Properly selected, the post-mining land use is part of the vision and leads to the design. The 2009 International Council on Mining and Metals guidelines said that the closure vision should be aspirational, but when selecting a post-mining land use, it should also ensure that it is both productive and sustainable.

Table 1. Post reclamation land use types[2]

<table>
<tr><th>№</th><th colspan="2">Post mining land use opportunities</th><th>Land use types for Open pit mines</th></tr>
<tr><td>1</td><td colspan="2">Agricultural</td><td>Pasture, hay making, and plantation</td></tr>
<tr><td>2</td><td colspan="2">Forestry</td><td>Green belt, reforestation, nursery and plantations</td></tr>
<tr><td>3</td><td colspan="2">Water reservoir/Fish farms</td><td>Water reservoir for different purposes such as fishery, recreational and a sports pool, and the water accumulation for the use of manufacturing and agricultural irrigation</td></tr>
<tr><td rowspan="3">4</td><td rowspan="3">Special purposes</td><td>Sports and leisure facilities</td><td>Develop and establish a cultural and recreational park, tourist camps, spa resort facility, and sport complex</td></tr>
<tr><td>Conservation and native restoration areas</td><td>Afforestation, revegetation, green zone, and research site</td></tr>
<tr><td>Construction facilities</td><td>Build manufacturing, civil and other construction objects, and facility for the storage of mountain rocks, construction waste, and mineral processing wastes</td></tr>
</table>

Source: MNS 5915: 2008. Environment. Classification of land destroyed due to mining activities

Post-closure management requirements

After mine closure and lease relinquishment, some rehabilitated mined land may require ongoing management and monitoring. In order to receive sign-off by regulators and stakeholders, these issues will need to be discussed with the regulators and workable solutions to post-closure management and monitoring issues need to be finalized.

Responsibility for management following mine closure and lease relinquishment will depend on what is required, who owns the land and is responsible for managing it, and any legal aspects. Typically, post-relinquishment management that may be required can include:

- Noxious weed control;
- Surface and groundwater quality management, erosion control, and remediation if necessary;
- Exclusion or control of grazing animals;
- Control of public access;
- Fire management;
- Maintenance of safety signs and fences; and
- Operation and maintenance of any dams in the closure landscape.

The mechanism for funding any post-relinquishment management and monitoring that may be required will need to be determined by the regulatory authorities and stakeholders. One method that has been suggested is to establish a trust fund and use the interest generated from the fund. Whatever agreement is reached, it is important that when implemented, mines are absolved of any ongoing financial liability and there is no long-term financial burden on government or society. For example, Australia has drafted regulations requiring companies to undertake a post-closure risk assessment to identify potential post-closure hazards and risks. An option is for license holders to propose a post-closure bond. These bonds would be held and funds drawn down to remediate potential areas of failure.

[2] Responsible mining: Training Manual, UNDP, Mongolia 2016

Policy guidance for post-mining land use planning

Closure planning is a progressive process and Mine Closure Plans are living documents that should undergo ongoing review, development and continuous improvement throughout the life of a mine. The level of information required needs to recognise the stage of mine development (i.e. exploration, planning and design/approvals, construction, operations, decommissioning, post-closure maintenance and monitoring), with detail increasing as the mine moves towards closure. At all stages, Mine Closure Plans must demonstrate, based on reliable science-based and appropriate site-specific information, that ecologically sustainable closure can be achieved.

Good closure policy should encourage the development of carefully thought-out closure plans early in the mine life, prior to permit approval and construction, with regular updates and approvals throughout operation and closure.

INVOLVE STAKEHOLDERS	In modern practice, the vision of post-closure land use is determined not only by the operator, but also by many groups of stakeholders, particularly local communities. Closure policy can help ensure early consultation and engagement between key stakeholders with a focus on defining an acceptable land use or (more commonly) a range of land uses.
ALIGN WITH ALL LEVELS OF PLANNING	Ideally, the post-closure land use is developed in a way that considers and aligns with landscape level planning, watershed level and basin level planning, and ecosystem services protection and enhancement.
START EARLY	Target post-closure land uses will influence, and be influenced by, all aspects of closure planning (e.g., landform design, access, revegetation).
BE ADAPTABLE	While policy needs to encourage the definition of post-closure land use during the planning stage of closure, it should not restrict the evolution of the planned approach in response to changing community expectations or the appearance of innovative approaches. A clear framework that fosters innovation, clarity, and realistic goals assists regulatory bodies, and also the ultimate land users (communities and the environment).

Successful mine closure requires early planning, on-site rehabilitation and closure rehabilitation during the mining phases and land acquisition, and handing over to the closure commission.

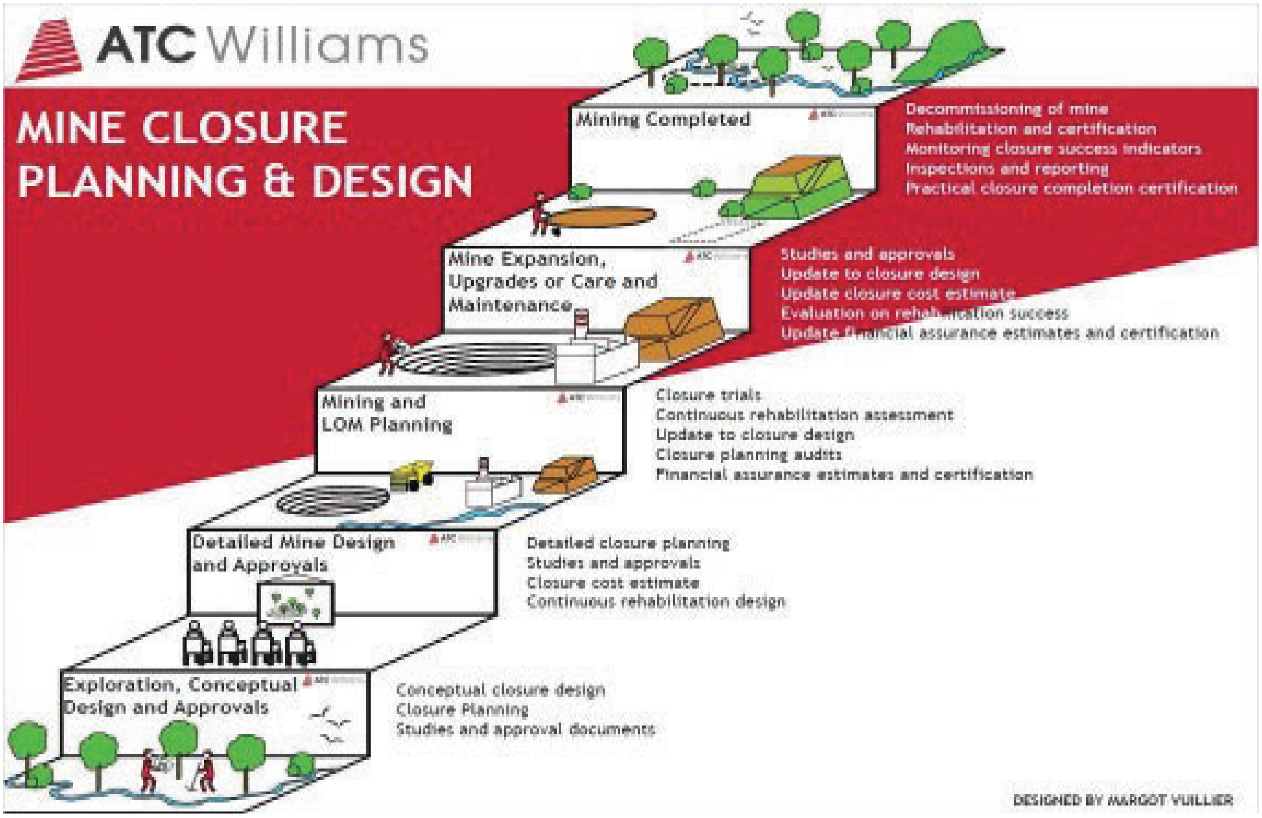


Diagram 6. Mine Lifecycle presentation by ATC Williams company

Mine closure is a process. To be successful, it should commence with early planning, involve progressive reclamation during operations, and culminate with final decommissioning, reclamation and relinquishment. Closure may be only temporary in some cases, or may lead into a program of care and maintenance. Closure options and strategic possibilities can be lost as mining progresses and irrevocable decisions are made on final closure landforms. Policy must include regulatory controls that direct appropriate closure decision making for final landform construction.

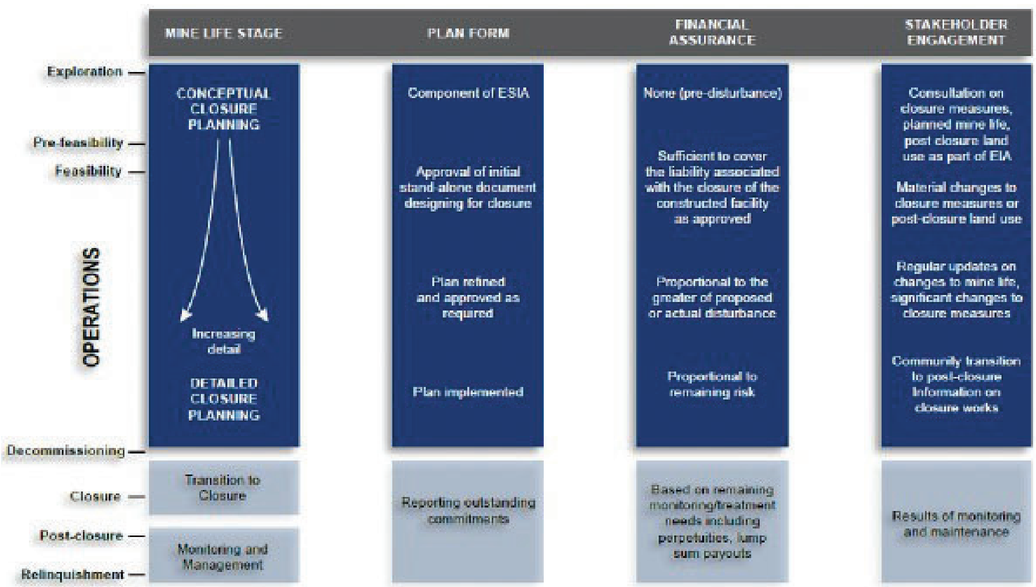


Diagram 7. Progressive closure

Updated closure plans should be a part of annual Environmental Management Plans to ensure that company commitments are clearly understood by the public and regulators.

Early planning:

- Allows flexibility in closure options, resulting in better closure outcomes;
- Limits unnecessary handling or placement of materials (e.g., prevents additional costs for re-handling of salvaged topsoil or to cover acid generating materials) and allows for the identification of opportunities for the salvage and direct placement of topsoil to avoid re-handling of salvaged topsoil; and
- Improves the ability of operators to carry out and pay for closure measures during operation (progressive closure) while there is positive cash flow to support the activities.

Photo 2. MNO mine closure model

4. KEY COMPONENTS OF CLOSURE – SUSTAINABLE LANDFORM DESIGN

4.1 INTRODUCTION

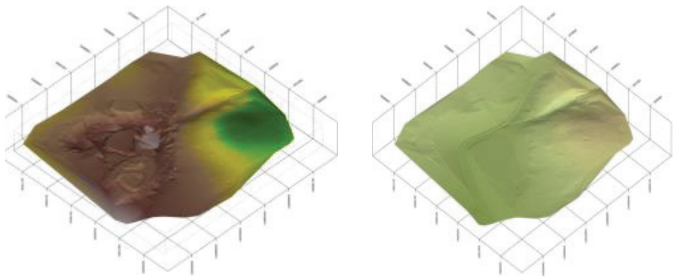


Photo 3. Landform model

Sustainable landform design is the collaborative and multidisciplinary effort to create mining landforms (for example, waste rock dumps, tailings storage facilities, and pit lakes), and closure landscapes (the mine site as a whole) that are constructed and reclaimed to meet specific design goals and objectives; fulfill the promised land uses; and reduce risk, costs, and liabilities. The main goal of landform design is successful reclamation, which is achieved when the reclaimed mining landforms and landscapes meet the stated goals and objectives; users are allowed back on the land; and the mine, the regulator, and local communities sign off that the reclamation is complete. Referring to these facilities as landforms helps telegraph that these new hills and valleys and streams need to fit in with the natural landforms in the region, and will be an important part of the region for eons to come, long after the mine has closed - they are the main legacy of the mine. Having a safe, stable, and useful reclaimed landscape is extremely important to local communities who will use the land and ultimately care for it.

Mining landforms are designed by a multidisciplinary team that typically includes a mine planner, a geotechnical engineer, a surface-water hydrologist, a groundwater hydrologist, a geochemist, a soils scientist/agrologist, and an ecologist, plus any other specialists needed for site-specific conditions. The work of the team ideally begins before mining starts. They work closely with local communities throughout the design, construction, reclamation, and the period of aftercare for each landform – a process that typically lasts many decades. Mine surface shaping design team

- Mining Engineer;
- Geotechnical engineer;
- Surface and groundwater researchers;
- Geochemist;
- Soil researcher;
- Ecologist; and
- It also consists of a variety of professionals who should be employed depending on the specific conditions of the area.

The team works closely with the community throughout the pre-operational phase of the mine, from design, construction, rehabilitation and maintenance of the derivative surface.

This section deals with the physical aspects of landform design:

- Decommissioning of infrastructure;
- Construction of new infrastructure for post-mining land use;
- Isolation of mine waste;
- Geotechnical stability;
- Post-reclamation settlement;
- Bearing capacity/trafficability;

- Erosion control;
- Pit-wall stability;
- Monitor surface water and groundwater quality and quantity; and
- Underground workings.

In most cases in Mongolia, the landforms will be designed and reclaimed to provide land for grazing, cropping, or for ecological values such as wildlife habitat. Protection of downstream resources (mainly surface-water quality) is often a major focus.

It is rare that the reclaimed land does not need some level of monitoring and maintenance to continue to achieve the agreed upon goals and objectives, but most mines attempt to minimize the frequency and cost of such activities. Typically, there is a more intensive monitoring and maintenance period in the years following reclamation where things like gullies or contaminated seeps are remediated, followed by a longer period of very low levels of maintenance, and often only required after large rainstorms.

Mine regulation requires that land disturbed by mining is reclaimed to stable and beneficial agreed uses for neighboring local communities and businesses.

Beneficial use – e.g. stable native bush land, grazing or cropping, ideally with no ongoing liability to the operating company or the community.

Stable landform – the requirement to place waste rock, overburden, and tailings to final landform design standard. Stability covers both geotechnical and erosional stability though it is recognized that the landform will continue to evolve and change over time.

Preservation of downstream water quality – existing and future use of the downstream water not compromised. Silts, salts and acids are not released from the reclaimed landforms to adjacent creeks, wetlands, and lakes or to groundwater aquifers. At some mines, this requirement will require long-term capture and treatment of contaminated water.

In the case of Mongolia, pit slope design and compaction are regulated by procedures and standards such as Methodology for Technical and Biological Rehabilitation of Land Affected by Mining Activities and National Standard MNS 5917:2008 Environment: Reclamation of land destroyed due to mining activities. General technical requirements. The standard determines general requirements on reclaimed land.

Examples of mining landforms

Common mining landforms include: mined-out pit, pit lake, underground workings, borrow pit, ore stockpile, reclamation stockpile, heap leach pile, landfill, waste-rock storage facility, rock drains, tailings storage facility (dam/beach/plateau/pond), dredge spoil piles, plant site/mill site, linear infrastructure; townsite/camp/contractor/laydown area; surface-water drainage system; reservoirs; and sedimentation pond. This chapter focuses on the main mining landforms that cover the largest areas of a mine site: tailings facilities, waste rock/overburden dumps, pits and pit lakes, and the surface-water drainage system.

4.2 BEST PRACTICES FOR SUSTAINABLE LANDFORM DESIGN

Decommissioning of infrastructure

One of the first steps in mine reclamation is decommissioning of infrastructure. This often involves removal of power lines and substations, pumps and pipelines, buildings, instruments, disused roads, fences, and debris. The design may call for some infrastructure to remain to support ongoing monitoring and maintenance, and various land uses.

Best practice is to decommission infrastructure progressively as it is no longer needed, and to complete the final decommissioning soon after mining activities have finished in the area to be reclaimed.

Construction of new infrastructure for post-mining land use

In some cases, plans call for construction of new infrastructure in support of proposed land uses. This might include new roads or trails, fencing and gates, dugouts/livestock watering stations, wells, new or relocated buildings, or other facilities.

Best practice is to construct this new infrastructure just before or just after reclamation activities. Usually there is minimal new infrastructure required – often this work simply amounts to repurposing the mining roads.

Isolation of mine wastes

Waste rock and tailings often have physical properties that present physical or chemical hazards (such as high erodibility, susceptibility to dusting and acidic pore-water) or provide a poor substrate for proposed land uses (such as coarse waste rock and soft tailings). Accordingly, reclamation cover systems are placed on mining landforms to help isolate the mine wastes from the environment. Such covers may involve only thin layers of reclamation material (soil) to promote vegetation growth, while other thicker, more engineered covers (with multiple layers) may be employed to reduce erosion or limit percolation of water into the mine wastes (which can result in large quantities of contaminated seepage requiring costly water treatment). Covers are designed to be geotechnically stable and to have low rates of erosion while promoting good vegetation growth. Common cover depths range from 0.1 to 2.0m. Placing and maintaining covers on slopes that are steeper than 3H:1V is often difficult.

Best practice is to provide a design basis for the covers that details their function and provide a cover that is of sufficient depth and built from salvaged soil and overburden such that it has sufficient water holding capacity and nutrients in the rooting zone to support the intended land uses. The reclamation material used in such covers is typically salvaged and stockpiled ahead of mining, but sometimes needs to come from borrow areas if there is insufficient stockpile volume.

Geotechnical stability

There are three aspects to geotechnical stability – ensuring slope stability (avoiding slumps and other kinds of landslides), avoiding excessive settlement (particularly of soft tailings or sinkholes into underground voids), and providing bearing capacity (for building foundations)/trafficability (for people/animals/equipment). The main focus of this section is slope stability. Settlement and trafficability are discussed briefly at the end of the section. Specifically, the focus is on slope stability for waste rock dumps and tailings dams. A discussion of long-term pit-wall stability is captured later.

Note that even the most modest slope instability can lead to excessive erosion, and vice versa. Limiting surface erosion is the focus of the next section.

The overall height of a waste rock dump or dam is the vertical distance from the crest to the lowest point of natural ground (usually a creek channel) at the toe of the slope. Often, the slope has a number of intermediate horizontal benches (like terraces) – the vertical distance between these benches is often called the bench height, the slope between two benches is often called the intermediate slope and is steeper than the overall slope from the crest to the toe of the landform.

If the overall slope of the waste rock or tailings landform is too steep, a landslide will result. The slip-plane may extend partway up the slope, or to the crest of the overall slope. The slip plane may cause the original ground under the mine waste to slide (often on a natural clay layer), or the slip plane may be entirely within the waste material. Slumps are the most common form of landslide in mine waste; slumps are rotational movements along a curved surface. Slip off failures, shallow planar failures where the cover slides off the mine waste, are also common. More rarely, a translational failure will occur where the movement is along a weak, often horizontal layer in the foundation.

The water pressures (specifically pore-water pressures) within the mine waste and the foundation greatly affect the strength of the various materials. Almost all landslides are caused by elevated pore-water pressures – sometimes through slowly rising water tables, sometimes due to large rainfall events (with runoff water infiltrating through cracks), and sometimes due to rapid loading that squeezes the pores and elevates water pressure faster than it can drain away.

On the whole, steeper and higher slopes are more likely to fail (undergo land sliding) than lower and shallower slopes. To design against geotechnical instability, the geotechnical engineer investigates the foundation geology, and assigns strengths to each material, estimate the pore-water pressures, and runs computer software that computes the balance of driving forces and resisting forces. Where driving forces exceed the resisting forces, a landslide will occur. Often the landslide occurs slowly with lots of warning and moves slowly (mm per year at first, then perhaps several meters per hour). In other instances, movement can be sudden without warning and can move rapidly (20 km/hr. or more). Designers choose slope angles and heights to have an adequate factor of safety against failure to limit the risk of a landslide. They typically make the slope as steep as practical (keeping to the minimum required factor of safety) to maximize the volume of mine waste in a dump or tailings storage facility and to minimize the footprint area. The most critical time for slope stability is often right at the end of construction, when the dump or dam reaches its final height.

For reclamation, the slopes are typically regraded to have a flatter overall slope angle to improve the long-term geotechnical slope stability. The final slope angle is an important consideration in landform design – the designers need to leave enough room at the toe of the slope to allow it to be pushed down and flattened by dozers. The use of benches helps to reduce the volume of material that needs to be dozed. Final overall (crest to toe) slope angles are typically 2H:1V to 5H:1V but may be flatter if the foundation conditions are weak. Some jurisdictions require slope angles flatter than 3H:1V, typically for land use requirements (see Table 3).

The interbench slope angles are also important – they are typically constructed at angle of repose (often 36 to 38° for waste rock), then later regraded (dozed down) to 2H:1V to 5H:1V. Over-steepened interbench slopes are prone to slumps or slip-off failures which are typically small, but often problematic.

Table 3 provides a list of other practices for waste rock dumps and tailings structures.

Table 2. Dimensions of lateral slope angles[3]

Directions for the use of rehabilitated land	Slope angle, in degrees
Agricultural land, arable land and pastures	0-18
Building	0-5
Physical education and sports (stadiums, various playgrounds)	0-0
Forest zone and protection zone	0-25
Lakes and ponds	0-18

[3] "Methodology for technical and biological rehabilitation of land damaged by mining activities" approved by Minister of Nature, Environment, Green Development and Tourism Resolution № A-138 of 2015

Piping/tunneling/internal erosion may occur where internal seepage velocities are too high and the material is too finely grained. This is a common design concern for dams constructed of tailings sand. The seepage water carries sand and silt particles out of the dam, leading to the formation of a narrow-diameter tunnel that can enlarge very rapidly and cause a dam breach within minutes or hours. Piping is avoided by compacting the finer grained materials, avoiding having coarse gravel or cobble fill in contact with silt or sand (which can wash into the voids of the gravel), by keeping seepage velocities and seepage gradients low, ensuring there are no conduits or other mechanism for preferential flow through the dyke (paying particular attention to the abutment contacts), and by use of internal drains to control seepage. Piping is common around the outside of drainage pipes in fine grained material. For this reason, constructing pipes through dams are avoided.

Best practice is to:

- Conduct a thorough site investigation prior to construction;
- Design and construct slopes with a factor of safety that meets regulatory requirements and provides an adequate safeguard against instability;
- Design the slopes to be easy to regrade for reclamation and to regrade and reclaim the slopes progressively if practical;
- Include drains (coarse rock or sock-slotted pipe) under or within the mine waste to control water pressures;
- Install instrumentation (prior to or soon after construction starts) to monitor slope movements to confirm the design assumptions and provide early warning of slope movements. If unexpected movements occur, a toe berm may be added, the crest elevation restricted, or the overall slope angle reduced. Other remedial options may be available. Slope inclinometers and survey monuments are common slope monitoring instruments. Visual monitoring is an important element of the monitoring program – looking for any signs of cracking, scarp formation (down dropping of the head of a landslide leaving a vertical step in behind), bulging of the slope (particularly at the toe), or unexpected seepage on the slope or at the toe. Even for experts, it is sometimes difficult to determine whether small cracks on the slope are signs of a landslide, or are simply settlement or desiccation/drying cracks;
- Monitor construction closely to ensure the landform is built to design and is performing as intended. For some landforms, this may be as simple as a daily inspection of construction by a trained person. For large tailings facilities, monitoring may involve dozens of people reading instruments, analyzing data, adjusting designs, and reporting performance. Often, the design requires compaction of the mine waste in thin layers (0.3 to 1m thick layers are common) to increase the strength of the materials and limit future settlement;
- Avoid ponded water on benches or near the crest. Ponded water can penetrate cracks, causing water tables to rise, or creating high hydraulic pressures within deep cracks, causing geotechnical instability. Because of this, best practices are to seal cracks with a dozer soon after they are detected; and
- Design against piping failure and control seepage in dams.

Table 3. Best practices for geotechnical stabilizing above-grade landforms - waste rock and overburden & tailings structures

Waste Rock and Overburden	Tailings Structures
Practices should ensure: • Slopes in equilibrium with local topographic relief, rainfall and soil conditions; • Minimize erosion, thaw settlement, slope failure, collapse, and the release of contaminants or sediments; • Balance the size of the pile's footprint with its height, taking into account future use targets, physical stability and other factors; • Blend piles with current topography and revegetate as necessary to be compatible with wildlife use, and/or meet future use targets; • Re-grade waste rock to stable landform and leave in place if it can be proven that material is geochemically inert and will not provide a source of contamination due to metal leaching and acid rock drainage processes; • Cover waste rock piles a cover system to control metal leaching and acid rock drainage processes and migration of contaminants and to limit surface erosion; • Remove weak or unstable materials from slopes and foundations. Off-load materials from the crest of the slope; • Leave waste rock piles composed of durable rock "as is" (at angle of repose) at the end of mining but only if there is no concern for deep-seated failure or erosion and if the future use targets can be achieved (a rare case); and • Revegetate waste rock/overburden to control surface erosion	Post-closure reclamation activities for tailings facilities may include: • Stabilize embankments by removing weak or unstable materials from slopes and foundations and/or construct toe berms to flatten overall slope; • Breach water retention dams and drain impoundments to avoid post-closure impoundment of water, where possible; • Use a natural body of water that has sufficient storage capacity to hold the tailings and allow a natural unimpeded flow via the drainage outlet if a permanent water cover is used (this may not be viable if the supernatant water quality does not meet discharge water quality standards); • Increase freeboard of embankment and/or upgrade spillway to prevent overtopping and to prepare for possible erosion of embankment by extreme precipitation events; • Relocate and/or deposit tailings into underground mine workings or into flooded pits, depending on water quality considerations; • Cover tailings with a cover system to control metal leaching and acid rock drainage processes and migration of contaminants and to limit surface erosion; • Divert non-contact runoff away from the tailings facility to avoid contamination ("keeping clean water clean"); • Remove structures and decant towers, pipes, and drains where they already exist. If they cannot be removed, plug decant towers, pipes, and drains with high slump (relatively liquid concrete which will flow to fill all voids) or preferably, expansive concrete; • Where diversion dams and channels are necessary, maintain them indefinitely to meet long-term stability and hydraulic design requirements; • Design diversions and spillways for extreme events suitable for long-term stability; • Provide a frost protection cap over the phreatic surface for water-retaining dams; • Ditch, berm, fence, or use alternative methods, if compatible with future use plans, to deter access of motorized vehicles; and • Establish native vegetation, soil, riprap, or water cover to control erosion.

Post-reclamation settlement (waste rock dumps)

Post-reclamation settlement is typically only a minor issue for waste rock dumps. Such dumps typically settle about 1% of their total height, though settlements for certain materials may be greater. Differential settlement can lead to cracking in the covers or ponding of water.

Best practice is to:

- Regrade terraces/benches and plateaus to have a 1 to 4% slope (the benches are "tipped out") to limit ponding and soil salinization;
- Create a system of swales and ridges on dump plateaus to limit the extent of any ponded water. Include shallow surface water swales/ditches to carry surface water from the plateau, down the old haul ramp, and safely to the toe of the landform. This drainage system needs to be designed by a qualified hydrologist;
- Avoid inclusion of slop, snow, or any other loose materials within the waste rock dump unless anticipated in design;
- Compact mine waste in thin lifts to limit settlement if required; and
- Install a 1 to 2m high watershed berm (sometimes called a bund) of moderate to low permeability material near the crest to act as a watershed divide and avoid ponded water from spilling over the crest and eroding the slope (to avoid the most common type of gully erosion for mining landforms).

Soft tailings

Excessive post-reclamation settlement in tailings is sometimes a problem, particularly if the deposited tailings has a significant clay fraction which causes the consolidation (release of excess water) to be very slow. "Soft tailings" is defined as that which is too weak (even fluid like) to allow even foot traffic, much less trafficking by mining equipment for capping and reclamation. These low-density tailings are prone to large settlements over decades or longer. At some mines, most of the tailings is not trafficable. Even for mines without clays in the tailings, often the tailings slurry segregates during deposition, with the sand dropping out at the top of the beach and the finest silts collecting at the far end of the beach, near the water return system. This localized zone of saturated fine tailings (often 10 to 20 hectares) is often very weak, difficult to cap, and prone to settlement as it dewaters over years or decades.

As noted above, fine-grained saturated tailings may have very low strength and are usually untrafficable to normal mining equipment – these are defined as "soft tailings." Usually, amphibious equipment is used to access these areas. These areas present a hazard to people, equipment, and animals and are extremely expensive to stabilize and cap.

Best practices are nearly the same as listed above, which is to:

- Avoid or minimize the production of soft tailings; and
- Identify areas of soft tailings that have unacceptable trafficability and remove or stabilize the tailings in place to allow only acceptable settlements.

Most mine wastes will undergo enough post-reclamation settlement that precludes the use of these areas for the post-mining construction of steel-framed or wood-framed buildings (such as plant sites, warehouses, office buildings, and houses) which can typically only accommodate about 25mm of differential settlement without cracking, structural damage, or damage to utility connections. If the post mining land use requires settlement-intolerant buildings, the landforms and the building foundations will require special design. Trailers and other mobile buildings are often much more tolerant to settlement.

Surface water – managing water quality and managing erosion

For reclaimed landscapes, water is both a key to life and a great agent of disruption. At most mines, most of the water that falls on a reclaimed landscape (as rain or snow) evaporates, while some runs off and some percolates into the landform, to eventually reappear as a seep or discharge into a creek downstream. The main focus of landform design is managing water in the reclaimed landscape, particularly surface water. However, design for erosion control of waste rock dump and tailings dam slopes is an immature science.

It is often difficult to predict the amount of water falling on a mining landform unless there is a nearby climate station that has been operating over many decades. There are various methods to estimate rainfall and snowfall amounts using data from remote climate stations. The fate of the water that falls on the landform, particularly the amount of evaporation and evapotranspiration, the amount of runoff, the percolation into the soils and mine waste, and the changes in the water stored in the root zones is also difficult to estimate – complex models combined with expert judgement and design are used.

As discussed in a later chapter, the thickness and composition of the cover on the mine waste is often designed to reduce the amount of water that percolates into the mine waste, and to maximize the amount of water available for vegetation (ensuring enough water to sustain the vegetation during dry periods). To this end, the layering is often more important than the absolute thickness. What is key is that the construction follow the design, using tight quality control and quality assurance to make sure the cover is constructed to design and provides acceptable performance.

In terms of water quality, water that touches the ore or the mine waste materials is often referred to as contact water. At many mines, this water has elevated metals or salts and/or is too acidic or basic for discharge to the natural environment unless it is treated. It is part of the contact water circuit and is often stored (often in the tailings facility), recycled to the mill, or treated for discharge. Because water treatment is typically expensive and proportional to the total volume treated, it is usually advantageous for the mine to have a clean-water system, where water running onto the mine site is diverted before it becomes contact water. Most mines hope that in the long-term, the water running off the reclaimed lands will be suitable for discharge without treatment, and the landforms and drainage system are designed for this. Often it is not recognized that it may take years or decades for the water running off reclaimed surfaces to meet discharge water guidelines. In some cases, perpetual water treatment is required.

Water-dependent systems are parts of the environment in which the composition of species and natural ecological processes are determined by the permanent or temporary presence of flowing or standing surface water or groundwater. The in-stream areas of rivers, riparian vegetation, springs, wetlands, floodplains, estuaries, karst systems and groundwater-dependent terrestrial vegetation are all examples of water-dependent systems. Rainfall runoff is water flowing over ground surfaces and in natural stream and drains as a direct result of rainfall over a catchment.

The development of the open pits, stockpiles, waste rock dumps, tailings storage facilities, processing plant and infrastructure often interrupt some of the natural drainage paths. Interference with drainage patterns may result in deprivation of water to drainage systems downstream of the mining development or localized 'shadowing' effects on some vegetation which may be reliant on intermittent flows.

Best practice is to:

- Minimize the volume of contact water (keep clean water clean through diversion); and
- Capture all water running off from reclaimed land and test its suitability for discharge (and

store or treat if not). Many mines have simply and erroneously assumed that water from the reclaimed areas is clean. This is seldom the case for metal mines.

Mines around the world struggle with designs to limit surface water erosion, particularly with fine grained mine wastes, tailings sand dykes in particular, but also for all mining landform slopes. Several types of slope erosion are recognized, which are:

- Wind erosion;
- Splash erosion;
- Rill erosion;
- Gully erosion; and
- Stream and channel erosion.

Erosion rates are high in arid and semi-arid environments (where there is limited vegetation cover), moderate to low in temperate areas (where there is modest precipitation and lush vegetation), and high in tropical environments (due to very high and intense rainfall).

Wind erosion and splash erosion are mainly issues for unvegetated or poorly vegetated areas (and notably in arid and semi-arid sites). The vast majority of problem mining landform erosion is gully erosion which can cut through covers, expose mine waste, and cause cover and waste material to be deposited at the toe of the slope and into constructed and natural streams, causing geomorphic change, impacting aquatic life and drinking water quality.

One of the challenges for designers is that many techniques to manage slope erosion show early success, only to be proven ineffective in large runoff events – good early performance does not necessarily mean good long-term performance.

There are numerous design strategies employed to manage slope erosion, including:

- Avoiding ponded water on the benches and crests of mining landform that can spill over and erode slopes;
- Using covers constructed of low erodibility materials (clay or gravel); avoid fine cohesionless substrates (like tailings sand). In the extreme, the slopes may be entirely armored with riprap, precluding most land uses;
- Relying on full percolation into coarse grained mine waste (coarse waste rock) to preclude runoff;
- Using thick covers to minimize the chance of gullies eroding down to mine waste;
- Constructing long-planar slopes to promote sheet flow, limiting concentration of runoff water, and minimizing gully erosion;
- Constructing short planar slopes with benches at regular intervals to “slow the runoff water” (a strategy that does not actually slow the water and more often, leads to concentration of flow and gullying - often water ponds on the benches). Tipping the benches outward at 1% to 4% can help to limit the risks of ponding;
- Using armored cross-slope interceptor ditches on the benches to capture water from the slope above and convey it laterally off the landform (onto more stable ground) or into steep downslope armored channels. In some cases, armoring may be accomplished with dense vegetation. In other cases, rip rap (coarse rock) is needed. Historically concrete channels, culverts/penstocks were employed but have fallen out of favor in most jurisdictions due to concerns regarding longevity and maintenance. Use of a wide mid-slope bench (20 to 50m wide) can allow room for a general lateral berm channel and access road for maintenance;
- Constructing the slopes with a catena profile (steep at the top and ever shallower approaching the toe) mimicking some natural slope profiles (though full-scale testing is limited);

- Using corrugated topography (downslope rills spaced at 0.5 to 2m) to channel flow down the slope, avoiding concentration of flow;
- Using rough-and-loose topography – common in temperate areas, using small hummocks (0.2 to 1m high, spaced 1 to 20m) to break up flow patterns;
- Landform grading to divide the slopes into a series of swales and ridges, concentrating flow from very small catchments into an armored swale;
- Keeping the toe away from infrastructure and natural creeks, allowing room for sediment fans to form. Offsets of 50 to 200m are sometimes employed; and
- Using temporary measures such as geofabrics and other materials to protect slopes while vegetation is established. This is common in heavy civil applications but uncommon in mining. Use of mulches and tackifiers to limit erosion during vegetation establishment is common in semi-arid conditions. Use of silt fences and hay bales to limit erosion is common, but often ineffective in a mine environment (water typically flows around or under these measures).

Many of the above may be intentioned to require no long-term maintenance, but most sites will require periodic inspection and maintenance, especially over the first two to three decades and after major runoff events.

Best practice is to:

- Avoid placing highly erosible materials at the surface of mining landforms (many sand dams suffer from excessive erosion even after covered);
- Adopt a design and construction strategy acceptable to local communities and the regulator and tailor the design to local conditions. Ensure designs are done by a qualified hydrologist and built to design;
- Minimize slope lengths and watershed sizes. (Note that for landforms of the same height, flatter slopes increase slope lengths and watershed sizes which may lead to increased erosion); and
- Allow and provide for low levels of long-term monitoring and maintenance (aftercare), properly perform necessary monitoring and maintenance measures.

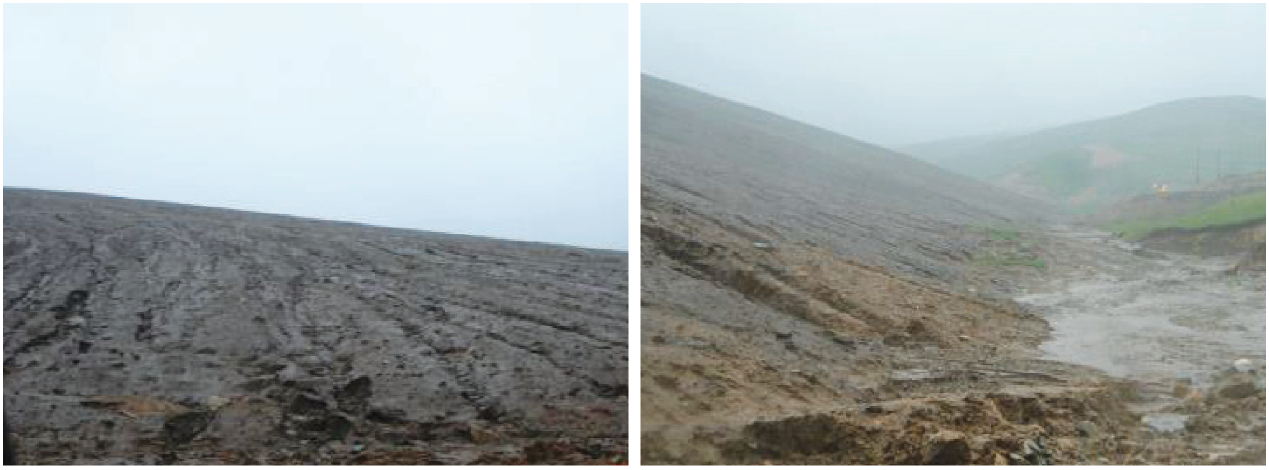


Photo 4. Reclaimed area on the left side slope (July 15, 2010 during heavy rain)

Case narrative: Erosion Control

Some erosion is natural, but in reclamation cases, "erosion" is generally referring to excess erosion caused by wind and water. It is critical to ensure that the reclaimed area has a natural slope contour. Overall curved slope should ensure that runoff water maintains the same speed or slows down as it progresses down slope. The runoff water picks up more sediment as it speeds and increases erosion. If the slope shape promotes erosion, the most cost-effective erosion control measure to ensure long term stability is to return to the recontouring phase and re-shape the slope.

Erosion and sedimentation occur naturally, but the actions of humans change the rates of erosion. The global average natural geological rate of soil erosion is about 0.6 tons per hectare per year. This rate of erosion is about equal to the rate at which soil is naturally created.

- Construction, farming or logging - 3.7 tons per hectare per year;
- Cropland - 50 tons per hectare per year; and
- Mining sites can experience soil loss from 370 to 500 tons per hectare per year.

Excess erosion can cause flooding, further erosion, and alteration of the hydrology of an area. Habitat for wildlife can also be altered or destroyed. Erosion can also result in the transportation and deposition of metals, pesticides, or other pollutants.

Causes for Soil erosion at reclaimed land of Boroo gold mine

Just after completion of biological reclamation at a waste dump area, a heavy rainfall occurred on 15 July 2010 and 27.7 mm of precipitation fell on the ground. Surface flows and erosion resulting from this rainfall displaced and removed topsoil and planted perennial seeds.

Sediment ponds

During operation, the use of large sediment ponds to limit offsite transport of eroded mine waste is required. These ponds also allow for temporary store of runoff water that allow time for water quality testing to see if the waters are suitable for discharge. These engineered ponds collect sediment which must be periodically removed and spoiled with other mine waste. These sediment ponds are maintained until well after upstream reclamation is complete, and the water quality, both in terms of concentrations of dissolved solutes and suspended sediment, reliably meets discharge requirements.

Groundwater

Protection of groundwater resources (such as aquifers) is an important aspect of landform design. Geochemistry considerations are detailed in a flowing section. Groundwater management strategies include limiting percolation into mine waste through the use of covers, avoiding ponded water, use of liners under-mine waste landforms, and collection and treatment of contaminated groundwater through a combination of interceptor ditches, pumping wells, and bentonite cutoff walls.

Best practice is to consider potential groundwater impacts in design, design to minimize impacts, and design and employ contingency plans if monitoring wells detect an unacceptable plume of contaminated groundwater.

Geotechnical stability of pit walls

It is typical that the rock in hard rock pit walls is highly fractured and mineralized and typically has poor long-term stability. Raveling, wedge failures, and even multibank landslides are common during mining and continue to manifest after mining is complete. These geotechnical instabilities present varying levels of risk to future land users.

Best practice is to:

- In most cases, restrict access to the pit crest, slopes, and toe areas, essentially sterilizing this land to future users. Often a berm or rugged fence is used to surround the pit crest to avoid inadvertent access. Users of pit lakes may be at risk to raveling of boulder-sized materials from the pit walls. Large slump blocks falling into the pit lake may cause dangerous waves;
- In the case of soft rock mines and placer operations, regrade pitwalls to angles similar to those of reclaimed waste rock dumps or to meet regulatory requirements; and
- In some cases, use tailings or waste rock to backfill pits to grade, eliminating or greatly minimizing the remaining unstable pitwall slopes.

Pit lakes

It is common to establish pit lakes in mined out pits. The pits may be partially backfilled with mine waste, and require a stable outlet that produces water periodically. Water is pumped into the lake or allowed to accumulate naturally over time. Pit lakes are not just holes in the ground filled with water - they need to be designed, constructed, and managed to meet land use and other goals as set out in the closure plan. The four most common design issues are related to water quality, pitwall stability (discussed above), shoreline erosional stability, and biological productivity (for aquatic life, sometimes fish, and for downstream water users).

The water quality must meet certain objectives to support the proposed land use, to meet regulatory requirements, and for discharge to receiving streams. Ideally, the pit lake has a large catchment of clean water that allows the lake to have an outlet that is active each year, which acts to flush the water in the lake, and avoid the build-up of salts and contaminants. Lake dynamics are complex, and many pit lakes have waters that are stratified (often a shallow layer and a deep layer of waters with different temperatures and salinity) and periodically overturn/mix.

Shoreline erosional stability relates mainly to small wind-generated waves that can erode sand and fine-grained fills around the lake perimeter, removing beach and contributing to suspended solids in the lake. Such shorelines may be armored with rip rap or vegetation to limit erosion.

Often, lakes are designed to be biologically productive, which typically requires having a very shallow littoral zone that underlies a certain minimum percentage of the lake. The littoral zone is key to the lake ecology. Its water needs to be shallow enough and clear enough to allow plants to receive sunlight and be able to become established in this zone.

In some cases, pit lakes may be located in mined out pits wholly located in river aquifers, and much of the inflows and outflows will be by seepage through gravel aquifers.

Best practice is to:

- Design the mine pits to be easy to convert to useful pit lakes. Many regions will benefit from having pit lakes with clean water and fisheries resources. Involve limnologists familiar with pit lake design and construction;
- Design the lake to have an excess of water (from the watershed) to permit flushing, to have adequate water quality for proposed land uses (especially habitat, recreation, fishing, and in cases where water quality is very high – drinking water);
- Regrade the pitwall slopes to stable angles to reduce the risk of landsliding and raveling;
- Include a suitable sized littoral zone to promote biological productivity (often 10% to 30% of the surface area of the lake);
- Design the shoreline to manage erosion; and
- Establish access and recreational facilities.

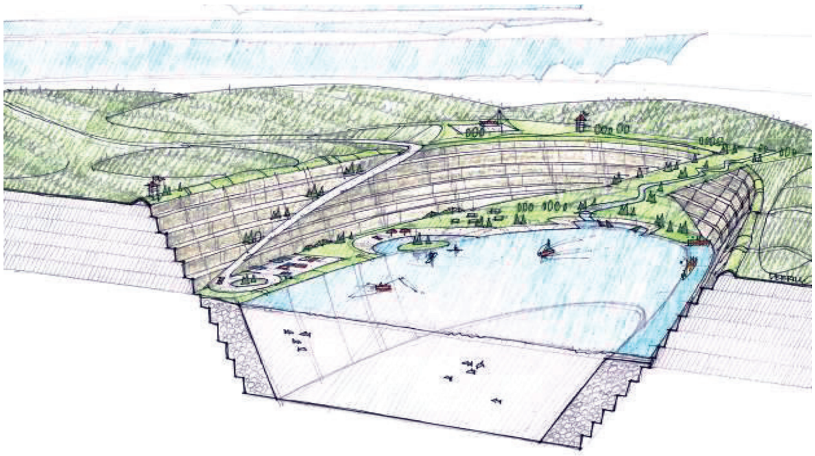


Photo 5. A successful pit lake

Historic or active underground workings

- Underground workings (shafts, portals, drifts, raises, block caving glory holes, etc.) can present major hazards to dams and tailings facilities, and to land users outside of the present scope for this document. Subsidence control is the use of techniques to prevent or reduce subsidence movements to avoid or minimize damage to surface structures; and
- These techniques are also referred to as ground control, surface stabilization, or subsurface stabilization. Information on controlling hazards is available in the literature.

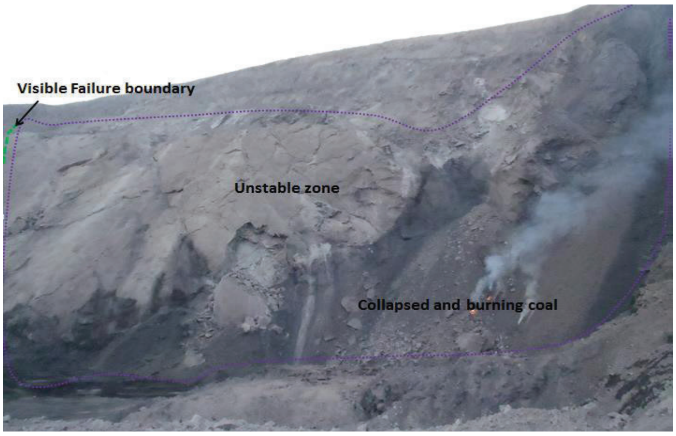


Photo 6. Coal fires

Other

Because mining practices and local conditions vary so widely, this document cannot anticipate all design cases. This section highlights a few cases that are not uncommon in mining:

Coal fires: Coal mine waste rock dumps contain significant amounts of coal material which oxidize, causing thermal heating, and may spontaneously combust, or otherwise come to be on fire. Extinguishing such fires is not always practical. There are various methods to limit this risk. Fires in underground coal mine workings are also not uncommon.

Gases: Some mine wastes produce radon gas which presents a major health hazard. Others produce oxygen-deficient pore gasses which can migrate into adjacent culverts, sumps and buildings, and can lead to rapid death to the unprepared. Others can produce methane or H2S. It is best practice to avoid constructing buildings or tents on mine waste (especially waste rock) unless a hazard assessment is complete and precautions followed.

Dam breach: The best practice is to avoid leaving behind dams in the reclaimed landscape due to the need to monitor and maintain them forever, partly due to the risks to downstream land users. However, for a variety of reasons, many mines choose to leave behind dams. Methods to manage dam safety are outside the scope of this document, but guidance is widely available.

Geochemical stability

Most mines affect the geochemical stability of the mine site – mineralized rock (and overburden) that has been largely undisturbed for millennia or longer is exposed to the atmosphere, allowing oxidation of the minerals and subsequent leaching by surface water and groundwater. Metals mines often have issues with acid rock drainage (due to the oxidation of sulphide minerals) and metal leaching. This can be an issue at coal mines too. At other mines, the drainage has a neutral pH but can still leach certain metals. At some mines, leaching of salts can affect soils and water courses. Both surface water and groundwater may be affected. The main source of geochemical reaction and poor water quality is usually waste rock piles, tailings facilities, and pit walls and underground workings. Often, waste rock or other mine wastes are used indiscriminately in roads and other infrastructure and may be sources. Where acid rock drainage is an issue, a characteristic red stain in the water and on rocks is common, but at many sites, the contaminated water may appear clear and colorless. Poor water quality in creeks and wetlands or contaminated groundwater aquifers can affect human health and safety, lead to environmental impacts, and limit land use.

Management of mine wastes for geochemistry involves having a good understanding of the properties of the mine waste. Usually, there is extensive laboratory testing and often, small field trials to characterize the mine wastes and how they interact with water and oxygen. Waste rock dumps and tailings are designed to reduce the amount of water that flows through them (through clean water diversion and use of engineered covers), and sometimes the dumps are built and covered to minimize oxygen ingress. Some wastes are stored below the water table (in pit lakes or permanently flooded tailings) to avoid oxidation. Capture (through the use of interception ditches and groundwater pumping wells) and treatment of contaminated water is common, though it is typically impossible to capture all the contaminated water. For all these reasons, water-quality monitoring is an essential component of mine waste management.

Monitoring involves visual inspection, soil testing, water quality sampling from seeps, ponds, wetlands, and creeks, and water quality sampling in groundwater wells in aquifers.

Testing Soil pH: Soil pH or soil reaction is an indication of the acidity or alkalinity of soil and is measured in pH units. Soil pH is defined as the negative logarithm of the hydrogen ion concentration. The pH scale goes from 0 to 14 with pH 7 as the neutral point. As the amount of hydrogen ions in the soil increases, the soil pH decreases, thus becoming more acidic. From pH 0 to 7, the soil is increasingly more acidic and from pH 7 to 14 the soil is increasingly more alkaline or basic.

Balancing pH: Standard indicators of the pH

pH<4.0	pH 4.0-4.9	pH 5.0-5.9	pH 6.0-6.9	pH 7.0	pH 7.1-8.0	pH 8.1-9.0	pH 9.0<
Extremely acidic	Very strongly acidic	Medium acidic	Slightly acidic	Neutral	Slightly alkaline	Medium alkaline	Strongly alkaline

Best practice is to:

- Characterize all mine wastes prior to mining and update testing over time;
- Divert clean water away from mine waste;
- Segregating potentially acid generating or metal leaching material from other material to facilitate efficient management of this material and to reduce the volume of material that needs to be managed in a way that prevents or controls acid generation and metal leaching;
- In some cases, blending of potentially acid generating waste rock with neutralizing waste material can limit acid production and metal leaching. Intimate contact between the wastes is required for this strategy to be effective;

- Dispose of potentially acid generating waste rock or tailings under a water cap (such as in a backfilled mine pit), or in underground workings (such as cemented paste backfill);
- Monitor the geochemical and seepage performance of waste rock, tailings, and areas of exposed rock (in pit slopes and at the exit of underground workings).

Monitoring the landforms

Monitoring of rehabilitated land is critical and the last step in technical rehabilitation that deserves special attention as this procedure enables successful completion of the biological rehabilitation process. Common monitoring methods include remote sensing, visual monitoring, settlement/ topographic monitoring (using Lidar. photogrammetry, or INSAR), instruments for geotechnical stability (inclinometers, survey monuments, and piezometers), surface water monitoring (flows using weirs and water quality through periodic sampling), groundwater monitoring (through sampling of environmental wells), soils and vegetation monitoring, and monitoring of wildlife. Monitoring by reclamation inspectors is detailed in Chapter 7.

Best practice is to:

- Establish a landscape monitoring program before mining begins (or as soon as practical for existing mine operations) to monitor the performance against the design basis and regulatory requirements;
- Establish a robust data management system for the monitoring data with quality control and quality assurance checks;
- Where performance does not meet expectations, make repairs to the reclaimed landscape and update practices to prevent recurrence; and
- Report on the performance and maintenance/repair activities annually.

Post-Closure Care and Maintenance (Aftercare)

The extent of care required after closure of mining and processing activities (also called aftercare) falls into three basic levels:

- Active care: Requires ongoing operation, maintenance, and monitoring to ensure there is minimal (acceptable) risk to public health and the environment (active water treatment falls into this category);
- Passive care: Requires ongoing need for occasional monitoring and periodic maintenance to ensure there is acceptable risk to public health and the environment (low levels of ongoing monitoring and maintenance are the best way to maintain the site safety and values; and
- Walk-away: A third level of care, the concept of a "walk away" solution, infers that no additional monitoring or maintenance is needed. Experience shows that some parts of a mine site or mine components may be left in a "walk away" condition. However, it is rare that an entire mine site can be left in a "walk away" condition – the few sites that achieve such status are typically small, lacking geochemical issues, and have minimal long-term residual risks (many quarries and gravel pits).

Best practice is to:

- Plan for long-term care, factor this into the design, and provide funding to ensure the reclaimed landscape is properly maintained in the long term; and
- Design to the landform to require only minimal monitoring and maintenance after the active care phase.

5. KEY COMPONENTS OF CLOSURE – SOIL CONSERVATION AND RECONSTRUCTION

5.1 DEFINITIONS

Soil is the fertile surface horizon that develops on geologic materials over time as result of the influence of climate, weathering, geochemistry and flora/fauna.

Soil conservation is a comprehensive activity designed to recover the economic significance and fertility of disturbed land to support land use consistent with the public interests as defined in Methodology for Technical and Biological Rehabilitation of Land Affected by Mining Activities. In particular, it includes the protection of soil from surface disturbance (i.e., mining activities), erosion, and other types of deterioration, so as to maintain soil fertility and productivity.

In the context of mine closure, soil conservation and subsequent soil reconstruction/restoration are undertaken to recreate a permanent and healthy soil profile that will support the intended end land use for the mine site.

The general strategy of soil resource management is to strip suitable soil resources from the proposed disturbance areas and directly replace on rehabilitation areas or store in dedicated stockpiles for re-use during progressive rehabilitation works. The strategies/objectives for management of soil resources include:

- Characterization of the suitability of the material for rehabilitation purposes prior to stripping;
- Ensuring that soil resources are stripped and stored selectively and managed according to their suitability for rehabilitation purposes;
- Ensuring that sufficient subsoil and topsoil quantities are available for rehabilitation purposes; and
- Ensuring that, where possible, progressive rehabilitation of final landforms is conducted as soon as practical after completion of the landforms or when areas are no longer required.

Country profile – Soil

Mongolia is located in a vegetation transition zone between the Siberian taiga, forest steppes, steppes, desert steppes, and the Central Asian desert region where the vegetation changes from the northern forest to the central steppe and southern desert. There is also a unique combination of geological conditions and topography. These variations in environmental factors in different parts of the country specify Mongolia's soil distribution, which changes from north to south following a longitudinal zonal schema.

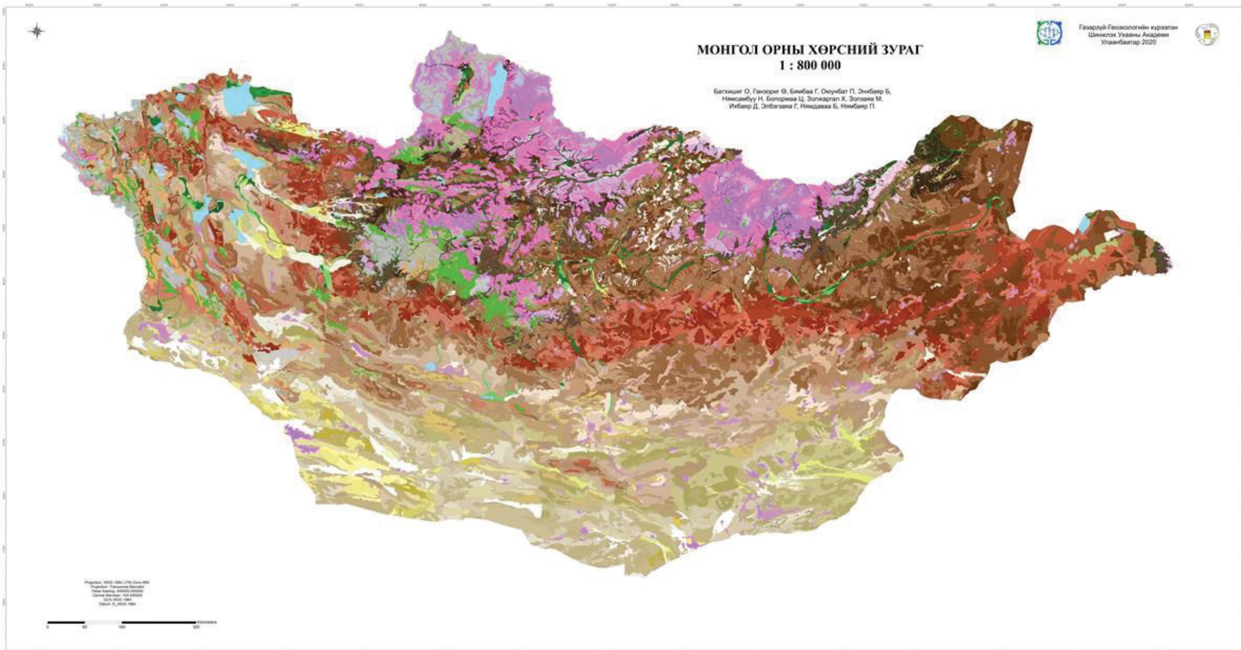


Photo 7. Soil map of Mongolia

More than 80% of territory of Mongolia is over 1000 m with the majority of Mongolia at an altitude of 1,500 m or more above sea level and permafrost is sporadically distributed across the country. Its short biologically active period is about 3-5 months per year and the process of chemical weathering and clay formation is slow. Mongolian soils are characterized by a long winter season and very little soil moisture. Thus, Mongolia has relatively limited soil resources.[4]

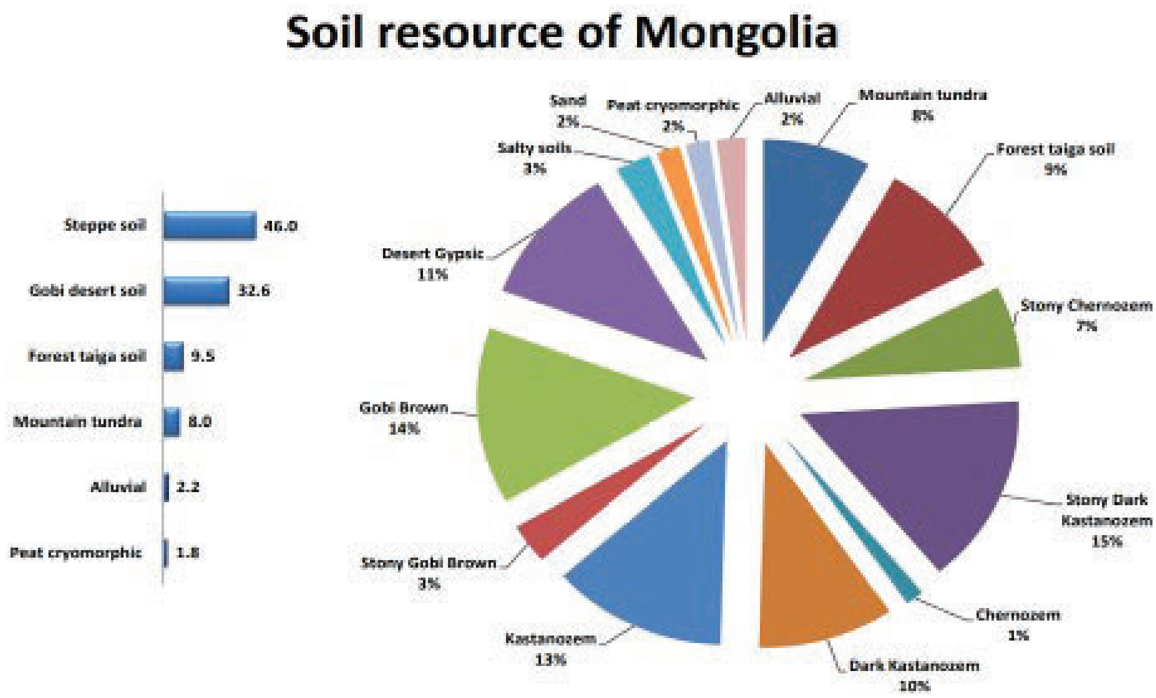
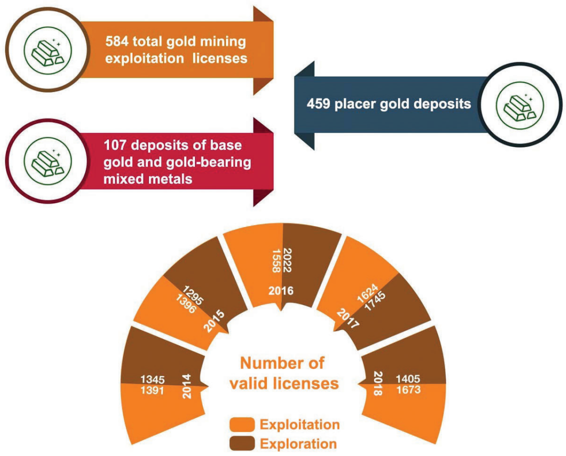


Diagram 8. Soil resource of Mongolia

[4] Soil Diversity in Mongolia, Kenji Tamura, Maki Asano, Undarmaa Jamsran, Springer Link, 2012

In general, the dominant soil texture in the top 50-cm layer at the selected stations is sandy. The northern part of Mongolia is covered by forested mountain ranges with a dry sub-humid climate, whereas the southern part encompasses the Gobi-desert at lower elevations with a drier climate (Batima and Dagvadorj, 2000).

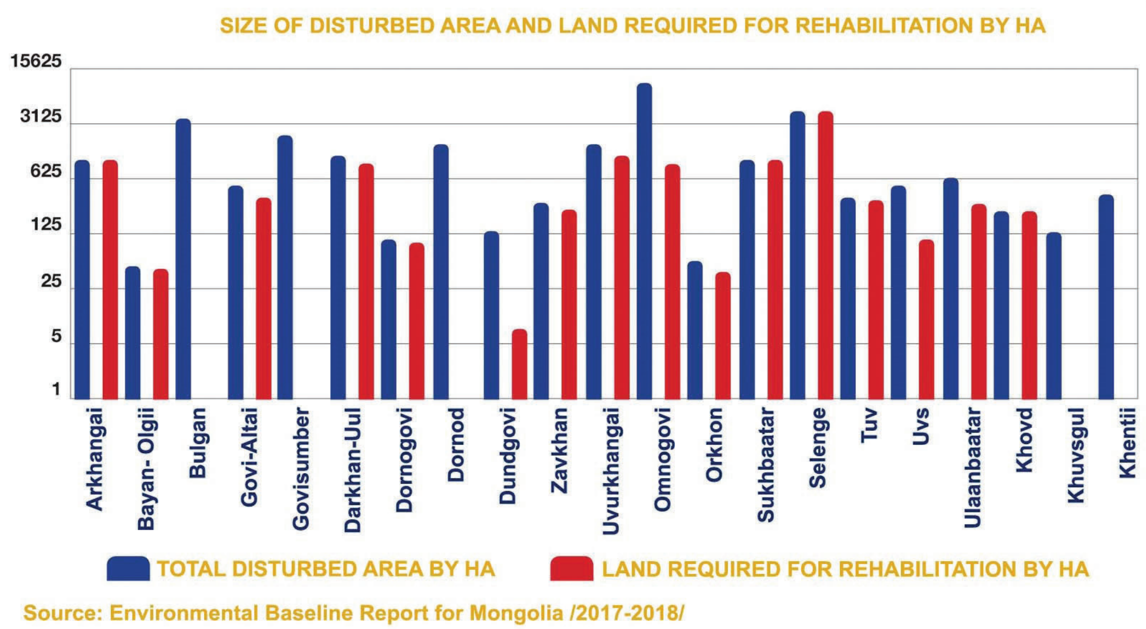
5.2 BEST PRACTICES FOR SOIL CONSERVATION AND RECONSTRUCTION



Source: Environmental Baseline Report for Mongolia /2017-2018/

In terms of time frame, the life of mine continues through various stages from exploration to post-reclamation and closure, requiring decades of time. It will affect the local or regional environment. Proper rehabilitation of mine sites, however, strives to avoid many risks including topsoil loss or degradation.

There are many negative consequences of inadequate rehabilitation. As of 2017-2018, a total of 24,347.5 hectares of land was damaged by mining in all aimags of Mongolia. The number of abandoned land in need of rehabilitation is 1491 and thecovering an area of 9,381.4 hectares. Best practice rehabilitation activities are designed to limit or avoid these impacts to the greatest degree possible.



Source: Environmental Baseline Report for Mongolia /2017-2018/

Though a listing of the legislative, regulatory, or best practices standards governing mine rehabilitation is specified in respective sections of this manual, a few prominent examples are worth highlighting. For example, the soil conservation practice standards of global key player countries involved in the extractive sector were described to have a threefold purpose for land reclamation:

1. Prevent negative impacts to soil, water, and air resources in and near mined areas;

2. Restore the quality of soils to their pre-mining level; and
3. Maintain or improve landscape visual and functional quality

In the following paragraphs, a brief discussion is provided on each of soil-related procedure across the different stages of mining life.

Pre-disturbance soil assessments

Successful reclamation of disturbed mine landscapes requires the establishment of native plant communities. The goal is to restore the site to a state that resembles the pre-existing plant community. Mine operators are required to return a disturbed site to a land capability equivalent to its pre-disturbance land capability.

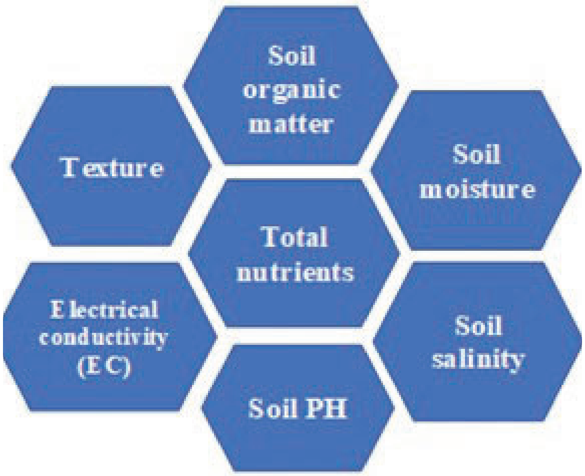


Diagram 9. Important Elements for the Soil performance and Productivity

Success, therefore, involves a comparison of the pre-existing landscape with the reclaimed area.

Baseline soils resource information is essential to successful revegetation and sustainable post-mining land use.

The pre-disturbance assessment serves two purposes:

1. To establish the pre-disturbance land capability of the site; and

2. To provide guidance to operators on appropriate soil salvage requirements.

Soil chemical and physical characteristics documented in a site-specific soil survey are useful in determining suitability of pre-mining soils for revegetation as well as an aid in determining volumes of suitable material. In arid and semi-arid areas, soils provide many factors that are the foundation for successful reclamation. Soils provide both biotic and abiotic (physical) factors necessary for plant establishment, growth, and long-term survival.

Pre-disturbance assessment information available for a site can explain or defend a conclusion that is different from a conclusion reached by comparing off-site controls to the reclaimed site data. This commonly occurs when adjacent controls do not represent the pre-disturbance land capability of the site very well, or when the pre-disturbance land capability is not apparent from the reclaimed site. Since a large proportion of borrow sites are developed on previously disturbed land, and borrow sites frequently have drastically different topography after reclamation as compared to before, it is in the best interests of operators to carry out pre-disturbance assessments on all sites.

Stripping procedures

Photo 8. Topsoil stripping

The first step of mining operation is stripping. The size of the stripping area, the amount of soil to be stripped, and the depth must be reflected in the mining plan for the year. Stripping soil is the material above the mineral layer, and if there are many layers, their top layer can also be defined as stripping soil. Stripping soil contains seeds and vegetative material (i.e., roots) of native plant species which can contribute to revegetation after the soil is replaced over technically rehabilitated land.

Soil stripping depths shall be based on the survey results of the original soil profile. Consistent with the soil resource management strategy, disturbance areas will be clearly delineated and stripped of soil resources including topsoil, followed by the separate removal of subsoil (where subsoil is deemed suitable for rehabilitation purposes). This will be followed by the separate removal of topsoil and subsoil, where required. Stripped soils would be either directly replaced on rehabilitation areas or stored in separate topsoil or subsoil stockpiles. Where re-handling is necessary, this will typically be undertaken using excavators and dump trucks. Through all stages of soil stripping earthworks, soil stockpiling and re-application for rehabilitation, operations shall be closely supervised to maintain correct recovery depths of suitable soils based on results of soil testing or typical stripping depths. There should be a soil resource management plan and strategy applied to direct and control the recovery, handling and management of site soils. Soil stripping strategy and plan should include:

- Delineation of areas to be stripped;
- Delineation of suitable stockpile areas;
- Direction of soil collection/haulage equipment to designated stockpile locations according to soil type;
- Recording of volumes stored (including date, location, soil type, volume and descriptions of any ameliorants added to stockpiled materials for recording in the soils database); and
- Installation of signs for all soil stockpiles with the date of construction and type of soil.

Storage procedures

Topsoil is a key resource in post-mining rehabilitation, and the management of its quality and quantity throughout the mining lifecycle affects the outcome of rehabilitation. If the topsoil is not used directly during the operation, it must be stored in a special area. Topsoil stockpile locations shall be strategically located to assist the sequence of future rehabilitation, outside the active mine path and away from drainage lines. Where possible, stockpile sites will be selected to maximize protection from `the prevailing winds, particularly if the material is friable in nature (e.g. sand or silt). If needed, separate stockpiles for topsoil and subsoil shall be formed, particularly in arid regions and Gobi areas.

The height of the topsoil should be not higher than 5 meters, and slope of topsoil heaps should ideally be 18.5° in order to prevent excessive erosion. If topsoil is stored in the stockpiles for a period greater than 2 years, the outside of the stockpiles should be protected from the wind and water erosion, generally by planting a grass cover-crop on the stockpile[5]. The duration of storage is also a major factor in maintaining soil health and productivity.

Photo 9. Topsoil re-distribution

Photo 10. Topsoil storage

[5] MNS 5916:2008. Environment Requirements for fertile soil removing and its temporary storage during the earth excavation

Therefore, the erosion control and maintenance strategy shall be put in place to minimize the loss of topsoil material respreads on rehabilitated areas and promote successful vegetation establishment. Maximizing the opportunities for direct placement of topsoil from pre-strip to rehabilitation areas is the most appropriate strategy and the mining operation planning should consider the possibility.

Topsoil Redistribution and Reconstruction

In order to improve the potential for establishing diverse plant communities consistent with the specific revegetation goals for an approved post-mining land use, topsoil must be re-distributed in a manner that achieves an approximately uniform, stable thickness, contours, and surface-water drainage systems.

Reconstruction of topsoil profiles involves placement of soil, subsoil and overburden materials in such a way as to establish physical and chemical characteristics suitable for revegetation at and just below the surface of the landscape. The assessment of the soil and underlying material is needed to plan proper reconstruction operations of mined land.

Protection from wind erosion

Wind erosion is a major cause of soil loss in arid and semi-arid regions like Mongolia. The best way to minimize wind erosion is to provide permanent vegetation coverage. Coverage rates of 30–50 % are usually sufficient to this end. The following measures are recommended:

- Minimum tillage, including creation of rough surfaces on uncovered sites;
- Intermediate sowing of grass seeds on topsoil storage areas or areas requiring a second re-cultivation to control wind erosion;
- Use of straw crimping to protect soil from wind until seed germination has advanced;
- Subdivision of large areas by wind breaks perpendicular to main wind direction; and
- Avoid/shorten fallow periods through intermediate sowing and mulching.

Benefits of Direct Topsoil Placement

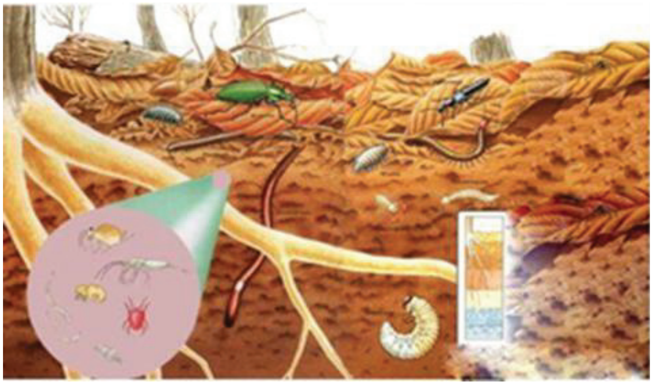
Topsoil quality and quantity decreases rapidly with time if stockpiled for rehabilitation purposes. Pertinent issues include compaction, nutrient leaching, loss of micro-organisms, dilution of the seed bank and a loss of organic matter.

Topsoil placement is undertaken as either a single or two-phase operation. When topsoil placement is done in a single operation, the excavated topsoil shall be moved directly to its final position without intermediate stockpiling. When done in two phases, the first phase of the work consists of excavating select topsoil from the designated sources and hauling to stockpile sites. The second phase involved hauling and redistributing this material over sites that become available for biological rehabilitation.

Photo 11. Direct topsoil placement, UulsZaamar LLC, Zaamar soum, Tuv aimag, 2019

When topsoil placement is done in a single operation, the excavated topsoil is moved directly to a site that is available for biological rehabilitation without intermediate stockpiling. Stripping and immediate replacement of dry, fresh topsoil (i.e., direct placement) is the best alternative for improving reclamation success in mine rehabilitation, as it contains viable seeds and vegetative material (i.e., roots) of native plant species which can contribute to revegetation after the soil is replaced over technically rehabilitated land.

Post-reconstruction soil assessment



Soil structure

Once the reclamation plan is complete and vegetation has established, the assessment of the reclaimed site is necessary to evaluate the success of ecological restoration. Evaluation of reclamation success focuses on:

- Measuring topsoil depths, organic content and nutrient content;
- Measuring the occurrence and distribution of soil microflora community; and
- Reclamation success also measures the structure and functioning of mycorrhizal symbiosis and various enzymatic activities in soil.

Soil acts as a medium for plants and living organisms like worms, fungi, and numerus other microscopic organisms. All of these have significant role in creating organic matter that has a clear reflection on the condition and the health of the soil. As such, proper management of soil organisms is one of the important activities to the achievement of better soil performance. However, the challenge is in determining what aspects of the soil need to be monitored for optimum performance and better soil health.

Soil improvement and fertilization

Mining and restoration activities significantly alters the plant community characteristics, soil properties, and ecological stability. Restoration activities can include the application of soil amendments such as livestock manure, sawdust and new or well-preserved topsoil and can result in improved soil conditions for the colonization and establishment of plant species in rehabilitated areas.

Photo 12. Soil assessment

The amount of humus, which is the main indicator of soil fertility, varies depending on the natural and geographical conditions, and there are often insufficient fertile soil resources to cover during mining. Therefore, it is possible to use animal manure, grain straw and peat to increase the fertile soil resources for rehabilitation. When these materials are not readily available, they can be easily decomposed into specially dug pits to mix biomass-producing food waste, plant stems and leaves, coal dust waste, and sawdust into compacted soil and compost. The following materials are widely used to improve soil fertility. These include:

Fertile soil: Depending on the natural zone of the country, different types of topsoil are formed in different places, and the possibility of using mining for land reclamation varies. For example, forest-steppe soils have high concentrations of organic matter, good water and moisture supply, thick topsoil, and high levels of fertility, while soils in the Gobi and desert regions have extremely poor vegetation cover, mostly sand and gravel, and fertility levels are relatively low. Therefore, the supply of topsoil for the rehabilitation of degraded lands is very poor in the Gobi and desert regions, but sufficient in the forest-steppe zone.

Manure: Manure is stored in the soil for a long time, increases fertility and is relatively available in the country. In the case of direct use of livestock manure for land reclamation, it can be finely ground and mixed with topsoil to increase the fertile soil resource to 20-30 tons per 1.0 ha. Manure is estimated at 8-10 tons on 1.0 ha of loamy soil and 15-20 tons on 1.0 ha of sandy soil, and if the soil is fertilized every year, the humus balance will not be lost. Also, biofertilizer obtained by decomposing manure with moisture red worms is available in the country, so it is suitable for 1.0 tons per 1.0 ha.

Straw: Grain straw is widely available in agricultural areas and is widely used for soil improvement.

Peat: Peat is common in forest-steppe zones and wetlands, and due to its high organic content, it can be used for soil improvement. Peat is classified into two types according to its stable location: highland (mountain top), lowland (intermountain, river valley) and has a high water retention capacity. However, peat distributed in the highlands is less fertile, while peat stabilized in the lowlands is composed of thicker layers with higher organic content. Therefore, such peat can be used for land reclamation. When covering with peat, moisture accumulates well in the topsoil and creates favorable conditions for air heating.

Table 4. Nutrient content of soil improvement materials

Materials for soil improvement		Fertility content,%		
		Nitrogen (N)	Phosphorus (P_2O_5)	Kali (K_2O)
Manure	/dry/	0.62	0.34	0.64
Semi-liquid manure	/cow/	0.40	0.06	0.46
	/pig/	0.65	0.14	0.27
Peat	low ground	2.50	0.25	0.10
	elevation	0.80	0.05	0.25
Straw	cereals	0.50	0.25	0.80

Weeds can also be mixed with other minerals in an anaerobic environment and composted to produce compost.

5.3 CASE STUDY 1–TOPSOIL AND SUBSOIL STRIPPING IN SOUTH GOBI SANDS LLC

Project description: Ovoot Tolgoi mine of South Gobi Sands LLC (SGS) is a coal mine, operating in Gurvantes soum of Umnugovi aimag.

Part 1. Soil stripping, Relevant Standard: MNS 5916: 2008 - Fertile soil /topsoil/ stripping and its temporary storage during the earth excavation.

Larger area of land is used in the case of open pit coal mining for purposes such as roads, infrastructure, coal washing plants and piling up waste dumps etc. Therefore, the company performs timely topsoil stripping for each of these sites prior to the utilization of above-mentioned purposes. This stripping operation is compulsory in accordance with the company's internal procedures and relevant laws and regulations of Mongolia. The company's environmental policy clearly states that the topsoil shall be stripped completely without any loss and the topsoil shall not be mixed with waste rock.

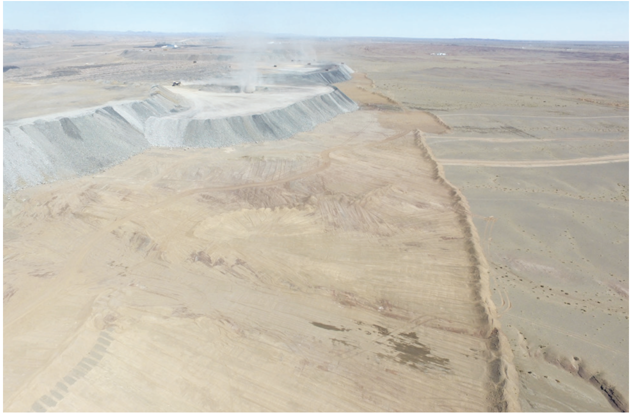


Photo 13. Stripped area


Photo 14. Stripping by dozer

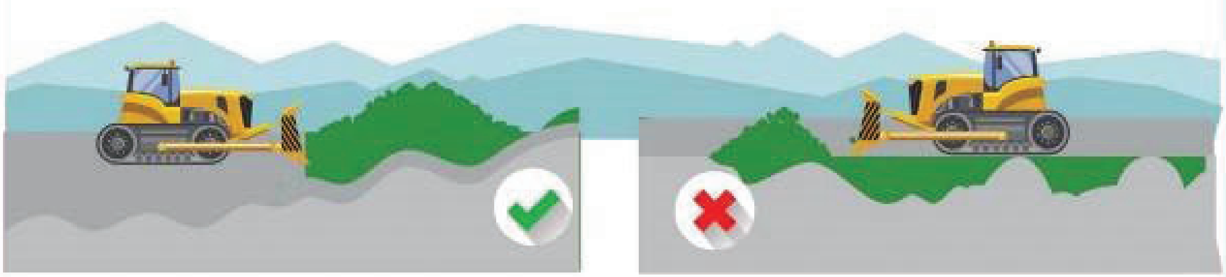

Photo 15. Stripping operation

How company meets standard requirements: During mine operation, topsoil is stripped and stored in accordance with the standard MNS 5916: 2008 "Stripping and storage of fertile soil during earthworks". The stripped topsoil is stored for use later in the rehabilitation of disturbed land. Topsoil and subsoil stripping thickness is about 40 cm to completely use these fertile layers.

The total size and number of topsoil piles are marked by different colors on the map of the mine.

Case narrative:

1. Topsoil stripping is completed by the company;
2. Unskilled dozer operators made mistakes in terms of completely collecting the topsoil along with subsoil. Hollow areas and gullies are accidentally filled by stripped soil and not stored properly but left behind;
3. Therefore, actual stripped topsoil is less than the actual volume it is supposed to be;
4. Inspectors do not always pay due attention to this issue; and
5. Due to this topsoil and subsoil loss, later, the collected topsoil and subsoil are not sufficient for the redistribution during the rehabilitation.



It is repeatedly observed that a large amount of topsoil left at the stripped area thus, it is not stored in stockpile and protected properly. This is result of improper topsoil stripping operation which is not conducted according to the standard requirements.
The negative consequence of this practice leads to the shortage of topsoil during rehabilitation phase. State environmental inspectors are not able to thoroughly and systematically monitor this issue.

Diagram 10. Practical problem in stripping

Consequence: Above-described incident leads to improper technical rehabilitation and topsoil and subsoil is wasted.

How inspector verifies this issue in practice: The inspector visits twice a year and inspection takes place according to the inspection directives. The inspector gets assistance of the company's Mine Surveyor to take measurements. Then the inspector calculates the total volume by multiplying the thickness of the topsoil included in the DEIA with the total stripped area.

Afterwards, the topsoil pile locations aggregated into the calculated value is reviewed and matched to the markscheider's measurements. Usually, no discrepancies are found in the company experience.

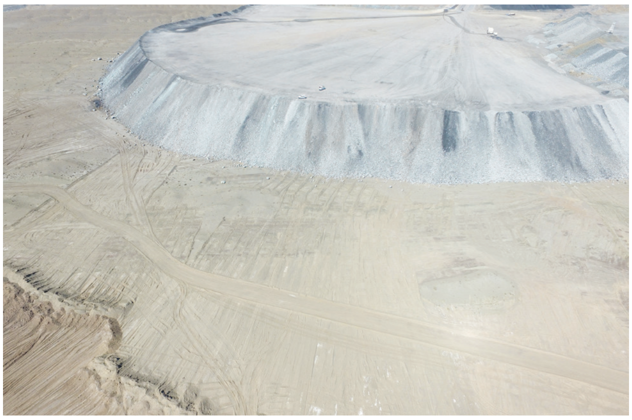


Photo 16. SGS Stripping operation

Photo 17. SGS stripped area

Any gaps, problems and challenges faced by both the company and the inspector: The problem is that the inspectors do not always properly monitor or inspect whether the topsoil has been adequately removed, or there is a lack of knowledge and information to realize the importance of topsoil for future rehabilitation.

Solution: Inspector shall carefully execute "Step-by-step operating procedure for field inspections of topsoil stripping".

SGS best practices are as follows:

1. Environmental officer of the company conducts proper training for dozer operator;

2. Environmental officer of the company conducts regular monitoring during the process of stripping operation;
3. Engineers order surveying to measure and control that the topsoil and subsoil has been stripped up to its potential maximum size (in terms of depth and coverage area);
4. Each land disturbance at the mine is reported to the Environmental Department and the total amount of disturbed land is also notified to the parent company so that the budget estimation for future rehabilitation costs shall be revised accordingly;
5. Monitoring is undertaken to ensure that the topsoil and subsoil has been stripped to the extent that it should be stripped, by taking photos or videos using a remote-controlled drone; and
6. Check that the ordered target area for stripping is fully completed. This is how the company monitors if area to be stripped is fully covered by stripping operation.

6. KEY COMPONENTS OF CLOSURE-REVEGETATION

6.1 DEFINITIONS

Establishing vegetation is an important activity in reclaiming mined lands. Revegetation encourages mine soil development, creates an aesthetically pleasing landscape, and contributes to productive post-mining land use.

As the biological rehabilitation, the following principles should be applied in combination or alone, as the local situation dictates:

- Species/site-matching: Selection of plants whose physiological and ecological properties comply with local site conditions, i.e. mostly pioneer nitrogen-fixing plants with robust rooting and self-propagation properties, capable of quickly producing biomass and resilient allopathic behavior; and
- Sustainable development: The composition of plants should, in the long run, be able to generate ecological, economic, and social benefits required by rural development goals at the particular location.

6.2 BEST PRACTICES FOR REVEGETATION

Pre-disturbance vegetation assessment

Pre-disturbance vegetation assessment to determine species composition and soil requirements of natural vegetation communities within the mine footprint, as below:

- The composition of the plant species in the environment;
- Distribution and resources of rare, very rare and useful plants;
- Vegetation cover;
- Productivity/yield of vegetation cover; and
- Usage direction.

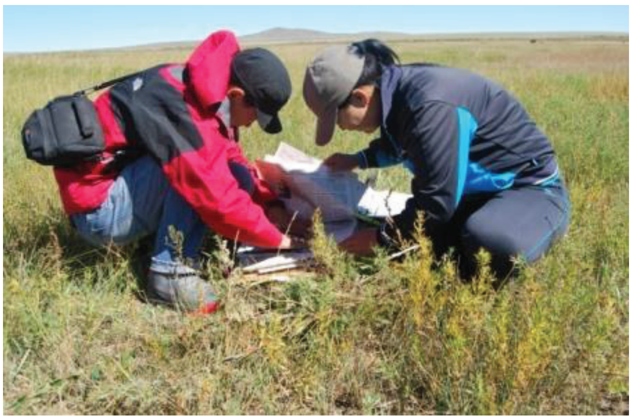


Photo 18. Vegetation assessment

Comparison with natural plant communities and their species composition on neighboring undisturbed sites may provide guidance when establishing artificial ecological communities.

Selection of reclamation species

When establishing vegetative groundcover on mined sites, the two most important factors influencing species selection should be soil properties and post-mining land use. Those are;

- First, the structure and properties of the soil; and
- Second, after the mine closure, the land is intended for further use.

Three general categories or types of plants are used for revegetation of mined areas: grasses, shrubs, and trees.

Due to harsh continental climate and fragile ecosystems in Mongolia, natural succession of plant communities is slow. To accelerate vegetation recovery, it is paramount to screen for pioneer species suitable for the establishment of resilient plant communities. Pioneer species are generally characterized by a high tolerance to frost, desiccation by drought, wind and snow damage, waterlogging and alkalinity and more importantly, availability of large amounts of propagation material.

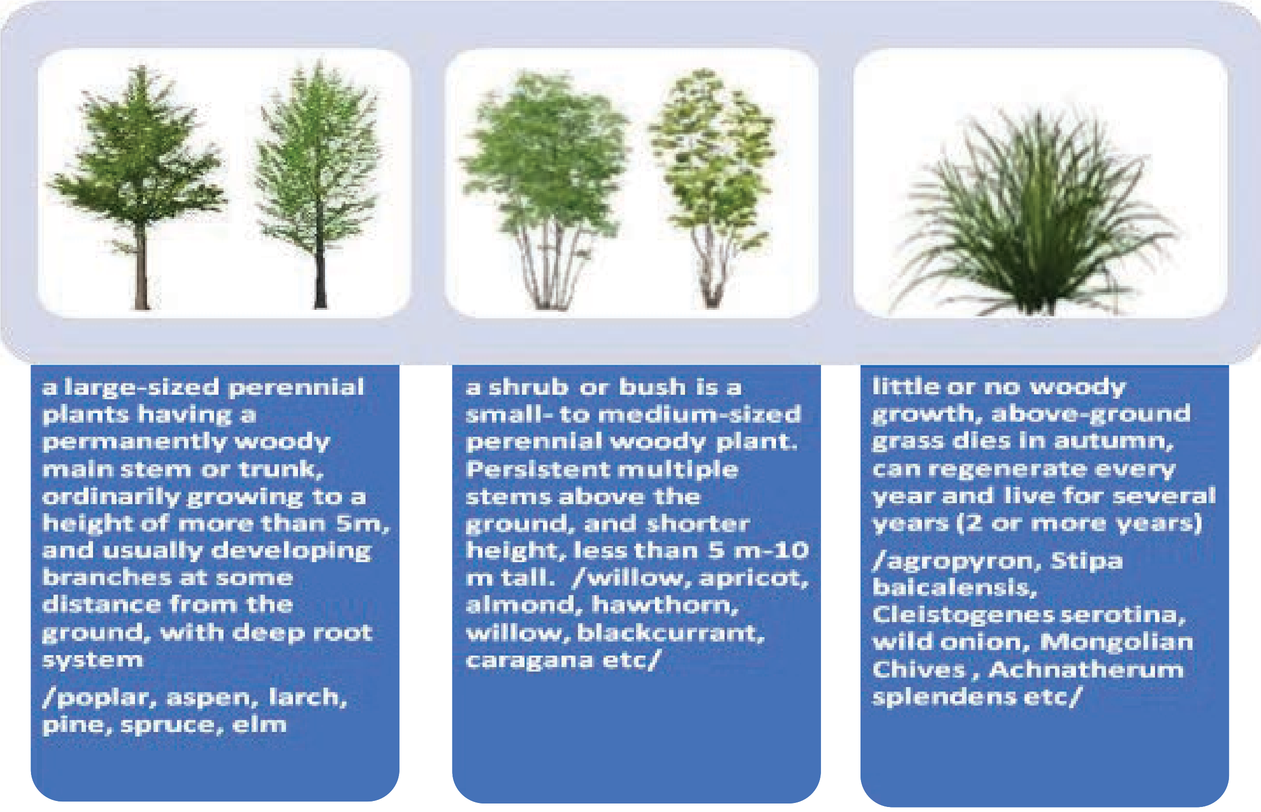


Photo 19. Plant groups

Species selection shall depend on the following factors:

- Ecoregions;
- Registered plant species prior to the mining activities; and
- Further land use purpose etc.

Table 5. Selection of species by natural zones[6]

№	Natural zones		Perennials: Vasculer plants	Perennials: Dicots	Annuals and biennials
1	Higth mountain zone		Elymus L Bromus L Agropyron Poa prantensis L Alopecurus	Medicago L Vicia Melilotus Hill Astragalus Caragana	Avena sativa L Hordeum vulgare L
2	Taiga forest zone				
3	Mountain forest zone				
4	Steppe zone	Mountain steppe	Elymus L Agropyron Bromus L	Medicago L Melilotus Hill Trifolium pratense L Caragana	
		Steppe			
		And steppe	Agropyron Elymus L Stipa baicalensis Festuca rubra L Koeleria macrantha		Avena sativa L Salsola tragus Chenepodium album
5	Gobi zone	Desert steppe			
		Gobi desert		Caragana	
6	Desert zone	Semi-desert	Stipa baicalensis Cleistogenes serotina		Salsola tragus Chenepodium album
		True desert			
		Extremely and desert			

Seed quality. Perennial seeds retain their viability (germination) at different times. In other words, the longer the seeds are stored, the lower their germination capacity. In most cases, perennials produce the most abundant and high-quality seeds in the second or third year of life, after which the yield decreases and the quality of the seeds deteriorates. Therefore, it is important to know the date planted and the date the seed is harvested.

Seed quality information must include laboratory seed germination and purity. These are the most important parameters for the seeds of plants for rehabilitation. Seed laboratory germination is the number of seed that can germinate from 100 matured seeds, while purity is the number of pure seed in a given seed sample. Laboratory germination and purity are determined in laboratory conditions and expressed as a percentage (%) and based on which the quality of the seed to be sown is calculated.

Table 6. Herbaceous, plant germination and seed menopause

Plant	Germination, %		Seed menopause, %	
	Class 1	Classa 2	Class 1	Classa 2
Medicagol	70	60	90	80
Siberian Elymus	70	50	95	90
Elymus dahuricus	60	40	90	80
Bromus L	75	65	95	90
Gaertu	80	65	95	90

Selection of species composition and planting densities

When selecting the species and planting method for disturbed land revegetation, take account of the soil structure, mechanic composition, topography and other conditions based on the Environmental Baseline Assessment outlined in the Detailed Environmental Impact Assessment Report of the project.

[6] MNS 5918:2008. Environment. Revegetation of destroyed land. General technical requirements.

Table 7. Plant seeds quantity

Latin Name	Mongolian name of the plant	1 hectare /by kg/
Medicado L	Царгас	8 – 10
Onobrychis L	Хуцэнгэ	25-30
Melilotus Hill	Хошоон	15-20
Bromus L	Согоовор	18
Elymus L	Өлөнгө	15-20
Agropyron Gaertn.vkco	Ерхөг	15-18

Table 8. Planting density of trees

Natural zone	Species for rehabilitation	Space between rows, m	The space between the trees,m	Quantity of seeds, ha/pcs
Mountainous region	Birch	4.0	4.0	500
	Poplar			
	Aspen			
	Larch			
	Pine-tree			
	Spruce	4.0	3.0	833
Steppe and desert region	Poplar	4.0	3.0	833
	Aspen	4.0	3.0	833
	Spruce	3.0	3.0	1111

Table 9. Planting density of shrubs

Natural zone	Species for rehabilitation	Space between rows, m	The space between the trees, m	Quantity of seeds, ha/pcs
Same for all natural zones	Black currant	3.0	1.0	3333
	Sea-buckthorn	4.0	1.5	1666
	Cherry, Bramble	3.0	1.0	3333

Weed control

Revegetation measures reintroduce appropriate species to the site in order to establish a self-sustaining vegetative cover, usually consisting of local, native species. Perennials planted in revegetation areas may be affected by weeds because they grow slowly in the first year of life. Weeds are non-native plant species that have been designated "noxious".

A weed monitoring and control program can allow mine operators to recognize potential weed problems early, control them before they reproduce and spread, and maintain adequate follow-up control. The weed monitoring includes below measures:

- Hand pulling and/or hand digging may be used to remove noxious weeds;
- Forest Service or approved herbicides will be used to prevent and restrict the spread of noxious and invasive weeds; and
- Certified noxious weed-free mulch and seed mixtures will be used to reclaim disturbed areas and control the spread of invasive and noxious weeds.

For weed control, herbicides can be used which have a selective effect on plants. The right choice should be made depending on the type and species of plants planted for revegetation. Alternatively, weeds can be removed by hand tools in a small area, before the weed seeds matured and drop to the ground. But, the best practice for weed control is to ensure the seed materials used for revegetation are clean and free from weed seeds.

Widely spread weeds in Mongolia

Hyosyamusniger

Peganumnigellastrum

Euphorbia discolor

Aconitum barbatum

Aconitum turczaninovii

Dracocephalumfoetidum

6.3 CASE STUDY 2 – REVEGETATION

Relevant requirements of national standard

MNS 5918: 2008. Environment. Revegetation of destroyed land. General technical requirements.

3.1 When selecting the species and planting method for disturbed land revegetation, take into account the soil structure, mechanic composition, topography and other conditions based on the Environmental Baseline Assessment outlined in the Detailed Environmental Impact Assessment Report of the project.

3.4 For revegetation of disturbed land, seeds of I and II class in germination (65-80%), and cleanliness (80-95%) shall be used.

3.9 For reclamation, preferably use local trees, bushes and shrubs.

3.14 All kinds of saplings for rehabilitation shall be healthy, free of any disease and pest insects, not frozen and their roots in good condition.

Part 1. CURRENT PRACTICES AT COAL MINE COMPANY (SGS)

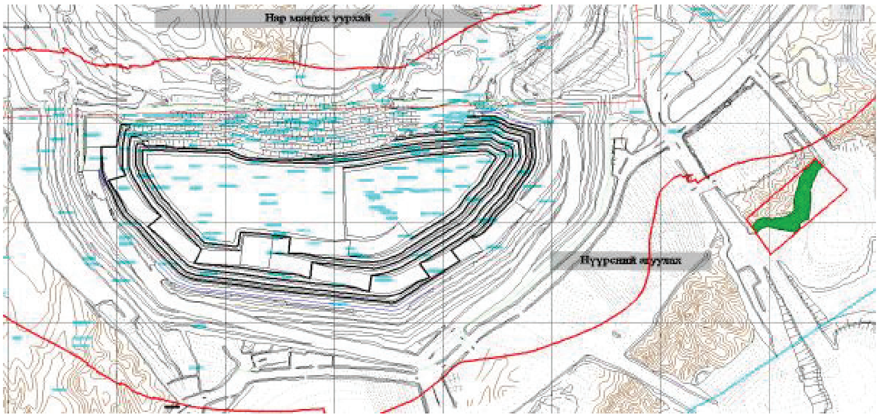


Photo 20. The area rehabilitated in 2019 is marked in green at Sunrise open pit

Project background: In 2019, SGS planned to carry out biological rehabilitation work on 1.3 hectares of land in the vicinity of the sunrise open pit of the Ovoot Tolgoi mine that was disturbed by mining operations, but will not be affected again in the future. The company performed biological rehabilitation as planned.

The Ovoot Tolgoi mine is located in Gurvantes soum in Umnugovi aimag. According to the ecosystem atlas of Mongolia (2019), this area falls in the extra arid biome. It was also classified to the region of extreme desertification in the status map of desertification in Mongolia. Therefore, it is apparent that the rehabilitation here in terms of ecological zone will be complicated.

Quality of seed: The company progressively rehabilitates the disturbed land when the site is no longer used by mining operations. The seeds from local plants are cultivated for purposes of biological rehabilitation.

- Before sowing the seeds in the field, seed quality is determined, cleaned and disinfected.
- Seed quality is analyzed by the Environmental Department in its laboratory using simple methods. Seeds with a viability of more than 50% are selected and planted in the field.
- Growth rate is affected by whether seeds are properly collected (harvesting of fully ripe seeds, timing of seed collection is properly scheduled) and stored in suitable conditions (i.e., cleaning of harvested seeds from other contaminants, maintenance of standard dry and cool conditions). Loss of viability due to poor storage conditions will have direct impacts on the vegetation growth;

Photo 21. Preparation of seeds for inspection, cleaning and disinfection

- A total of 405.4 kg of local plant seeds were planted. Planting was carried out using the seeds of tree and shrub plants: Haloxylon ammondendron and Amygdalus mongolica; and

- More than 80 percent of the total vegetated area was covered by Haloxylon ammondendron and the remaining 20 percent was covered by annual plants which were grew out of the seeds stored in the topsoil. No growth results for Amygdalus mongolica, as nuts did not germinate. Haloxylon ammondendron seeds were more viable.

Community involvement in the revegetation

Activity 1: Creating the Seed bank

In 2018, local plant seed collection was organized with the participation of 60 students under the lead of B.Batzul, the teacher of the "Khulan" environmental club in Gurvantes soum. During the seed collection, a total of 260.4 kg of seeds of 7 species were collected.

Photo 22. SGS revegetated area

During the field training, seeds of Cyperus rotundus, Phragmites communis and other cereal grasses were collected from the fenced area around the Khurshuut spring.

Haloxylonammondendron seeds were collected from saxaul forests in the middle river without damaging plant stems and branches.

Photo 23. Seeds collecting

Activity 2: Fence springs and create plantations

Pilot implementation of this activity was undertaken with involvement of the local community. Sukhant spring was fenced with cooperation from local citizens Davaa and D.Batochir. A small-scale plantation was created including tree, shrub plants and grasses.

Observation/Recommendation

1. According to the Mongolian Standards on revegetation, species of plants to be used for reclamation are very generally specified for the biomes;

2. The standard emphasizes the importance of planting with local plant seeds. There are no specific guidelines for choosing plants that can grow quickly and produce many seeds:
   i) The inspector should consider whether species suitable for the area to be rehabilitated have been planted in sufficient volumes. Plants such as Tamarix ramosissima and Reaumurea soongarica grow well, not from seeds, but instead from green twigs;
   ii) It is necessary to prepare the seeds of the most-seeded plants from the local area, as well as to build a seed bank by fencing off springs and nurturing plants that will produce the most seeds in certain area using surface water; and
   iii) Selecting plants that are more adapted to dry climates and mixing them with locally collected plant seeds will help to ensure successful rehabilitation.
3. If the number of seed species collected and the total mass is insufficient compared to the area of reclamation land:
   i) Collect seeds from a larger area, including the area surrounding the mine affected zone with a 50 km radius, and remote areas with similar ecological conditions;
   ii) In the vicinity of springs, if the surface drainage water meets the standard, establish a seedling plant/plantation that produces the most plants locally and collect a large number of seeds each year and have a seed bank;
   iii) It is more effective to have a fence around the spring and provide additional care to the fenced land than to collect seeds from there. This enables the possibility of collecting a large amount of good quality seeds from a smaller area compared to collecting seeds from a radius of 50 km around the land to be rehabilitated. The area without fencing will be used as pastureland and as a result, seed collecting will be less productive; and
   iv) Native plants from the region such as saxaul, pine, Mongolian almond, alfalfa, leek, sagebrush, and larchleaf saltwort must be cultivated in greater volume in the plantation.
4. Mongolian almond seeds do not grow or grow poorly if planted directly as intact nuts. It grows well when it is sown in a suitable environment after the nutshell is broken and the seed sprouts; and
5. The Shariin Gol mine, located in the forest-steppe zone of Selenge aimag, shows a case study[7] where the grass cover increased depending on which plants were used in the vegetation. Planting of Medicagofalcate resulted in a comparatively minimal coverage of grass, whereas planting of Erymus dahuricula and Bromus inermis showed the highest percentage of grass cover.

Part 2. FIELD MONITORING OF REVEGETATION

SGS planted 1.3 hectares in 2019 and is now in its second year. In September 2020, the inspector from Aimag Professional Inspection Department conducted the on-site monitoring of rehabilitation.

- Monitoring was conducted on the basis of the approved directive;
- Monitoring was performed using a checklist and scores were assigned. The checklist contains a very general level monitoring parameters; and
- Revegetation in the rehabilitated area was inspected visually. The inspector was able to identify plant species visually and positive feedback is provided regarding the revegetation performance.

Considerations during field monitoring

At the Shariin Gol mine, located in the forest-steppe zone, it was observed that weeds were initially dominant in the reclaimed landscape and then decreased naturally in the following years as the reclamation species became more established. In other words, weed plants play a certain role in re-establishing vegetation growing conditions in degraded/eroded soils and bare areas. This should be taken into account when examining the requirements for the rehabilitation in terms of weeds (the

[7] Article from Journal of Agricultural science

percentage of weeds can be at 15-25% pursuant to methodology[8] for rehabilitation, approved by the MET). This means that the timing of the monitoring in comparison to the revegetation phase should be taken into account well.

[8] Methodology for rehabilitation of disturbed land by mine operations, approved by the MET, 2015.

SECTION II.
ON-SITE MONITORING

GENERAL SUMMARY

The following chapters provide an operational framework for the implementation of monitoring measures to evaluate the success of reclamation and closure. In total 11 monitoring directives should address the following, where appropriate:

SUSTAINABLE LANDFORM DESIGN

1. Closure progress
2. Geotechnical stability
3. Geochemical stability

SOIL CONSERVATION AND RECONSTRUCTION

4. Topsoil stripping
5. Topsoil storage and protection
6. Topsoil redistribution and reconstruction
7. Dust settlement and soil contamination

REVEGETATION

8. Viability and germination rate of plant seeds
9. Species composition and performance of species growth
10. Vegetation coverage rate
11. Growth of species per square meter

For a case study on mining rehabilitation from a legal perspective, please refer to the Annex 10.1.5:

Case study 3 - Inspection of Environmental Rehabilitation

7. ON-SITE MONITORING OF SUSTAINABLE LANDFORM DESIGN

This chapter provides three sets of on-site monitoring procedures for sustainable landform design: closure progress, geotechnical stability, and geochemical stability. These three areas relate to monitoring of mine waste materials and pit slopes with a focus on assessing how the plans match closure plan and reclamation plan designs, and on the physical performance (subsequent chapters provide monitoring sets related to soil placement and revegetation). Applicable to all three landform design monitoring sets, a list of regulatory requirements required from the company and tools are provided in Section 7.1.

Glossary

- **The length of the side (slope)** is the distance from the apex of the surface specified in the mine surface design to the line perpendicular to its base edge;
- **Lateral slope angle** - The angle between the side of a derived surface and its projection in the horizontal plane: The ratio of the vertical and horizontal lines in degrees. (for example 4H: 1V). For a derived surface, compare the highest point of its apex with the edge of the horizontal plate. In the case of a bench, it is defined by the angle between the projections in the horizontal plane of the line connecting the upper brow perpendicular to the lower edge (mines, tailings storage facilities and stockpiles are created by forming a bench);
- **Derived ponds** is water that is temporarily or permanently accumulated on the surface due to errors in the construction of buildings. Ponds are sometimes needed, but are often subject to erosion (especially near the lateral slopes of the surface) or excessive water infiltration;
- **Lateral stabilization of a derived surface** means that the soil or rock that makes it up is stable to the appropriate level. Stabilization depends on the lateral surface angle, the strength of the foundation, and the hydrogeological conditions. Long slopes are expected to be unstable due to erosion, while steep slopes are prone to landslides (such as geotechnical instability);
- **Cracks** - fracture formed near soil stockpiles, tailings dams or open pits. Cracks are usually caused by geotechnical instability and are the first signs of rock collapse or landslides;
- **Hollow** is the occurrence of one or more cracks in the surface and movement down from the top of the surface. Hollow is a common sign that shows the soil stockpiles and tailings pond is unstable;
- **Waste accumulation** is the phenomenon of large landslides caused by heavy rains and flash floods The accumulation of waste rock may break the tailings dam, in other words the surface cracks and slides down when the soil is saturated with water;
- **Crushing** a group of rocks that have fallen apart from a pit;
- **Erosion is** the damage to soil or rock material caused by water, wind or ice impact;[1]
- **A ravine** is a channel formed by the flow of water to a natural or mine surface. Typically, these ravines are at least 30 cm deep and have steep walls;
- **Sedimentation** is the process by which water, wind (slowing down the flow) and ice (melting) cause solid particles to settle; and
- **Springs and infiltrations** are the phenomena of infiltration and outflow of groundwater to the surface.

[1] The last two definitions are included in the Geological Society's terminology. https://www.geolsoc.org.uk/ks3/gsl/education/resources/rockcycle/page3451.html#e

7.1 MONITORING OF CLOSURE PROGRESS

Inspection objective

Inspection of whether **closure progress** is compliant with project documents approved by relevant authorities and requirements of national standards.

This set of monitoring requirements is meant as an overview of general compliance with plans and commitments, with more detailed monitoring of landscape/geotechnical/geochemical performance detailed in Sections 7.2 and 7.3.

Summary outline

Performance issue
Closure progress

Monitoring parameter
Office and field inspection of reclaimed areas for general compliance with plans

Measurement techniques

- Current digital aerial photos; and
- Quantitative data from mine operator.

Sampling Location

- Reclaimed areas

Sampling Frequency

- At least yearly

Compliance criteria

- Reclamation commitments in current EMP, compliance with the closure plan, compliance with National Standards requirements (Table 10).

Requirements of relevant national standard

General technical requirements for rehabilitation of land affected by mining activities (MNS 5917: 2008).

Table 10. National standard requirements (applicable to Sections 7.1 and 7.3)

Standard requirements	Measurement techniques
10.1: Detailed rehabilitation project shall be developed and certified by an authorized organization and followed.	▪ Visual identification ▪ Photographic records
10.2: Biological rehabilitation shall be carried out in the presence of relevant professional personnel (of agronomy and botany etc.) and professional institutions.	▪ Visual identification ▪ Photographic records
10.3: Dry river beds affected by mining activity shall be rehabilitated in its original location and the slope of rehabilitated river bed shall not exceed 25^0.	▪ Visual identification ▪ Inclinometer measuring ▪ Photographic records
10.4: No underground lake and pond created by mining activity on purpose and those that are not fed by ground water shall remain.	▪ Visual identification ▪ Photographic records
10.5: If lake or pond created by mining activity and fed by ground water is to remain for farming purposes, all walls shall be sloped and not exceeding 25° and the ground above the water surface level shall be re-vegetated.	▪ Visual identification and measure with inclinometer
10.6: If the open pit mine in hard rock area is located in ground water spread zone, the bottom of the mine shall be sloped and levelled not exceeding 25° and the ground above the water surface shall be re-vegetated.	▪ Visual identification ▪ DEIA ▪ Measure with inclinometer

Table 11. General requirements on reclaimed area

Indicators	Rehabilitation purpose					
	Agricultural		Forestation	Pond & fishery	Special	Nursery & hygiene
	Arable	Hay and pasture				
Slope of dump surface, degrees (not more)	8	18	25	-	Stabilization angle	
Slope of the stockpile, degrees (not more)	-	25	25	-	20	

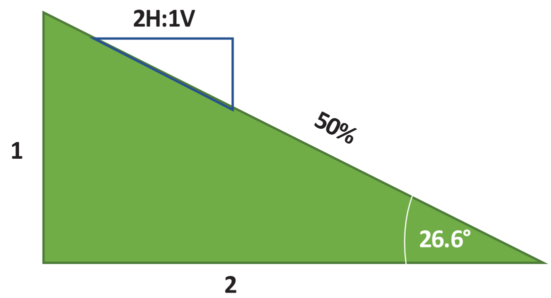
Methodology for technical and biological rehabilitation of damaged lands due to mining activities

The comprehensive methodology for technical and biological rehabilitation is approved by Order A-138 of Minister of Environment, Green Development and Tourism in 2015. The methodology is intended for licensed rehabilitation companies and mining companies, but the state environmental inspectors should know the process and the final outcome of the rehabilitation operation.

Table 12. Equivalent slope angles

Degrees	Gradient	Civil engineering ratio xH:1V
0	0%	∞
5	9%	11.4H:1V
10	18%	5.7
11.3	20%	5.0
14.0	25%	4.0
15	27%	3.7
18.4	33%	3.0
20	36%	2.7
25	47%	2.1
26.6	50%	2.0
30	58%	1.7
35	70%	1.4
37	75%	1.3
40	84%	1.2
45	100%	1.0
50	119%	0.8
55	143%	0.7
60	173%	0.6

As the table shows, as a first approximation, the slope angle in degrees is about half of the gradient (when expressed as a %).



Definitions

Closure progress – monitoring of progressive reclamation undertaken at scheduled intervals during the life of the mine. This allows an assessment of compliance and will also provide an adequate benchmark for rehabilitation monitoring that is undertaken at the end of the mine life.

Progressive reclamation monitoring for open pit mine workings may include, but is not limited to the following:

- Visually inspect progressively reclaimed landforms for signs of physical deterioration or settlement;
- Inspect backfilled pits with waste rock and/or tailings as operations proceed;
- Inspect pit slopes and pit lakes, created to manage and treat mine site water if backfilling is not feasible;
- Inspect exposures of mineralized rock in pit walls as they become apparent and ARD/ML assessments conducted; and

- Identify and monitor seepage locations and water quality from tailings structures or in-pit high walls during operations.

Sequence of field inspection work procedures for monitoring closure progress

It is expected that the inspections for closure progress, geotechnical stability, and geochemical stability will be carried out concurrently and will require only a single annual office review followed by a single annual field inspection though the steps for each inspection are set out separately in the following sections. Some sites may require more frequent inspections.

STEP 1. Review the following relevant documentations from the mining company:

- ☑ Quantitative data of the mine closure plan;
- ☑ Rehabilitation plan of DEIA and EMP;
- ☑ Mine closure plan;
- ☑ Design and as-built topographic maps, heat maps, and isopach maps listed below;
- ☑ Infrastructure map; and
- ☑ Other information as shown in Table 13.

STEP 2. Check that areas currently completed for closure are consistent with the company's mine closure plan. If necessary, use drone for further verification.

- ☑ Assess whether the top-of-mine waste as-built contours match the design contours;
- ☑ Assess whether the areas marked as reclaimed have reclamation material to the required depth (see also Section 8.3);
- ☑ Assess whether the as-built drainage channels have been constructed and armored according to the design and that they are connected to the adjacent off-landform drainage system. Assess whether there are any large areas of ponded water (or previously ponded water) inconsistent with the closure design;
- ☑ Determine whether pre-existing infrastructure has been decommissioned and whether post-reclamation infrastructure is present, meets the design, and is in working order. Infrastructure includes such things as roads and trails, shacks/buildings, signage and fences, barriers, monitoring instruments, stockpiles, power lines and pipelines, shafts and portals, and sedimentation ponds. The area should be free from such things as disused infrastructure, trash and debris, disused monitoring equipment, old mine equipment, old signage, and disused fences and culverts; and
- ☑ Determine whether the landscape performance monitoring instruments are in place, functioning, and being read, analyzed and reported on a periodic basis. Common monitoring instruments include climate stations, slope inclinometers, survey monuments and settlement plates, standpipes and piezometers, thermistors, and runoff weirs. Most landforms will have little post-reclamation instrumentation and rely mostly on visual inspection and water quality sampling and testing.

STEP 3. Monitor that technical rehabilitation is completed according to the applicable regulation:

- ☑ Visually inspect progressively reclaimed landforms for any deterioration;
- ☑ Inspect pits backfilled with waste rock and/or tailings;
- ☑ Inspect if protective measures were applied to pit lakes, created to manage and treat mine site water if backfilling is not feasible;
- ☑ Inspect whether drainage channels are built to design in the correct alignment, well graded, avoid ponding water, have rip rap or soil/vegetation armor as per design, have no areas of excessive erosion or deposition, free of debris or blockage, and are connected to adjacent drainage channels and creeks;

- ☑ Visually inspect flat areas, especially the landform plateau, for evidence of unwanted ponded water;
- ☑ Visually inspect slopes for signs of unexpected seepage existing slopes (springs, wet areas, salty crusted areas, lush vegetation) that could be precursors of geotechnical or erosional instability;
- ☑ Visually inspect if infrastructure has been decommissioned and removed from the reclaimed area and that the infrastructure in the reclamation plan is in place and functional using the list above;
- ☑ Visually inspect the monitoring instrumentation to determine that it is at the design location and in working order; and
- ☑ Examine the tailings beaches/plateau for unexpected accumulation of soft tailings (safety protocols required – additional caution is required for soft tailings beaches.).

STEP 4. Assess the performance:

- ☑ Compare technically reclaimed landforms against standard requirements; and
- ☑ Compare performance of landform stability against Company's closure management documents, the design documents, and the as-built documents.

STEP 5. Create a photographic record:

- ☑ Take photos of progressively completed reclamation for closed site/areas for documentation.

STEP 6. Document findings:

- ☑ Write conclusions on whether closure progress is compliant and note any deficiencies to be remediated; and
- ☑ Include a photo appendix of key photos with descriptions. Include representative areas showing good progress as well as any deficient areas or features.

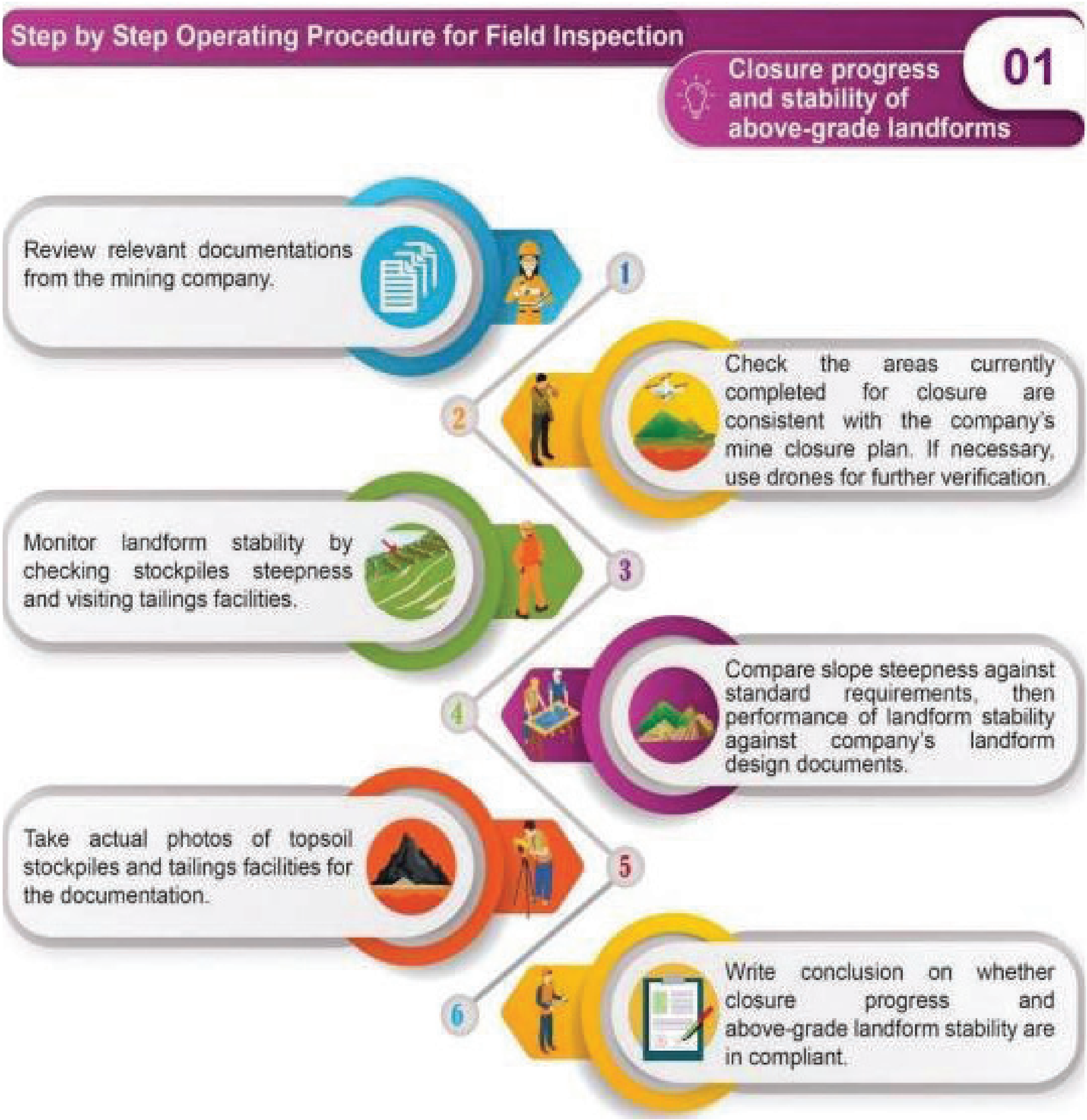
List of documents to be obtained from the company

Table 13. List of documents to be obtained

#	Primary document	Particular section
1.	- Mine closure plan (if developed)	Progressive closure planning section
2.	- Quantitative data from mine operator	Completed closure landforms
3.	- DEIA and EMP commitments	Annual rehabilitation plan
4	- Topographic map showing design contours for top of mine waste	These maps will need to be updated by the mine well before the inspection.
5	- Topographic map showing as-built contours for top of mine waste	
6	- Heat map showing contours of the difference between design topography and as-built topography	
7	- Isopach map showing contours of as-built thickness of reclamation material cover and audit soil pit locations	
8	- Map showing design and as-built locations of constructed drainage channels and pre-existing (natural) channels	
9	- Map showing location of decommission infrastructure and infrastructure required for the reclaimed landscape	

List of required equipment and tools

1. Inclinometer;
2. Photo camera;
3. Drone (UAV);
4. Handheld pH meter or pH paper; and
5. Conductivity meter.



Infographic 1. Step-by step procedure to mine closure process

7.2 MONITORING OF GEOTECHNICAL STABILITY

Inspection objective

Document whether mining landforms (e.g. waste rock dumps, tailings facilities, pit walls, pit lakes, surface water drainage channels, etc. that are reclaimed or about to be reclaimed) are geotechnically stable and compliant with project documents approved by relevant authorities and requirements of national standards related to geotechnical stability. This set of monitoring requirements require the inspector to critically review data supplied by the mine, compare closure progress to what was agreed upon, and conduct a field inspection to confirm performance. Ideally, the mine will flag any areas needing inspection, but the field inspection will attempt to visit and assess all relevant areas. This may take several days for large mines and require fair-weather conditions (and especially the absence of snow on the ground) suitable for the inspection. Issues of operational stability (for example active pit walls, active dumps) are not a fundamental part of the inspection unless poor performance is leading to changes in the closure or reclamation plans.

Summary outline

Performance issue
Geotechnical stability of mining landforms

Monitoring parameter
- Slope steepness;
- Evidence of mass wasting, in particular slumps;
- Evidence of hillslope erosion;
- Evidence of channel erosion; and
- Evidence of shoreline erosion;

Measurement techniques
- Visual identification of landform slumps, mass wasting, or subsidence;
- Inclinometer (for slope angles and channel grades); and
- Photographic records.

Sampling Location
Technically reclaimed areas

Sampling Frequency
At least yearly

Compliance criteria
- Government guidance documents on reclaimed slope steepness; and
- Relative degree of risk to humans or the environment

National standard revision

Rehabilitation of land destroyed due to mining activities. General technical requirements. MNS 5917: 2008. See Table 10 and Table 11 (Section 7.1) for additional information.

Sequence of field inspection work procedures for monitoring geotechnical stability

It is expected that the steps in this section regarding geotechnical stability will be performed concurrently with those for closure progress and geochemical stability.

STEP 1. Review following relevant documentations from the mining company:

- ☑ Quantitative data of the mine closure plan;
- ☑ Rehabilitation plan of DEIA and EMP;
- ☑ Mine closure plan;
- ☑ A summary of any slope instability events or evidence of abnormal slope movements or unexpected water table conditions since last inspection; and
- ☑ Other information as shown in Table 13.

STEP 2. Based on the information provided before the field inspection:

- ☑ Determine whether the geotechnical stability requirements are being met;
- ☑ Highlight any problem areas for inspection in the field tour; and
- ☑ Document instances of compliance and non-compliance with regulations and plans.

STEP 3. Conduct an on-site inspection to make the following measurements and notes:

- ☑ Measure the slope angle (steepness) of waste rock piles and tailings dykes, and any other permanently reclaimed landforms using inclinometer; record the crest-to-toe slope angle in degrees, and also the interbench slope angle; and
- ☑ Measure the grade (cross-slope angle) of the benches.

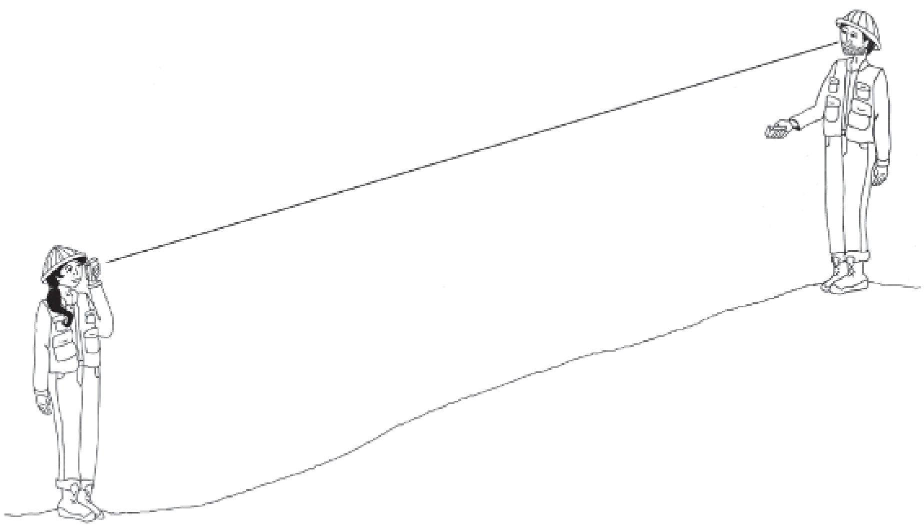


Photo 24. Measuring slope angles and ditch gradients: Method A: Eyeball to eyeball

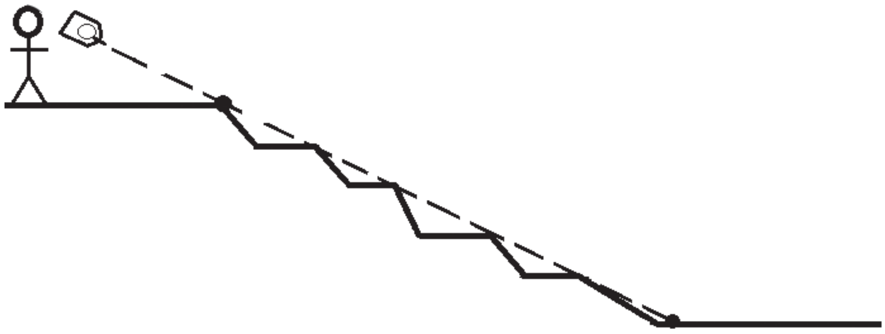


Photo 25. Method B: Measuring overall (head to toe) slope angle

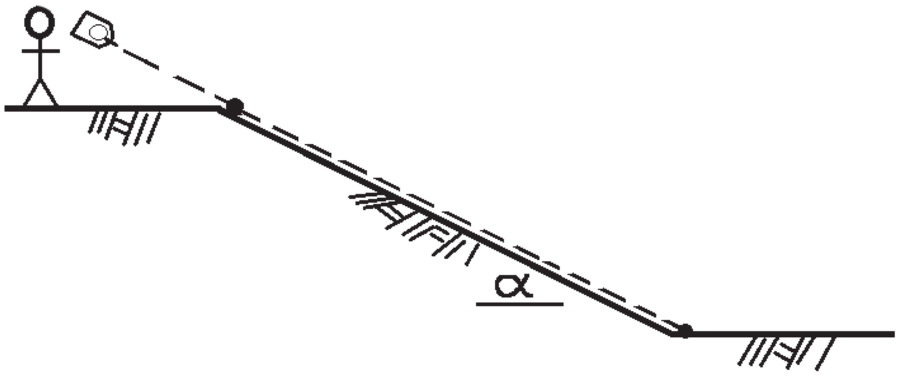


Figure 26. Method C: Measuring inter-bench slope angle

- ☑ Measure the grade (profile) of the center line of channels and the angle of the channel sideslopes.
- ☑ Measure the thickness layers of rip rap in permanent channels. Note the diameter and angularity of the clasts and the presence or absence of constructed filter layers under the riprap.
- ☑ Measure pit slope angles.
- ☑ Visually identify any evidence of mass wasting such as:
  1. Tension crack;
  2. Head scarp;
  3. Toe building/toe heave;
  4. Tilted trees or posts;
  5. Offset fences;
  6. Slump;
  7. Slip off failure; and
  8. Slumps or rockslides in pit walls.

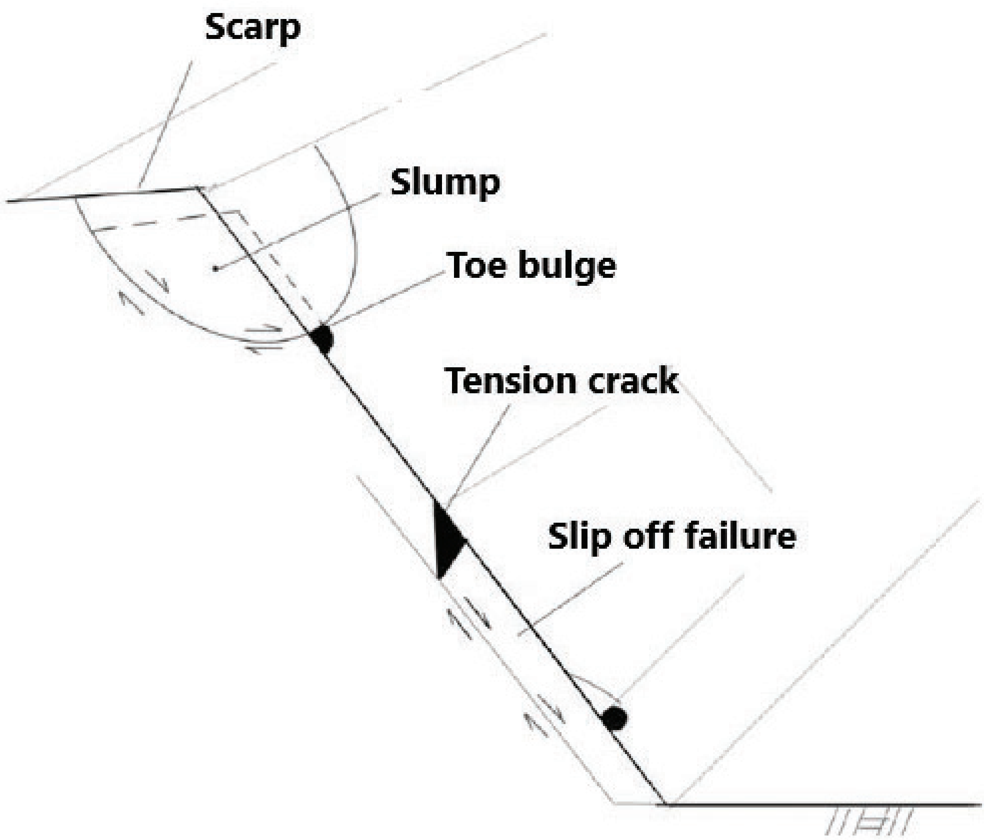


Photo 27. Common signs of geotechnical slope instability

Common signs of slope instability

☑ Visually identify signs of erosion and deposition such as:

1. Slope wash - loss of soil over a large area due to erosion, typically in absence of vegetation or between plants;
2. Rilling - downslope erosion channels <0.3m deep (measure length and depth). These often occur in rill fields – dozens of closely-spaced parallel rills;
3. Gullying - downslope erosion channels >0.3m deep (measure length and depth);
4. Internal piping/tunnel erosion;
5. Exposure of mine waste substrates due to erosion;
6. Depositional fan (measure radius);
7. Wind erosion (deflated areas) and deposition (sheets or small dunes). Most common in tailings;
8. Erosion of channels - down cutting or bank erosion (measure area and eroded depth);
9. Deposition in channel;
10. Shoreline erosion in pit lakes; and
11. Raveling and fan accumulation at pit walls.

- ☑ Describe performance of constructed channels:
  1. Conveyance of any flowing water;
  2. Ponding/flooding;
  3. Loss of flow (sinking);
  4. Bank erosion or slumping;
  5. Channel deposition/infilling/blockage; and
  6. Extent of any unarmored areas.

- ☑ Other:
  1. Seepage exiting on slopes or toes that may lead to geotechnical instability;
  2. Areas of excessive settlement;
  3. Unwanted ponding water on plateaus or benches;
  4. Soft ground (where people or wildlife may become mired);
  5. Smoke/glowing embers mine waste rock on fire (especially coal mines);
  6. Areas of poor vegetation performance that may lead to erosion;
  7. Users damaging the land (ATV erosion, roads or paths, over grazing, damage to infrastructure); and
  8. Hazards such as sinkholes, collapse features, open shafts, or open portals related to underground mining.

STEP 4. Assess the performance.

- ☑ Compare the measurements, observations, and performance against the designs, and against standard requirements; and
- ☑ Compare landscape performance against company's closure management documents.

STEP 5. Create a photographic record

- ☑ Take photos of landforms, with a focus on areas with deficiencies or pending problems.

STEP 6. Document findings

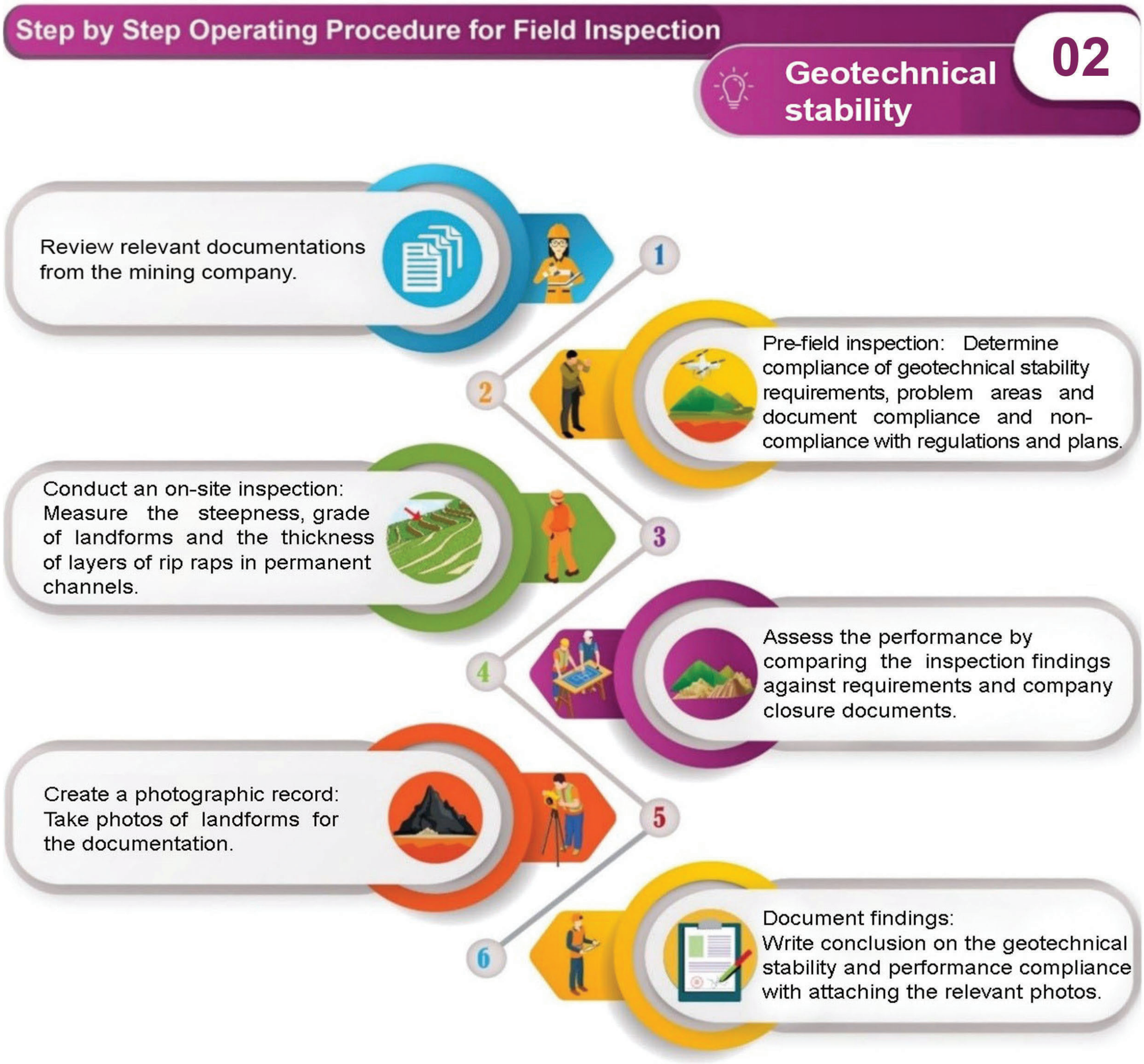
- ☑ Write conclusion on whether the geotechnical stability/performance is compliant; and
- ☑ Include a photo appendix of key photos, with descriptors.

List of documents to be obtained from the Company:

See Table 13 in Section 7.1.

Demonstration of necessary tools

Refer to the relevant list in Section 7.1.



Infographic 2. Step-by step procedure to inspect geotechnical stability

7.3 MONITORING OF GEOCHEMICAL STABILITY

Inspection objective

Document whether mining landforms (e.g. waste rock dumps, tailings facilities, pit walls, pit lakes, surface water drainage channels, etc.) that are reclaimed or about to be reclaimed are geochemically stable. Examine whether any weathering of waste rock, tailings, or pit slopes is producing contaminated leachate, and if so, whether this leachate it being adequately managed and the environment protected.

Summary outline

Performance issue
Geochemical stability of mining landforms

Monitoring parameter
- Examination of stability of refilled pit;
- Visual evidence of oxidation/acid rock drainage of mine waste;
- Visual evidence of contaminated water on or leaving mine waste landforms;
- Water quality testing of surface flows; and
- Water quality testing of groundwater samples

Measurement techniques
- Visual identification of oxidation/leaching;
- Visual evidence of impacts of poor vegetation performance;
- Laboratory water quality results of surface water samples or groundwater samples; and
- Photographic records,

Sampling Location
Technically reclaimed areas

Sampling Frequency
At least yearly

Compliance criteria
- Rehabilitation of land destroyed due to mining activities. General technical requirements. MNS 5917: 2008.
- Relative degree of risk to humans or the environment.

National standard revision

Rehabilitation of land destroyed due to mining activities. General technical requirements. MNS 5917: 2008. See Table 10 and Table 11 (Section 7.1) for additional information.

Sequence of field inspection work procedures for monitoring geochemical stability

It is expected that the steps in this section regarding geochemical stability will be performed concurrently with those for closure progress and geotechnical stability.

STEP 1. Review following relevant documentations from the mining company:

- ☑ Quantitative data of the mine closure plan;
- ☑ Rehabilitation plan of DEIA and EMP;
- ☑ Mine closure plan; and
- ☑ Other information as shown in Table 13

STEP 2. Based on the information provided before the field inspection:

- ☑ Check that the mine wastes and the water quality leaving these landforms areas is consistent with predictions in the company's closure plan, with regulations, and is not impacting local plants, animals, or any drinking water sources; and
- ☑ Compare the monitoring results provided by the company any other groups against criteria.

STEP 3. Conduct an on-site inspection to make the following measurements and notes:

- ☑ Observe waste rock piles and tailings facilities looking for signs of geochemical instability;
- ☑ Observe seeps, springs, wetlands, ditches, and creeks for signs of contaminated water or its affects;
- ☑ Observe vegetation for signs of contaminated soil;
- ☑ Take spot measurements of pH of ponded, seepage, or runoff waters, note results and watch for abnormally low (pH<5) or high (pH>9) values. These are spot checks that may lead to more formal testing later; and
- ☑ Take spot measurements of the electrical conductivity of the waters. The electrical conductivity is proportional to the total dissolved solids. Values higher than 2000 to 4000 umhos/cm may be indicative of salt loading to the waters and may warrant further investigation. Note measured values. These are spot checks that may lead to more formal testing later;

Note: Some natural waters may have pH levels out of the neutral territory or elevated salinity. This will be documented in the mine documents, particular those related to the environmental impact assessment.

Visual signs of potential geochemical instability:

1. Steam leaving waste rock piles (due to pyrite oxidation/acid rock drainage);
2. Warm ground – areas that quickly melt snow or are first to melt in the spring;
3. White, yellow, orange or red colored salts on waste rock, tailings, the reclaimed surface, or pit walls;
4. Poor vegetation health (or dead vegetation) particularly related to ponded areas;
5. Oddly colored drainage water (yellow, orange, red, sometimes green) often caused by iron oxide (a product of acid rock drainage);
6. Exceptionally clear water in ponds or lakes (often due to low pH which tends to cause suspended sediment to settle); and
7. Some contaminated water may provide little visual cues. Acid rock drainage is usually fairly easy to observe in mine wastes and mine waters.

STEP 4. Assess the performance

- ☑ Compare the measurements, observations, and performance against the designs and regulations; and
- ☑ Compare water quality against company's predictions in closure management documents.

STEP 5. Create a photographic record

- ☑ Take photos of areas with geochemical instability

STEP 6. Document findings

- ☑ Write conclusion on whether the geochemical stability/performance is compliant; and
- ☑ Include a photo appendix of key photos, with descriptors.

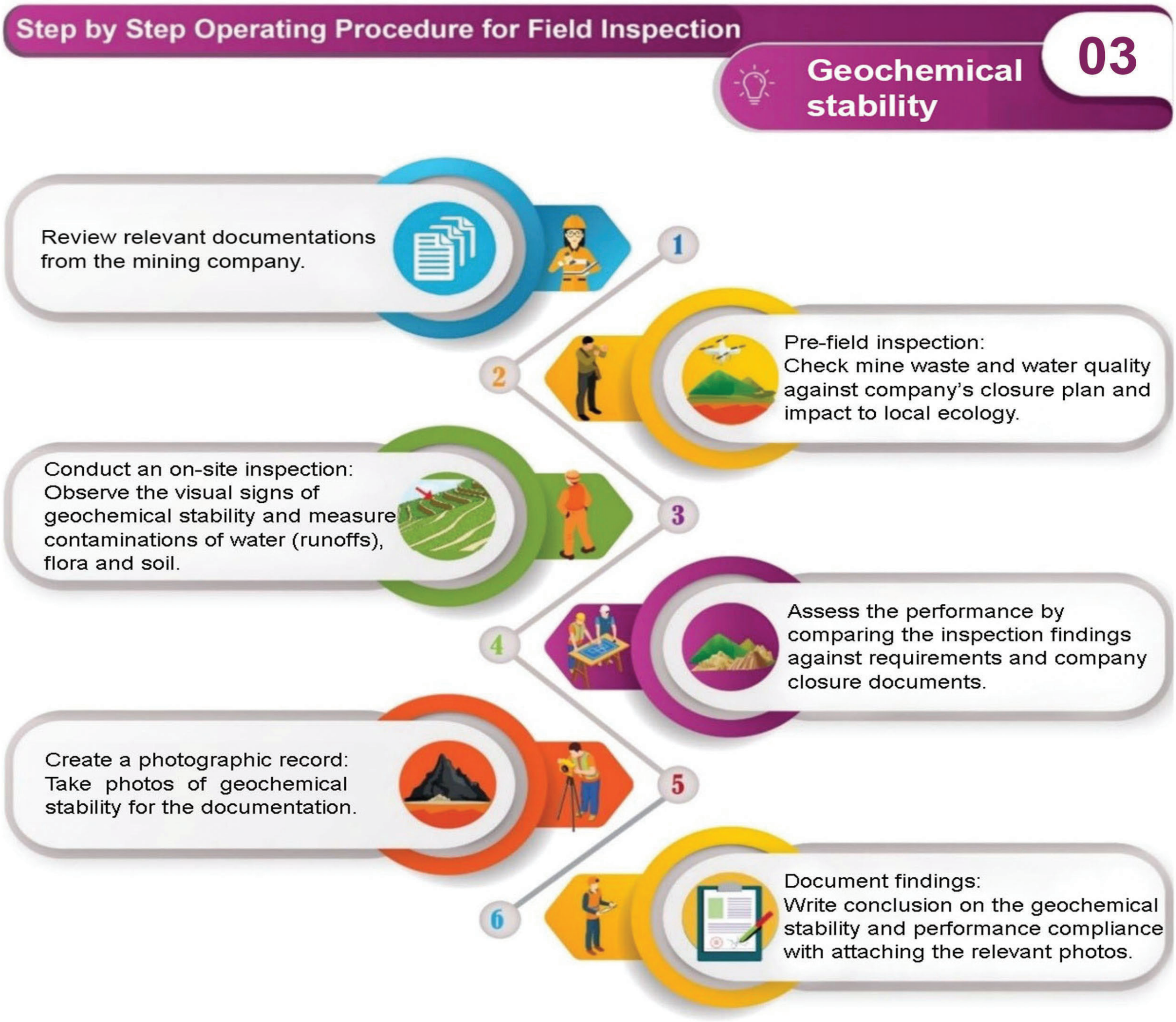
Note: Official field measurement and sampling of water quality requiring following strict protocols. The procedures above are only semi-quantitative and are used to highlight any problems that might require further investigation. Reports of these reclamation inspections that provide field values should note that they are indicative only and would need to be confirmed with more formal protocols.

List of documents to be obtained from the company:

See Table 12 in Section 7.1.

Demonstration of necessary tools

See the relevant list in Section 7.1.



Infographic 3. Step-by step procedure to inspect geochemical stability

8. ON-SITE MONITORING OF SOIL CONSERVATION AND RECONSTRUCTION

8.1 MONITORING OF TOPSOIL STRIPPING OPERATION

Inspection objective:

Inspection of whether performance of the topsoil stripping operation is compliant

Summary outline

Performance Issue
Topsoil Stripping Procedures

Measurable Parameter
- Topsoil stripping depths; and
- Calculation of area subjected to topsoil salvage.

Field Measurement Technique
- Measurements of depth of topsoil being stripped during active stripping operations;
- Laboratory test result; and
- Quantitative data from mine operator.

Sampling Location
- Active topsoil stripping operations; and
- Completed topsoil stripping areas for that year.

Sampling Frequency
- Coordinated with active topsoil stripping operations; and
- Sampling plan for given year.

Performance Criteria
Compliance with commitments in
- MNS 5916: 2008 Environment. Fertile soil /top soil/ removing and its temporary storage during the earth excavation;
- MNS 5917: 2008. Environment. Rehabilitation of land destroyed due to mining activities. General technical requirements;
- Mine operation plan of that year;
- Detailed Environmental Impact Assessment and Environmental Protection Plans; and
- Annual Environmental management plan.

National standard revision

MNS 5916: 2008 – Environment. Fertile soil removing and its temporary storage during the earth ex

Table 14. National standards requirements

Standard requirements	Measurement techniques
5.1: Fertile soil shall be set in the mining operation plan of that year in accordance with the feasibility study for using the deposit and report of detailed environmental impact assessment and shall be removed and stored in accordance with relevant project and documents during other earth work.	Project documents
5.2: Fertile soil shall not contain radio elements, heavy metals and remains of hazardous substances more than the allowed amount.	Laboratory test
5.3: Fertile soil shall not be contaminated by construction and manufacturing wastes, rocks, gravels and solid waste remains and shall not be epidemiologically hazardous.	Visual method Laboratory test
5.4: Big scale map of the soil shall be used for determining types, sub types, origins and structure of the soil.	Big scale soil map
5.5: The norm for removing fertile soil in an area that belongs to frost, taiga, forest and desert zone shall be determined partially.	Big scale soil Former frost map
5.6: No norm for removing fertile soil shall be set with regard to soil with rocky, gravely and stony textures or heavily washed soil.	N/A
5.7: The norms for removing fertile soil and overburden shall be calculated by the formula.	*Measure the depth* *Determine area* *Vsh = Hsh*S* Where: Hsh – average thickness to remove fertile soil, m S – area for removing soil, m^2
5.9: Determination of thickness of fertile soil and overburden to be removed shall be set in accordance with the feasibility study and DEIA.	Review of the relevant documents

This is the step-by-step approach of standard operating procedural methodology to assist inspectors to carry out field inspection on mining site during the topsoil stripping operation.

Definitions

Generally, topsoil is the upper most surface layer with the highest amounts of nutrients and organic material. The seeds of plants are also concentrated in the topsoil, and 80-90% of the roots of cultivated plants are concentrated in this layer. The normal thickness of topsoil is 5-25 cm. On arable land, topsoil is the layer regularly worked with tillage equipment.

Sequence of field inspection work procedures

STEP 1. Measure the depth (Hsh) by using soil sampling probe tool and take measurements at 5 neighboring areas to stripped locations. Simple digging method can be also applied.

STEP 2. Measure the area (S) by using handheld land area measurement tool

STEP 3. Calculate the total topsoil volume by using the equation below:

$$Vsh = Hsh * S$$

Hsh – average thickness to remove fertile soil, m

S – area for removing soil, m^2

STEP 4. A calculation of total amount of materials to be distributed for rehabilitation shall be estimated as follows:

Vo = (S1xh1) + … + (Snxhn)
Vo- total volume of stockpile, м3;
S1, … -average diameter of stockpile (area), м2;
h1, … - average height of stockpile, м.[2]

If available, the inspector can get support from the surveying engineer (Markscheider) of operation.

STEP 5. Fertile soil that will not be used for mine backfilling and will not be processed again but shall be removed and piled up. Check if this requirement has been met (Requirement 7.4 of MNS 5917: 2008. Environment. Rehabilitation of land destroyed due to mining activities. General technical requirements). The fertile soil pile shall not be higher than 5 meters.

STEP 6. Take photos of stripped area and topsoil pile for the documentation.

STEP 7. Compare the calculated volume against the quantitative data of mining operation plan and DEIA of that year.

STEP 8. Check overall area stripped of topsoil by using drone and compare with the mine operation plan.

STEP 9. Analyze the structure of the topsoil by taking samples from the topsoil to be stripped.

- Check whether fertile soil contains radio elements, heavy metals and remains of hazardous substances more than the allowed amount; and
- Check whether fertile soil is contaminated by construction and manufacturing wastes, rocks, gravel and solid waste remains, and not be epidemiologically hazardous.

STEP 10. Inspector provides conclusion on the performance compliance for the topsoil stripping operation.

Photo 28. Stripping process the fertile soil

Photo 29. Fertile soil pile

List of documents to be obtained from the Company:

Table 15. List of documents to be obtained

#	Primary document	Particular section
1.	- Mine closure plan	Topsoil stripping section
2.	- Quantitative data from mine operator	Notes/book for the recordings, laboratory test result
3.	- DEIA and EMP commitments	Annual rehabilitation plan

[2] Reference - Frugal rehabilitation field handbook

List of required equipment and tools

1. Big scale soil map;
2. Handheld GPS Land area measurer;
3. Calculator;
4. Photo camera;
5. Soil sampling probe tool;
6. Soil sampling tool kit for laboratory testing;
7. Drone (UAV);
8. Shovel; and
9. Tape meter.

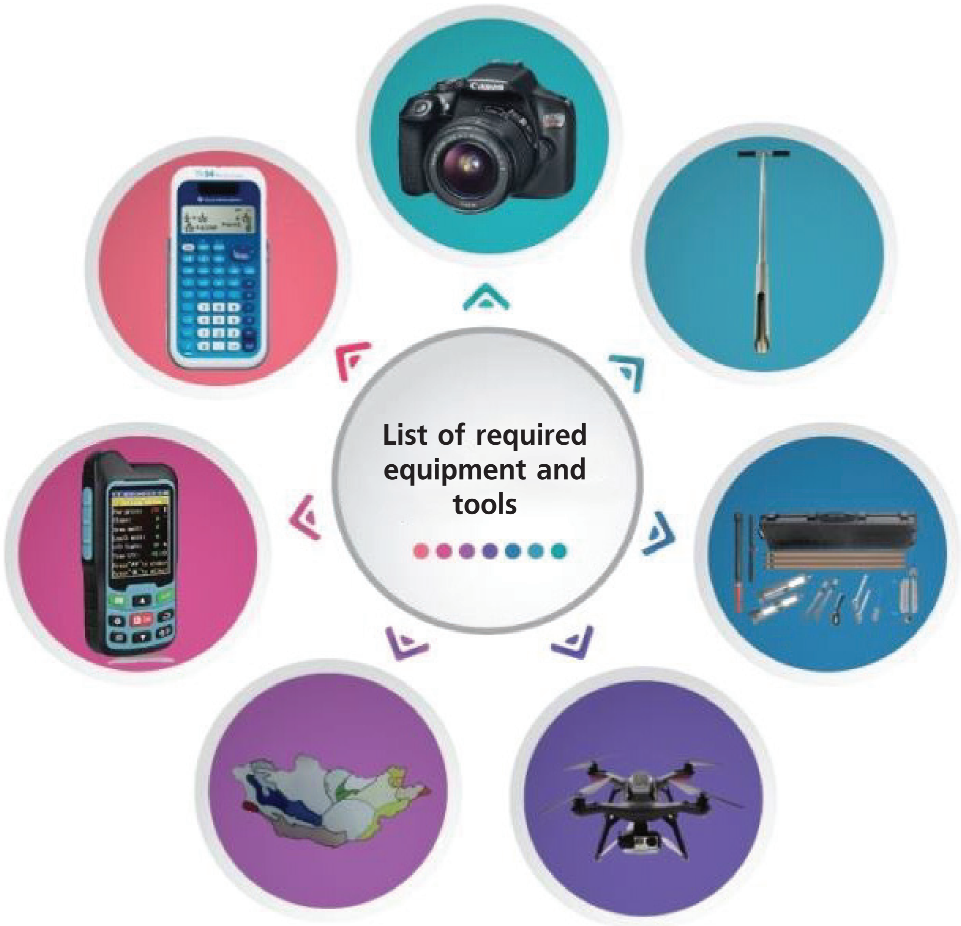
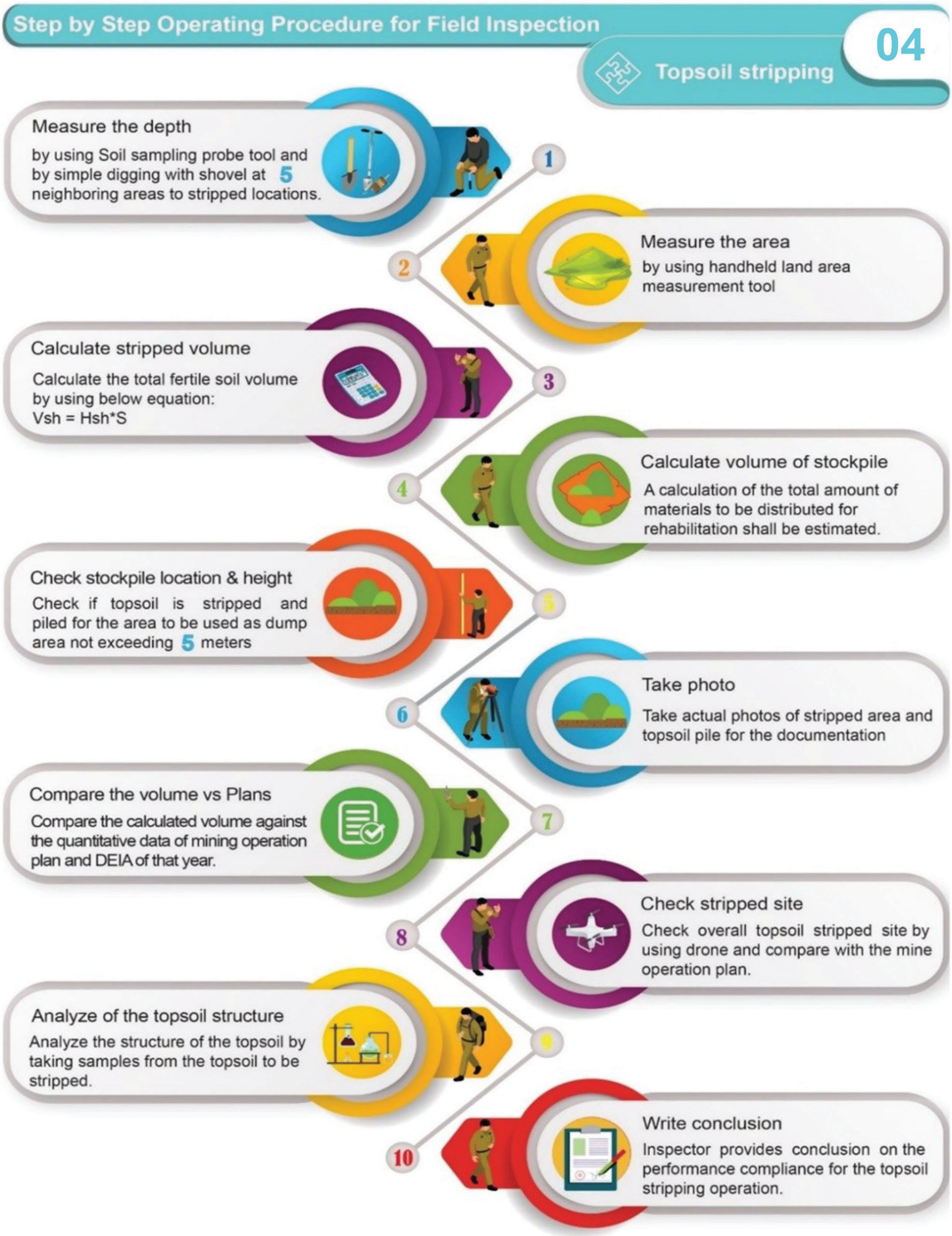


Photo 30. List of required equipment- Topsoil stripping



Infographic 4. Step-by-step procedure to inspect topsoil stripping

8.2 MONITORING OF THE TOPSOIL STORAGE AND PROTECTION

Inspection objective

Inspection of whether performance of the **topsoil storage and protection** is complying with the relevant requirements.

Summary outline

Performance Issue
Topsoil Storage Procedures

Measurable Parameter
- Potential mixing or contamination of stored topsoil; and
- Potential loss of stored topsoil.

Field Measurement Technique
- Visual review of the location and degree of isolation of topsoil piles relative to overburden, waste rock or hazardous material areas;
- Identification of on-going topsoil loss from wind or water erosion; and
- Lack of stabilization techniques.

Sampling Location
Topsoil storage locations

Sampling Frequency
- Coordinated with active topsoil stripping and storage operations; and
- Year-end assessment at active storage locations.

Performance Criteria
Relative degree of risk of topsoil loss to mixing or erosion
Compliance with commitments in:
- MNS 5916: 2008 Environment. Fertile soil /topsoil/ removing and its temporary storage during the earth excavation;
- MNS 5917: 2008. Environment. Rehabilitation of land destroyed due to mining activities; and
- Detailed Environmental Impact Assessment and Environmental Protection Plans; and
- Annual Rehabilitation plan.

National standard revision

MNS 5916: 2008 – Environment. Fertile soil /top soil/ removing and its temporary storage during the earth excavation

Table 16. National standards requirement

Standard requirements	Measurement techniques
7.1 The fertile soil shall be piled and stored in a special area if it is not used directly.	Visual method
7.2. Preventive measures shall be taken so that fertile soil pile is not affected by wind and water erosion, is not polluted or buried by solid, construction and other wastes or rocks. The pile shall be prevented from becoming saline.	Visual method
7.3. The top surface and side slopes of fertile soil pile, to be stored for more than two years, shall be stabilized and perennial grassy plants shall be grown.	Visual method
7.4. In case of storing the fertile soil in the pile for a long time, wind fencing adjacent to the piles shall be constructed and the surface shall be revegetated.	Visual method
7.5. Location, form and size of the fertile soil pile shall be so that the best storing condition is ensured. Its **height** shall not be more than 5 meters.	Visual method Height measurement laser tool
7.6. An entity shall conduct control and registration of storage, protection and caring of the fertile soil.	Check Registration of fertile soil storage, protection and caring.

This is a step-by-step approach of standard operating procedural methodology to assist inspectors to carry out field inspection on mining site with respect to **topsoil storage operation.**

Definitions

Topsoil or fertile soil is the upper portion with humus of the soil layer that has proper physical, chemical and agrochemical properties required for plant growth. The topsoil is usually removed with heavy equipment and then piled in large, deep piles for the duration of the mining project for post-mining land reclamation.

Fertile soil piles shall be placed in remote locations from soil piles and other poor-grade ore piles. Prevention measures shall be taken to avoid erosion and loss caused by water and wind.

Sequence of field inspection work procedures

STEP 1. Check current topsoil storage and protection condition using visual method by conducting inspection for below factors:

- ☑ Revegetation;
- ☑ Side slope stabilized with planting of perennial grass;
- ☑ Check if topsoil is not polluted or buried by solid, construction and other wastes or rocks;
- ☑ Prevention of soil loss from water erosion using the trenches around the pile;

Photo 31. Topsoil stockpile

- ☑ Selection of appropriate location to store topsoil, which is less exposed to various climate hazards and isolated from waste disposal site, rock stockpiles etc.; and
- ☑ Ensure that pile location will not adversely affect surface and underground water, and will not result in dust plumes and settlement in nearby towns (Requirement 7.3 of MNS 5917: 2008. Environment. Rehabilitation of land destroyed due to mining activities. General technical requirements).

STEP 2. Check the height of topsoil pile against the allowed height according to the standard height of 5 meters. Use laser measurer and mobile app.

STEP 3. Analyze the structure of the topsoil by taking samples from the topsoil piles.

- ☑ Check if topsoil is saline using electromagnetic Soil Salinity Sensor and visual method; and
- ☑ Check pH of the topsoil using soil pH test meter and humus % of the topsoil.

> Soil humus content is measured by weighing a dry soil sample, burning the humus in the soil, then weighing the soil left. The difference between the two figures is the humus content, which can be expressed as a percentage of the mass of fresh soil sample.[3]

STEP 4. Check mine operator's record keeping by obtaining the registration of storage, protection and maintenance activities for the topsoil.

STEP 5. Take photos of topsoil piles and its corresponding protection and storage conditions for the photo documentation.

STEP 6. Inspector provides conclusion on the performance compliance for the topsoil storage and its protection operation.

List of documents to be obtained from the Company:

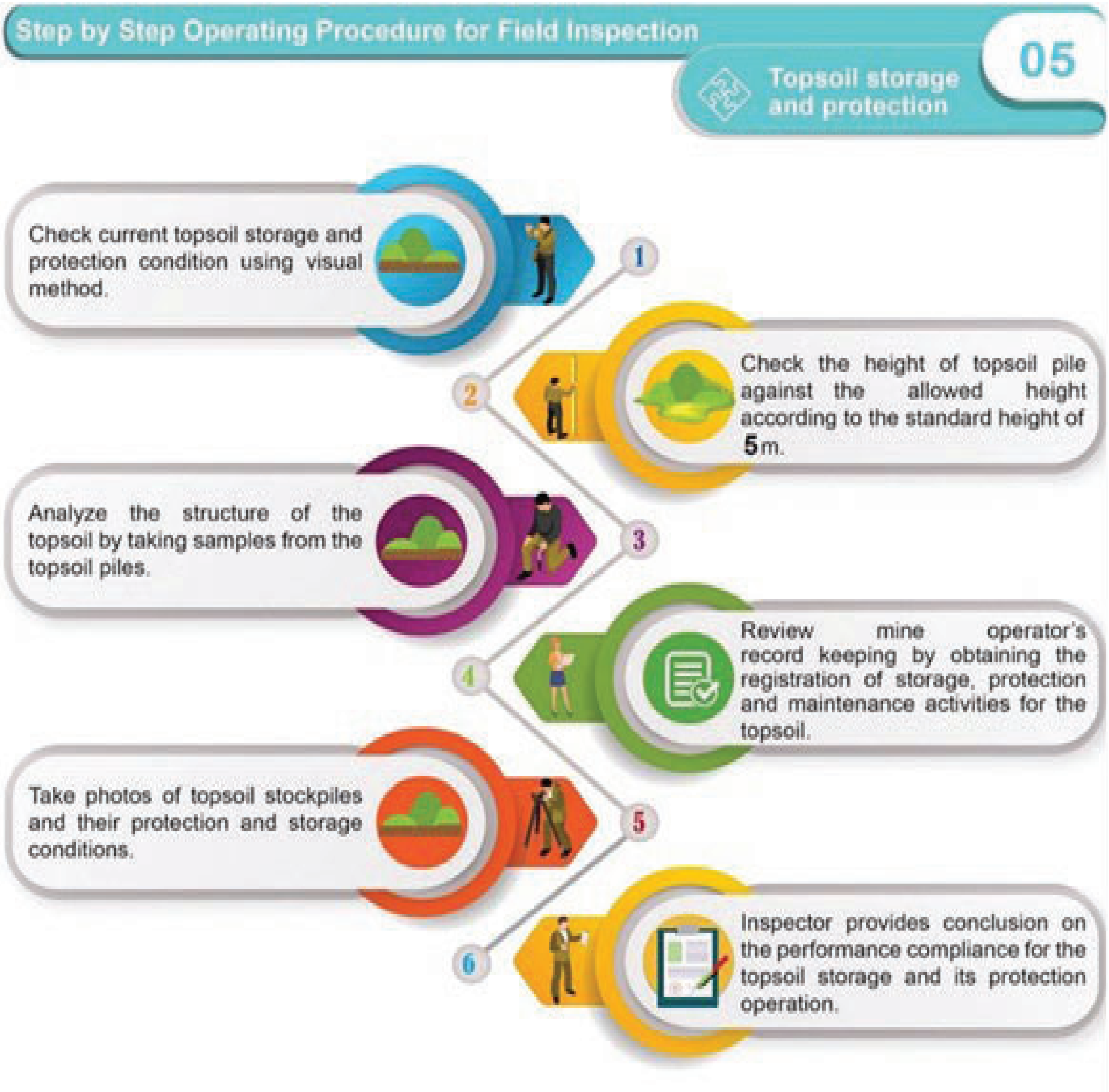
Table 17. List of documents to be obtained

#	Primary document	Particular section
1.	- Mine closure plan	Check the stockpile section
3	- Quantitative data from mine operator	Recording notes/book of topsoil and subsoil stockpiles
4.	- DEIA and EMP commitments	Annual Rehabilitation plan

List of required equipment and tools::

1. Photo camera;
2. Inclinometer;
3. Landscape map;
4. Laser height measurer and mobile app;
5. Mobile phone;
6. Calculator;
7. Tape measures;
8. Soil sampling tool kit; and
9. Soil pH testing tool.

[3] www.biology-fieldwork.org › a-level › abiotic-factors › soil



Infographic 5. Step-by-step procedure to inspect topsoil storage

8.3 MONITORING OF TOPSOIL REDISTRIBUTION AND RECONSTRUCTION

Inspection objective:

Inspection of whether performance of the **topsoil redistribution and reconstruction** is compliant.

Summary outline

Performance Issue
Topsoil Redistribution and Reconstruction

Measurable Parameter
- Matching of topsoil redistribution with the physical and chemical conditions of underlying landforms; and
- Reconstructed topsoil depth.

Field Measurement Technique
- Visual review of the topsoil types being applied to the underlying landform characteristics; and
- Measurements of depth of reconstructed topsoil.

Sampling Location
Active topsoil reconstruction areas

Sampling Frequency
Coordinated with active topsoil reconstruction operations

Performance Criteria
Compliance with commitments in:
- MNS 5917: 2008. Environment. Rehabilitation of land destroyed due to mining activities. General technical requirements;
- Detailed Environmental Impact Assessment; Annual Rehabilitation and Environmental Management Plans
- Annual Rehabilitation plan; and
- Mine closure plan (if developed).

National standard revision

MNS 5917: 2008. Environment. Rehabilitation of land destroyed due to mining activities. General technical requirements

Table 18. National standards requirement

Standard requirements	Measurement techniques
7.1 General requirements on reclaimed land surface are shown by each purpose of rehabilitation in the table.	Visual method and Study table

This is a step-by-step approach of standard operating procedural methodology to assist inspectors to carry out field inspection on mining site with respect to **topsoil redistribution and reconstruction.**

Definitions

Redistribution: Topsoil must be re-distributed in a manner that achieves requirements of the approved post-mining land use in terms of thickness, and nutrient/moisture conditions.

Reconstruction: Soil rehabilitation, namely creating the optimum physical, chemical, and biological conditions for promoting biological growth and restore soil productivity, is at the core of land restoration. It is, likewise, the foundation of reshaping landscapes, promoting vegetation growth and reducing soil erosion.

Reconstruction of suitable topsoil profiles after mining involves placement of soil and over burden materials in such a way as to establish physical and chemical characteristics at and just below the surface of the landscape.

Sequence of field inspection work procedures

STEP 1. Check general requirements on reclaimed land surface by visual method using the study table below.

Table 19. General requirements on reclaimed area (excerpt from National Standard)

Criteria	Rehabilitation purpose					
	Agriculture		Re-forestation	Water shed, fishery	Special purpose land	Health resort
	Crop	Hay, pasture				
Cover depth of fertile topsoil, m(min.)	0.3	0.1	-	0.20	0.20	-

STEP 2. Check if topsoil redistribution matches with the physical and chemical conditions of underlying landforms by taking samples for laboratory test.

- ☑ Open pit excavation up to 15 m deep;
- ☑ Side slope should not exceed 18°;

STEP 3. Inspect as observation and photographic documentation of the stockpile location to ensure that it is adequately protected.

STEP 4. Take soil samples from the area to be rehabilitated and check that they are physically and chemically compatible with the topsoil to be used for paving.

STEP 5. After the technical rehabilitation, tilling minimum of 18 cm deep shall be done for the area if it has been without any topsoil coverage for a long time prior to topsoil redistribution on this area.

STEP 6. Check the depth of redistributed soil using soil sampling probe tool.

STEP 7. Check overall topsoil redistributed site by using drone and compare with the rehabilitation map.

STEP 8. Inspector provides conclusion on the performance compliance for the topsoil redistribution operation.

List of documents to be obtained from the company:

Table 20. List of documents to be obtained

#	Primary document	Particular section
1.	- Mine closure plan (if developed)	Topsoil redistribution section
2.	- Mine operation plan	Annual redistribution plan
3	- Quantitative data from mine operator	Notes/book for the redistribution and photo records
4	- DEIA and EMP commitments	Rehabilitation plan

List of required equipment and tools:

1. Photo camera;
2. Big scale soil map;
3. Inclinometer;
4. Handheld GPS Land area measurement tool;
5. Soil sampling probe tool;
6. Soil sampling tool kit for laboratory testing; and
7. Drone (UAV).

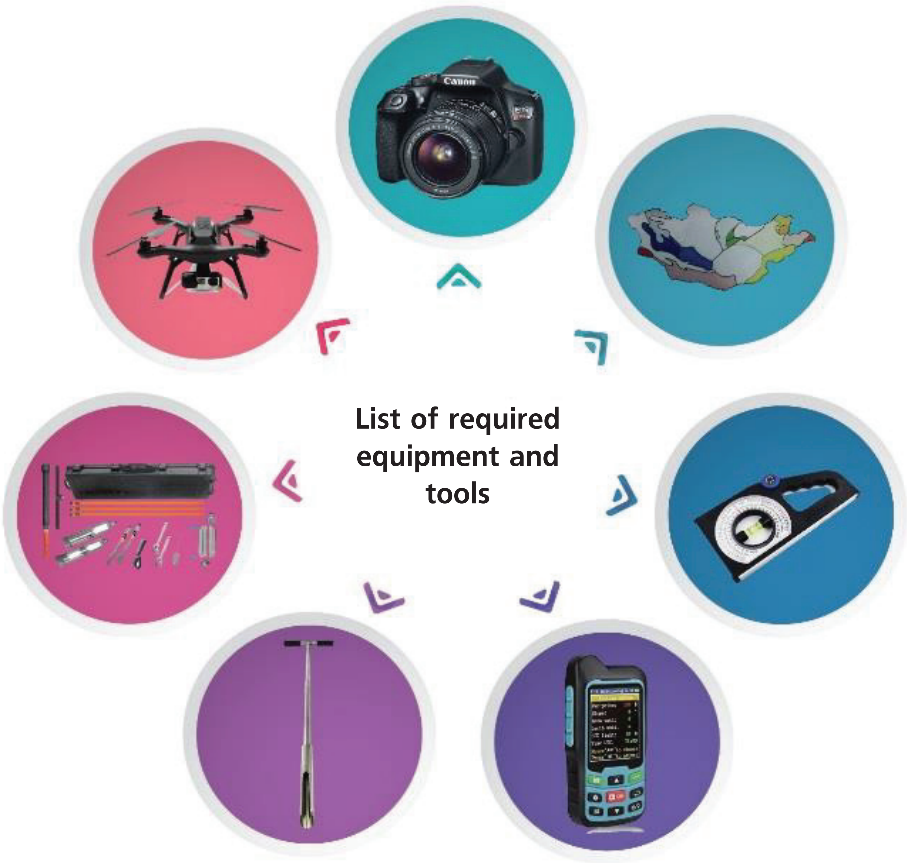
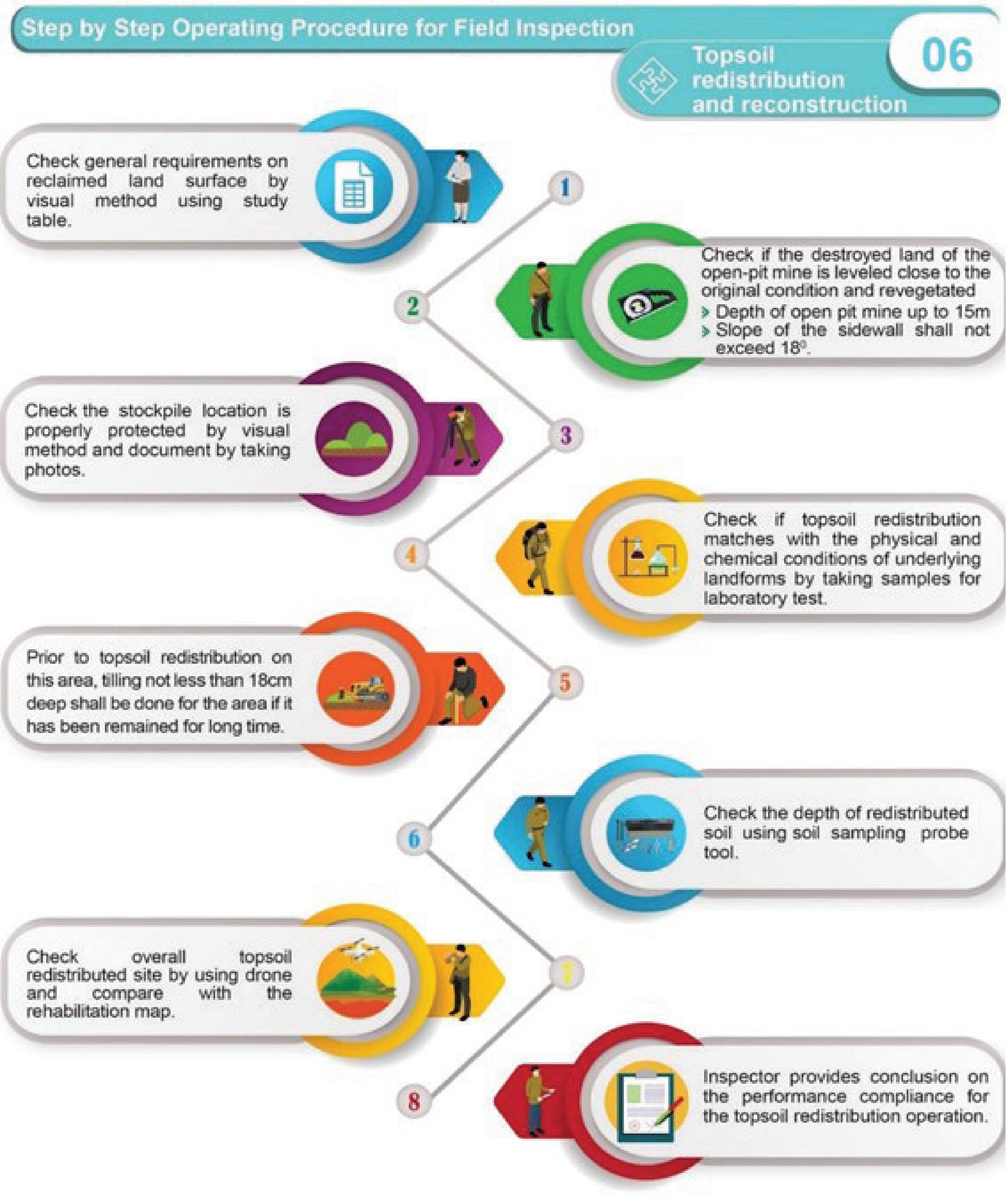


Photo 32. List of required equipment- Topsoil re-distribution



Infographic 6. Step-by-step procedure to inspect topsoil re-distribution

8.4 ON-SITE MONITORING OF DUST SETTLEMENT AND CONTAMINATION IN ACTIVE MINING SITES

Inspection objective

Inspection should check the **dust settlement and contamination** level within the mining site and adjacent to active mining sites compliance to the project documents approved by relevant authorities and requirements of national standards.

Summary outline

Performance issue
Dust settlement and air quality control within and adjacent to active mining sites

Monitoring parameters
Dust deposition rates on lands adjacent to the mine

Measurement techniques
- Passive dust collection devices;
- Soil sampling for contaminant levels (e.g., metals);
- Visual identification; and
- Photographic records.

Sampling Location
- Active mine areas; and
- Adjacent areas around the active mining sites (specifically areas downwind from the predominant wind direction).

Sampling/Testing Frequency
Every 2 years during mine operations

Compliance criteria
- Compliance with acceptable soil contamination levels for metals; and
- Compliance with commitments in Environmental Impact Assessment and Environmental Protection Plans.

National standard revision

There are no national standards directly regulating dust/contaminant deposition on soils. However, air quality standard MNS 4585:2016 contains some requirements with regards to dust settlement, in particular permissible amount and measurement frequency of dust particle matters.

Photo 33. Dust unsettled

Table 21. Air Quality. General technical requirements. MNS 4585:2016

Parameter	Measured in average of	Measurement unit	Permissible amount
Coarse particles (PM_{10})	1-year	$\mu g/m^3$	50
	24-hour		100
Small particles dust (PM2.5)	1-year		26
	24-hour		50

Definitions

The major adverse impact on soils adjacent to mines results from dust plumes generated from active mining areas and tailings facilities, and associated dust settlement in adjacent areas.

The monitoring for dust settlement during the active mining operation shall be undertaken at intervals as indicated in the standard (Air quality: General technical requirements MNS 4585:2016) during the life of a mine.

The dust settlement control will include the following:

- ☑ Review the mine company records pertaining to dust suppression and monitoring;
- ☑ Assess dust deposition rates using passive collectors at selected locations downwind on mine operations;
- ☑ Visually inspect dust settlements;
- ☑ Conduct interviews related to dust problems with mine workers and local community members who live in adjacent areas to the mine site; and
- ☑ Check the conditions of the main dust sources.

Dust deposition and associated soil contamination surveys should be conducted by a professional organization contracted with the mining company. Equipment of professional organization will be used for the testing.

Sequence of field inspection work procedures

STEP 1. Review following relevant documentations from the mining company:

- ☑ Dust suppression commitments of mining company; and
- ☑ Environmental monitoring plan of DEIA and EMP.

STEP 2. Check all the main dust sources such as topsoil and tailings facilities, roads, and technical rehabilitations.

STEP 3. Inspect all the corresponding dust mitigation measures including the placement of passive dust collection equipment in areas downwind of the mine to monitor dust deposition rates and contaminant loads. If necessary, use drones for further verification.

Photo 34. Testing air quality

STEP 4. Assess dust deposition rates using passive collectors at selected locations downwind on mine operations. Collect soil samples for contaminant testing (e.g., metals) and submit to appropriate labs for analysis.

STEP 5. Conduct interviews with mine workers and local community members who live in adjacent areas to the mine site about dust condition in the mine area.

STEP 6. Take photographic records of dust plumes and dust deposition in undisturbed native areas adjacent to the mine site.

STEP 7. Write conclusion on dust settlement and soil contamination compliance.

List of documents to be obtained from the company:

Table 22. List of documents to be obtained

#	Primary document	Particular section
1.	- Quantitative data from mine operator	Company records of any dust settlement or soil contamination monitoring activities
2.	- DEIA and EMP commitments	Environmental monitoring plan
3.	- Mine operation plan	Rehabilitation plan

List of required equipment and tools

1. Soil sampling equipment;
2. Passive dust deposition collection equipment;
3. Photo camera; and
4. Drone (UAV).

Photo 35. Air quality tester

Step by Step Operating Procedure for Field Inspection

07 Dust settlement and contamination

Infographic 7. Step-by-step procedure to inspect dust settlement and soil contamination

9. ON-SITE MONITORING OF REVEGETATION

9.1 MONITORING OF REVEGETATION

Summary outline

Table 23. Summary related to the evaluation of vegetation results

Performance Issue	Measurable Parameter	Field Measurement Technique	Sampling Location	Sampling Frequency	Performance Criteria
1. Suitability of recovering species for desired end land use (i.e., grazing)	Species composition and cover on reclaimed sites best suited for end land use	Quantitative sampling of species composition, richness and cover	Designated monitoring plots in recently reclaimed areas. Ensure sufficient sampling density to allow for meaningful data interpretation	Yearly measurements scheduled for growing season to allow for best species identification. Continue sampling for 5 years after year of planting	Compliance with end land use commitments in Environ-mental Impact Assessment and Environ-mental Protection Plans
2. Performance of recovering species by reclaimed land form and associated site type (i.e., moisture and nutrient regime)	Species composition and cover on each major landform and associated site type (i.e., moisture and nutrient regime)	Quantitative sampling of species composition, richness and cover	Designated monitoring plots in recently reclaimed areas on each reclaimed landform. Ensure sufficient sampling density to allow for meaningful data interpretation	Yearly measurements scheduled for growing season to allow for best species identification. Continue sampling for 5 years after year of planting	Compliance with end land use commitments in Environ-mental Impact Assessment and Environ-mental Protection Plans
3. Weed Control	Prevalence of weed species, particularly noxious or aggressively invasive species	Quantitative sampling of weed composition and cover	Designated monitoring plots in recently reclaimed areas on each reclaimed landform.	Yearly measurements scheduled for growing season to allow for best species identification. Continue sampling for 5 years after year of planting	Compliance with end land use commitments in Environmental Impact Assessment and Environ-mental Protection Plans

National standard revision

List of relevant national standards and regulations with respect to revegetation:

- MNS 5914 2008. Environment. Reclamation of disturbed land. Terms and definitions;
- MNS 5918 2008 Environment. Revegetation of destroyed land. General technical requirements; and
- "Methodology for technical and biological rehabilitation of land disturbed by mining operations", Resolution no. A-138 dated Mar 30, 2015 of the Minister of Environment, Green developments and Tourism.

Table 24. National standards requirement

Standard requirements	Measurement techniques
3.1: When selecting the species and planting method for disturbed land revegetation, take into account the soil structure, mechanic composition, topography and other conditions defined in the Environmental Baseline Assessment outlined in the Detailed Environmental Impact Assessment Report of the project.	Project documents
3.2: After the technical reclamation, the area shall be covered with fertile soil. The ground surface not covered by fertile soil for a long time is tilled not less than 18 cm deep.	Visual method Measure by tape meter
3.3: In case the mechanical structure, fertility and permeability of soil to be used for covering does not meet the relevant standard requirements, the soil shall be enriched with mineral fertilizers and compost and its mechanical structure shall be improved.	Laboratory test
3.4: Annual and biannual plants shall not be used for reclamation.	Quantitative data related to the performance
3.5: Planting time shall be selected as depicted in table #1 in conformity with the peculiarity of plant species, natural zone and climate.	Quantitative data related to the performance
3.6: If the slope for revegetation is more than 15°, plants shall be planted in a horizontal or gridding manner.	Visual method Measure by inclinometer
3.7: Before planting, soak 100 g perennial seed in 200 ml water for not less than 24 hours period and dry them out in the sun for 6-8 hours to improve their germination capability.	During execution document maintained by livability assessment method
3.8: The seeds shall be planted 2.0 cm – 2.5 cm deep in the soil.	Visual method Measure by tape meter
3.9: Rehabilitation shall be based on trees and shrubs growing in the area. In the Khangai region, birch, poplar, aspen, larch, pine, and spruce trees are planted 5 m between rows, 4 m between trees (500 pieces per hectare), elm 4 m between rows, and 3 m between trees (833 pieces per hectare). In the steppe and Gobi regions, poplar and aspen 4 m between rows, 3 m between trees (833 per 1 ha), elm 3 m between rows, 3 m between trees (1111 per 1 ha), all types of willow and apricot and almond Shrubs such as hawthorn and rowan are planted at a distance of 2 m between rows and 1.5 m to 2 m (3333 to 2500 pieces per 1 ha) between plants, regardless of the region.	Visual method Measure by tape meter
3.10 Space between the rows of black currant will be 3m and between plants 1m (3333 for 1ha), for sea-buckthorn it will be 4m and between plants 1.5m (1666 for 1ha), for cherry and bramble it will be the same as black currant (3333 for 1ha) and can be planted in any region.	Visual method and measure by tape meter
3.11 The most suitable planying time for trees, bushes and shrubs in Mongolia is between April 20 and May 15. For Gobi and desert region they can be planted 5 or 10 days earlier than the indicated date.	Visual method and method indicated in the related standard

Standard requirements	Measurement techniques
3.12 Trees, bushes and shrubs shall be planted in the reclamation area at least 20 days before the ground freezes or between October 05 and October 20.	Visual method and method indicated in the related standard
3.13 Height of trees for reclamation shall not be less than 1.5m and shall have 2-3 or more branches and height of fruit and berry saplings shall not be shorter than 50cm and shall have 2-3 branches. The roots of trees and bush saplings shall be in good condition and not damaged.	Visual method Measure by tape meter
3.14 All kinds of saplings for rehabilitation shall be healthy, free of any disease and pest insects, not frozen and their roots in good condition.	Visual and testing/ controlling methods
3.15 After planting, depending on the perennial plant sprouting and the growth of bushes, shrubs and saplings, an additional planting may be done or if necessary, other agro-technical steps shall be taken.	Visual and inventory methods

List of documents to be obtained from the Company:

Table 25. List of documents to be obtained

#	Primary documents	Particular sections
1.	- Mine closure plan (if completed)	Annual plan
2.	- Mine operation plan	Annual biological rehabilitation plan
3.	- Quantitative data from mine operator	Records and control notes of business entity
4.	- DEIA and EMP commitments planned works	The year plan for biological rehabilitation

9.2 INSPECTION OF REHABILITATION BY REVEGETATION

Each criterion discussed in the following section refers to a performance indicator that is selected for a specific rehabilitation objective, which is measured to quantitatively demonstrate the success of the revegetation processes.

- For revegetation, key measurement approach is the Quantitative sampling of species or weed.
- Sampling frequency needs to be on yearly basis and continues for 5 years after planting.

Weed control is the monitoring of the presence of invasive species after the revegetation. Perennial pasture plants grow slowly in the first year. Therefore, it is common that invasive or other weed plants will dominate in the site.

Sequence of Field inspection work procedures

Photo 36. Ramensky net

STEP 1. Observe the area by walking in horizontal or diagonal direction, in order to capture the general condition of the rehabilitated area. If area is too large, drone can be used for observational purpose.

STEP 2. Apply a Ramensky net (1m x 1m) at the points representing the vegetation composition and record the plants by species. In case of Gobi and desert zone, when the rehabilitated area is of large scale, then use a bigger size net (2m x 5m).

STEP 3. Take records (5-10 times per ha) of the plants as follows.

- ☑ Do sorting of the plants by species and record them in the vegetation template table;
- ☑ Calculate number of species per square meter using the formula; and
- ☑ Measure the height (cm) and determine the vegetation stage (leafing, budding, completed seedling, and seedling).

STEP 4. Count weed species in the sampling location, then calculate percentage of weeds in total quantity of species.

STEP 5. Repeat the above two steps of recording procedures in the undisturbed area outside of the rehabilitated area.

STEP 6. Take photos right from the top when applying the Ramensky net on the rehabilitated and undisturbed area then attach photos to conclusion or inspector's act.

STEP 7. Check if the recorded data meets compliance criteria:

- ☑ Species composition achieves a minimum of 30% of the species composition of the undisturbed area;
- ☑ Species composition is selected from the native species coverage within 50 km radius surrounding; and
- ☑ Check that the weed cover in the rehabilitated area is not more than 15% for mountainous and steppe area and 25% for Gobi and desert area.

List of documents to be obtained from the Company:

Table 26. List of documents to be obtained

#	Primary document	Particular section
1.	- Mine closure plan (if developed)	Rehabilitation section
2.	- Mine operation plan	Annual biological rehabilitation plan
3.	- Quantitative data from mine operator	Notes/book for the recordings from mine operator
4.	- DEIA and EMP commitments	Annual biological rehabilitation plan

List of required equipment and tools::

1. Ramensky net (1m x 1m);
2. Notebook, pencil;
3. Plant identification document, photo reference book;
4. Ruler;
5. Tape measure;
6. Photo camera;
7. GPS; and
8. Drone.

Photo 37. Required equipment and tools

Below are photographs that show how to measure the height of plant species.

Agropyron cristatum

Cleistogenessquarrosa

Stipa gobica


Artemisia frigida


Leontopodium leontopodioides


Saussurea salsa

Photo 38. Measuring the height of plant species

Template for Recorded Results

(T-1) Template

Area number where record was taken **[RA-1]**

Location: Aimag.................... soum.................,

License holder company .... LLC,

rehabilitated area ....ha,

GPS coordinates..............

T-1 Species composition

№	Name of species	Height	Vegetation stages
1.	Agropyron cristatum	29	Seedling finished
2.	Cleistogenes squarrosa	9	Seedling
3.	Stipa gobica	46	Seedling
4.	Artemisia frigida	20	Seedling
5.	Leontopodium leontopooides	21	Budding
6.	Saussurea salsa	36	Seedling
7.	Bassia dasyphylla	12	Seedling
8.	Chenopodium album L	28	Seedling

Note: This record is taken 5-10 times per hectare (n = 5) to quantify the composition of the species. Divide the number of plants registered in the census area by the number of iterations and calculate the number of plant species per each 1 square meter area.

T–1.2 Summary of data recorded

Rehabilitated area (RA)					
RA-1	RA-2	RA-3	RA-4	RA-5	Total
6	8	5	10	7	36 /7.2
Undisturbed area (UA)					
UA-1	UA-2	UA-3	UA-4	UA-5	Total
20	23	28	24	26	121/24.2

Formula:

$$\text{Species composition for rehabilitation (\%)} = \frac{\text{UA (24.2-100)}}{\text{RA (7.2-X)}} = 29.7\%$$

$$\text{Weeds (\%)} = \frac{\text{Total quantity of species recorded (8-100)}}{\text{Weeds (2-X)}} = 25\%$$

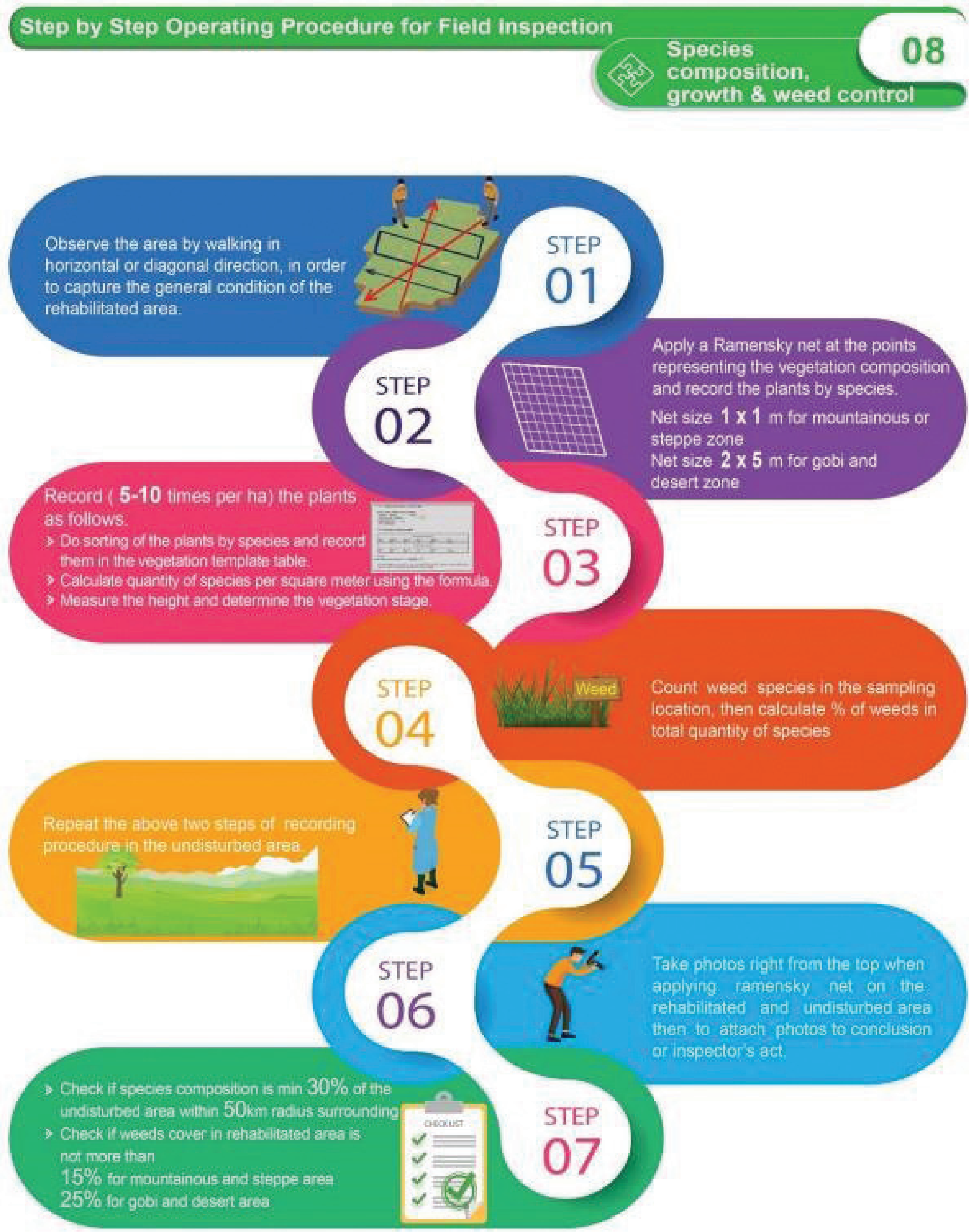
Note: Rehabilitation is considered to be successful if the plant species composition of the rehabilitated area is equal to 30% of the species composition of the undisturbed area.

(T–2) Illustrative example of the Inspector's Act (with sample recorded data)

According to the monitoring of revegetation progress of the rehabilitated area ....ha, it is determined the composition of the plant species (n = 5) per 1 square meter is 7.2 at average from which most of species are successfully seedling and budding. An average of 24.2 items per square meter were counted in the undisturbed area. The plant species composition of the rehabilitated area is 29.7% compared to the vegetation composition of the undisturbed area, which meets the standard requirements. Species composition, height, and vegetation stages were determined and attached as template T-1. According to the count in the rehabilitated area, percentage of weeds is 25% which meets requirements in the Methodology of rehabilitation approved by the MET. The height of each plant species is compared against the height of same species in the undisturbed area. The fact that most of the recorded plants are seedling indicates that further rehabilitation will proceed naturally. Attached are photos of recorded plants in the RA and UA areas.

Table 27. Basic requirement

Type of the site	Species composition richness (%)	Vegetation coverage (%)	Vegetation growth (%)
Undisturbed	100	100	100
Rehabilitated	30	60	30-40



Infographic 8. Step-by-by-step procedure to inspect species composition, growth and weed control

9.3 EVALUATE AND MONITOR VEGETATION OF REHABILITATED AREAS

Sequence of field inspection work procedures

STEP 1. Apply a Ramensky net 5-10 times at the points representing the vegetation coverage. Assess approximately the vegetation coverage per square meter by visual identification method and take records. For example, assessment approximation interval shall change at each 5-10 points.

Photo 39. Vegetation cover 30-35%

Photo 40. Vegetation cover 80%

STEP 2. Fill in the template table below by comparing the rehabilitated area and undisturbed area.

Table 28. Template table

Rehabilitated area					
RA-1	RA-2	RA-3	RA-4	RA-5	Average (%)
35	45	45	60	50	47
Undisturbed area					
UA-1	UA-2	UA-3	UA-4	UA-5	Average (%)
75	80	90	85	95	85

STEP 3. Compare the average coverage rate of the undisturbed area to the average coverage rate of the rehabilitated area.

RA coverage rate (%)=(UA (85-100))/(RA (47-X))=55.3%

STEP 4. Take a photo from the top when applying a Ramensky net on the rehabilitated and undisturbed area then attach photos to the inspector’s act.

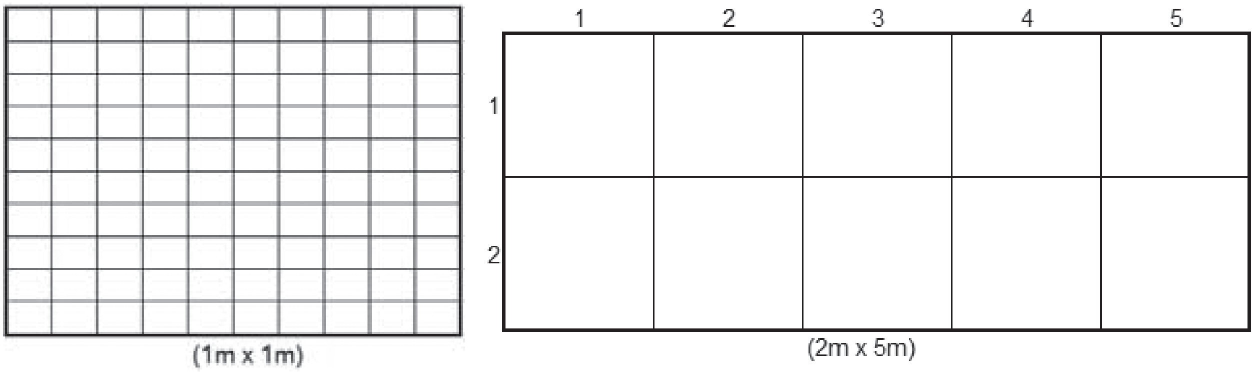


Photo 41. Ramensky net

STEP 5. Based on the measurements taken, make a conclusion on the suitability of species and their performance in terms of planting density.

List of documents to be obtained from the Company:

Table 29. List of documents to be obtained

#	Primary document	Particular section
1.	- Mine closure plan (if developed)	Rehabilitation section
2.	- Mine operation plan	Annual biological rehabilitation plan
3.	- Quantitative data from mine operator	Notes/book for the recordings from mine operator
4.	- DEIA and EMP commitments	Annual biological rehabilitation plan

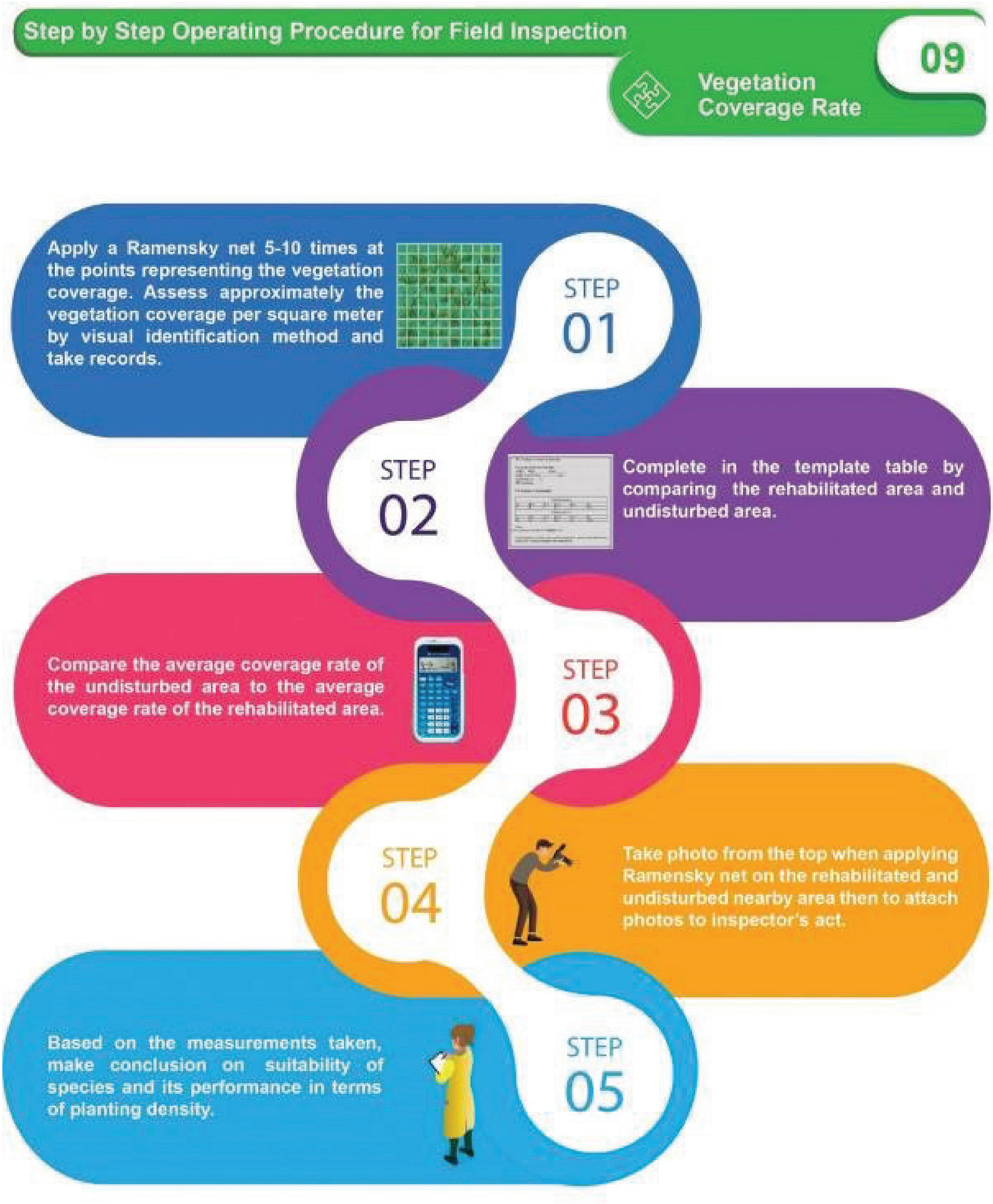
List of required equipment and tools:

1. Ramensky net (1m x 1m);
2. Ramensky net (2m x 5m) for Gobi and desert area; and
3. Notebook and pencil.

Photo 42. Record taking from Ramensky net

Template for Recorded Results

(T–3) Illustrative example of the Inspector's Act (with sample recorded data)
Area number where record was taken .... [RA-1]
Location: Aimag..................... soum.................,
License holder company .... LLC,
rehabilitated area ....ha,
GPS coordinates...............
According to the monitoring of revegetation progress of the rehabilitated area ....ha, it is determined the cover of the plant species (n = 5) per 1 square meter is 47% at average. An average cover rate of 85% per square meter were assessed for the undisturbed area. Thus, cover or the planting density in the rehabilitated area is compared against the undisturbed area. It is concluded that the result meets the standard requirements. Photographic documentation for the record taken areas is attached to this Act.



Infographic 9. Step-by-step procedure to inspect vegetation coverage rate

9.4 INSPECTION OF BIOLOGICAL REHABILITATION BY GROWTH (BIOMASS) OF SPECIES PER SQUARE METER

This measurement parameter is relevant to the performance issue 1 and 2 of revegetation outline.

Sequence of Field inspection work procedures

Photo 43. Inspect vegetation coverage - step 1

STEP 1. Make random selection of 5-10 (n=5, 10) key points/locations representing the vegetation growth in the area being rehabilitated.

STEP 2. Apply Ramensky net (or mark land plot sized 1m x 1m, using tape measure) to the selected points/locations and take note of the point/location.

STEP 3. Cut all plants grown in the given plot at height 1cm above surface soil.

STEP 4. Measure the weight of those cut plants using manual or electronic weight scale.

STEP 5. Measure the weight (grams) of those cut plants from 1 square meter of undisturbed area. Repeat last two steps 5-10 times in total.

STEP 6. Take records of the measurements as follows:

Table 30. Template table

Area being rehabilitated					
RA-1	RA-2	RA-3	RA-4	RA-5	Average (grams)
37	43	48	63	55	49.2
Undisturbed area					
UA-1	UA-2	UA-3	UA-4	UA-5	Average (grams)
80	87	93	84	105	89.8

Photo 44. Inspect vegetation coverage -Step 2

STEP 7. Compare the vegetation growth of the area being rehabilitated against the growth of the undisturbed area; and check if the growth rate is reasonable comparing to that of the undisturbed area.

$$\text{Growth (\%)} = \frac{\text{Growth per 1 square meter at area being rehabilitated (grams)}}{\text{Growth per 1 square meter at undistrubed (grams)}}$$

$$\text{Biological growth (\%)} = \frac{\text{UA (89.8-100)}}{\text{RA (49.2-X)}} = 54.7\%$$

Photo 45. Inspect vegetation coverage -step 3

Photo 46. Inspect vegetation coverage -step 4

List of documents to be obtained from the Company:

Table 31. List of documents to be obtained

#	Primary document	Particular section
1.	- Mine closure plan (if developed)	Rehabilitation section
2.	- Mine operation plan	Annual biological rehabilitation plan
3.	- Quantitative data from mine operator	Notes/book for the recordings and photos from mine operator
4.	- DEIA and EMP commitments	Annual biological rehabilitation plan

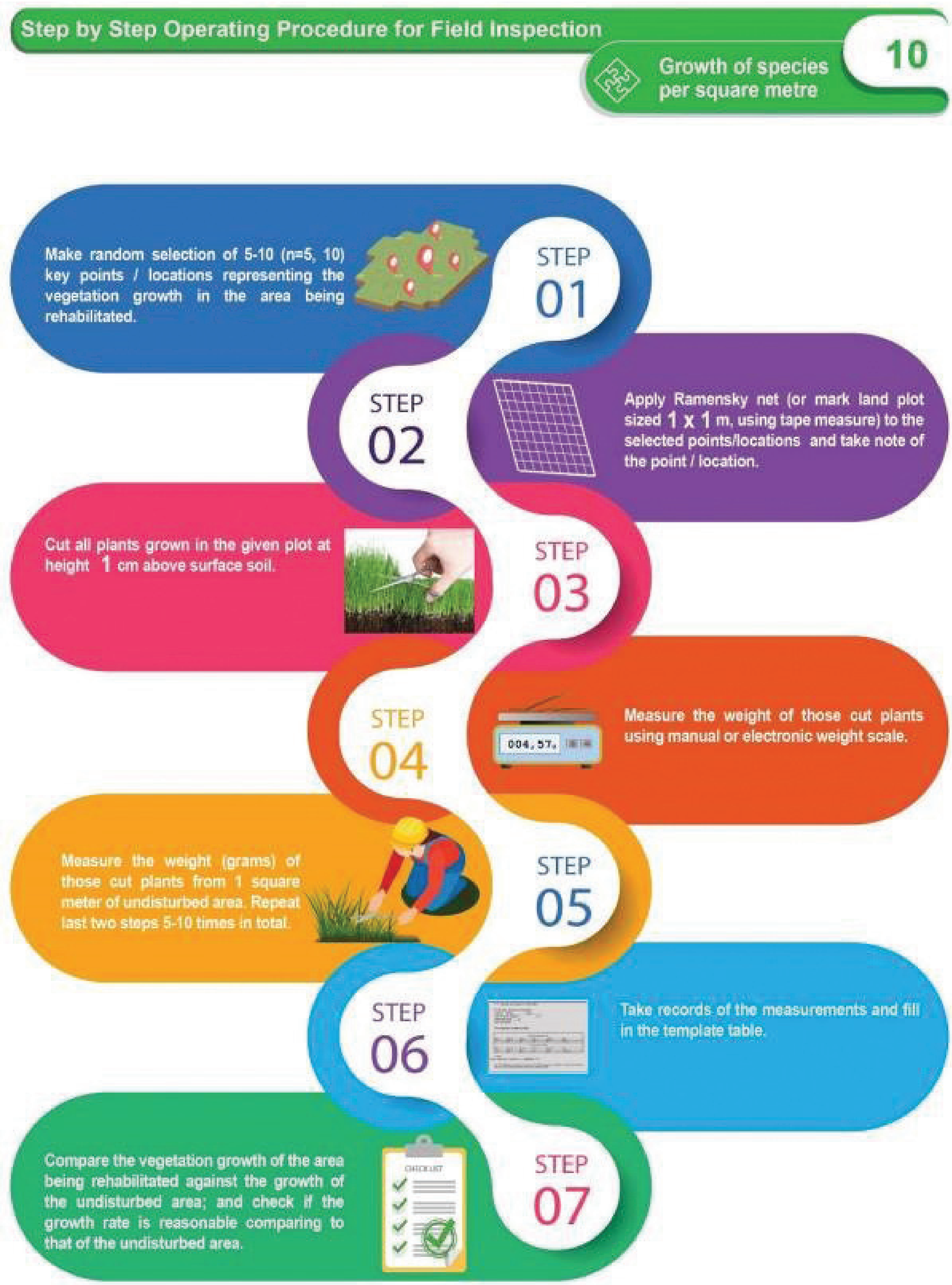
List of required equipment and tools

1. Ramensky net (1m x 1m);
2. Notebook, pencil;
3. Scissors;
4. Weight scale;
5. Tape meter;
6. Photo camera; and
7. GPS.

Photo 47. List of required equipment-growth of species

Template for Recorded Results

(T-4) Illustrative example of the Inspector's Act (with sample recorded data)
Area number where record was taken .... [RA-1]
Location: Aimag.................... soum.................,
License holder company .... LLC,
rehabilitated area ....ha,
GPS coordinates..............
According to the monitoring of revegetation progress of the rehabilitated area ....ha, it is determined the vegetation growth of the plant species (n = 5) per 1 square meter is 49.2g at average. An average vegetation growth of 89.9g per square meter were assessed for the undisturbed area. In practice, vegetation growth is deemed as normal if it resembles the undisturbed area at percentage 30-60. Thus, it is concluded that the result of vegetation growth in the rehabilitated area meets the standard requirements. Photographic documentation for the record taken areas are attached to this act.



Infographic 10. Step-by-step procedure to inspect growth of species per square meter

SECTION III.
ANNEX

GENERAL SUMMARY

10. ANNEX

10.1 REFERENCES

Laws:

1. Law on Minerals;
2. Law on Subsoil/Underground Resources;
3. Law on Environmental Impact Assessments;
4. Law on Land;
5. Law on Environmental Protection;
6. Law on Combating Desertification and Soil Conservation;
7. Law on Fauna;
8. Law on Flora ;
9. Law to Prohibit mineral exploration and mining operations at headwaters of rivers, protected zones of water reservoirs and forested areas;
10. Law on Buffer Zones;
11. Law on Air;
12. Law on Water;
13. Law on Waste ;
14. Law on Hazardous and Toxic Chemicals; and
15. Law on Hygiene.

Regulations:

- Procedure for mine closure and reclamation of land disturbed by mine site, mine operation and processing plant and mine closure;
- Methodology for Technical and Biological Rehabilitation of Land Affected by Mining Activities; and
- Regulation of the safety open pit mining. Approved by the Minister of Mining and Heavy Industry, Minister of Labour and Social Welfare Joint A / 231 and A / 368 of 2019.

Standards:

1. MNS 6297: 2011. Environment. Closure of heap and dump leaching facilities. General requirement;
2. MNS 5914:2008 Environment. Reclamation of disturbed land. Terms and definitions;
3. MNS 5915:2008 Environment Classification of Land Destroyed Due to Mining Activities;
4. MNS 5916:2008 Environment. Fertile soil /top soil/ removing and its temporary storage during the earth excavation;
5. MNS 5917:2008 Environment: Rehabilitation of land destroyed due to mining activities. General technical requirements;
6. MNS 5918:2008 Environment: Revegetation of destroyed land. General technical requirements;
7. MNS 5885:2008 Acceptable concentration of pollutants in the air, General technical requirements;

8. MNS 2305: 1994 Soil. Instructions to Sampling, Packing and Storing of Soil Samples; and
9. MNS 4585:2016 Air quality: General technical requirements.;

Additional references:

1. Using the Mitigation Hierarchy to manage impacts on biodiversity in Pacific Island Countries and Territories, The Biodiversity Consultancy, UK, 2018;
2. R5 – BMA Guideline for the design of sustainable mine landforms, BHP Billiton, Australia, 2008;
3. Mine Closure Checklist for Governments, Asia-Pacific Economic Cooperation, Canada, 2018;
4. Guidelines for Preparing mine closure plans, Department of Mines and Petroleum of Environmental Protection Authority, Government of Western Australia, 2015;
5. Restoration, Closure and Reclamation, Midas Gold Corporation, Canada, 2017;
6. Oyu Tolgoi Mine closure plan, AMEC Environment & Infrastructure, Mongolia, 2014;
7. Mine Closure and Completion: Leading Practice Sustainable Development Program for the Mining Industry, Australia, 2006;
8. The analysis of the existing terminology related to a post-mining land use: a proposal for new classification, Environ Earth Science, 2017;
9. Planning for Integrated Mine Closure: Toolkit, International Council on Mining and Metals, London UK, 2008;
10. Responsible Mining: Training Manual, UNDP, Mongolia, 2016;
11. Strategic Framework for Mine Closure, Australia, 2000;
12. Biodiversity offsets strategy for the Oyu Tolgoi project, Mongolia, 2012;
13. A Guide to Soil Salvage: Pre-disturbance steps to improve reclamation outcome, Natural Resources Canada, 2018;
14. Environmental Performance Reviews: Mongolia, United Nations Economic Commission for Europe, Geneva Switzerland, 2018;
15. Topsoil Management Plan for New Acland Coal Mine Stage 3 Project, New Hope Group, Australia, 2014
16. Best Practice Guideline - G5: Water Management Aspects for Mine Closure, Republic of South Africa, 2008;
17. Tailings Storage Facility Life of Mine Feasibility Design for Mount Polley Mining Corporation, Golder Associates Ltd, Canada, 2015;
18. Mongolia's State Policy on The Minerals Sector and Its Application in The Promotion of Sustainable Development, Mr. Otgochuluu, Managing Director and Chief Economist Erdenes Mongol LLC, Ulaanbaatar, Mongolia, 2016;
19. Soil Diversity in Mongolia, Kenji Tamura, Maki Asano, Undarmaa Jamsran, Springer Link, 2012; and
20. Frugal rehabilitation field handbook, MMHI, SDC &The Asia Foundation, 2016.

ANNEX 10.1.1 LEGISLATIVE AND ADMINISTRATIVE ACTS

Table 32. Summary of Laws and Legislative Acts

The relevant primary laws			
№	Laws	Amendments	Scope and Applicability
1.	Law on Minerals	2006-2019	Article 45 of this law regulates the whole or partial mine closure that are stated in the following provisions: • To inform the professional inspection agency by an official letter regarding the mine closure; • To take all necessary measures to ensure safe use of the mine area for public purposes; • To take all necessary measures for rehabilitation of the environment; and • Demobilize all machinery, equipment and other property from the mining area. Pursuant to this law, the Ministry of Mining and Heavy Industry will jointly approve the procedure for rehabilitation and closure of mines and processing plants in cooperation with the state central administrative body in charge of environment. In Article 45 of this law regulates the whole or partial closure of the mine closure issue. Moreover, in case of mine closure, the following aspects are regulated: i) Inform the GASI by an official letter regarding the mine closure; ii) Take all necessary measures to ensure safe use of the mine area for public purposes; iii) Implement all necessary measures for rehabilitation of the environment; and iv) Demobilize all machinery, equipment and other property from the mining area etcetera. In addition, this law requires that MMHI and MET shall jointly develop rehabilitation and closure procedure for mining plan and enrichment factory. According to the joint order No. A/181 of 2019, this procedure was approved.
2.	Law on Subsoil/ Underground Resources	1988-1994	The Law has provided the duties of subsoil users as follows: "The user of subsoil is obliged to satisfy the below listed requirements: • Hand over the site to the local government administrative authority that issued the permission, after rehabilitating the land that was damaged in the course of using subsoil. When handing over, the user shall ensure the safety of rehabilitated subsoil which ready to be used again for needed purposes including agriculture, tourism and forestry and etcetera; • Rehabilitate soil on top of the subsoil; • Eliminate all damages caused by environmental pollution due to subsoil disturbance activities; and • Approve and implement plan for community safety measures. "
3.	Law on Environmental Impact Assessments:	2012-2017	Article 8.4.6 of this law requires DEIA to include "Discussion of mine closure activities, objectives, scope and indicators of restoration measures and details of ex-situ conservation measures for petroleum, and mining projects and radioactive minerals projects", which contained some provisions for the mine closure planning. In addition, it is required to submit, at least three years prior to the mine closure, a rehabilitation and closure plan to the MET after having duly incorporated the comments of the MMHI. In addition, the law stated that "Local rangers, state environmental inspectors, governors of all levels, the relevant state central administrative organization and non-governmental organizations shall monitor the implementation of the environmental management plan and the mine closure management plan".

4.	Law on Land	2002-2019	Article 55 of the law contains the provision related to the rational use and protection of subsoil, such as: • "Users of subsoil shall have completed the environmental impact assessment and shall have planned land protection and rehabilitation projects." • Users of subsoil shall have land protection and rehabilitation projects, as well as annual plans developed based on the project. The State Central Administrative organization in charge of land shall approve these plans. Implementation of land protection and rehabilitation plans shall be discussed and assessed by Citizens Representatives Khurals of relevant levels in annual basis.
5.	Law on Environmental Protection	1995-2019	Article 31 of this law stated that "the business entities if engaged in environmentally adverse production and services shall provide annual budgets for implementation of restoring soil erosion, purifying polluted soil and water, and reintroducing plants and animals". It is one of obligations of business entities and organization but the law does not regulate liability in case nonfulfillment of this obligation. Therefore, this law regulation is difficult to execute.
6.	The Law on Combating Desertification and Soil Conservation	2012-2015	The law defines "soil rehabilitation" as the process of restoring degraded soil to its original state and increasing fertility. Also, Article 7.3.1 of this law indicates that "... legal entities engaged in mineral exploration and mining activities shall conduct biological rehabilitation". The introduction of advanced techniques for soil protection and desertification prevention in mining operations, and for the introduction of environmentally friendly techniques and technologies included as one of the incentives provided under this law.
The relevant secondary laws			
7.	Other relevant laws		The following laws include some provisions on the environmental rehabilitation, and these laws regulate some of the issues related to mine closure. Law on Fauna, Law on Flora, Law to Prohibit mineral exploration and mining operations at headwaters of rivers, protected zones of water reservoirs and forested areas, Law on Buffer Zones, Law on Air, Law on Water, Law on Waste, Law on Hazardous and Toxic Chemicals, and Law on Hygiene

Box 1. Improper water use/Lack of sufficient legal grounds

Improper water use/Lack of sufficient legal grounds. As described in the detailed environmental impact assessment, an entity planned to use water from a well and consequent signed water use agreement accordingly. In addition, water meter was officially installed at the well to measure the water use as agreed in the contract. Later, a little amount of water was used according to the water meter measurement and it was suspicious to use such little amount of water from the well for the mine operation. Relevant local authority visited the company's mine site to investigate the reason for such low use of water while mine operation is still ongoing normally. During the site visit, unregistered spring was found within the mine area, which seems to be supplying as a main portion of water used for mine needs. Now, the situation is that the spring was not registered in the national water inventory database; and it is necessary to make revisions on the DEIA to estimate water use from this spring and properly demand the corresponding water use payment. However, the company refuses to revise the DEIA, by explaining that relevant local authoritative organization does not have such rights. Therefore, this case currently do not have any adequate solution and still needs to be decided.

ANNEX 10.1.2 NATIONAL STANDARDS AND GUIDANCE DOCUMENTS

Table 33. List of relevant National standards

№	National standards	Scope and Applicability
1.	MNS 6297: 2011. Environment. Closure of heap and dump leaching facilities. General requirement	The purpose of this standard is to ensure: • Safety of mine facilities and structures to support desired land use, • Rehabilitation of degraded land, • Use of infrastructure and facilities, and • Mitigation of adverse environmental impacts during the closure of mine plant using heap and leaching technology. Scope of this standard covers the mine closure and reclamation activities for the mine operating in heap leaching method. This standard does not regulate the closure of an underground leaching plant.
2.	MNS 5914:2008 Environment. Reclamation of disturbed land. Terms and definitions	The purpose of this Standard is to determine terms and definitions related to the issue of reclamation of land disturbed by industrial activities.
3.	MNS 5915:2008 Environment Classification of Land Destroyed Due To Mining Activities	This standard has set forth general requirements for the developing and implementing rehabilitation plan for the disturbed land by mining industrial activities.
4.	MNS 5916:2008 Environment. Fertile soil /top soil/ removing and its temporary storage during the earth excavation	The purpose of the standard is to define requirements on fertile soil removing and its temporary storage during the earth excavation.
5.	MNS 5917:2008 Environment: Rehabilitation of land destroyed due to mining activities. General technical requirements	The purpose of the standard is to define general requirements on reclaimed land.
6.	MNS 5918:2008 Environment: Re-vegetation of destroyed land. General technical requirements	This standard determines the general requirements for re-vegetation of disturbed land.
7.	MNS 5885:2008 Acceptable concentration of pollutants in the air, General technical requirements	This standard sets out requirements for the tolerance level of air pollutants in order to create a healthy and safe living environment for the community and to ensure the balance of the ecosystem.
8.	MNS 2305: 1994 Soil. Instructions to Sampling, Packing and Storing of Soil Samples	The standard sets out all requirements relevant to sampling, packing and storing of soil samples.
9.	MNS 4585:2016 Air quality: General technical requirements	All the air contaminants and noise permissible level is defined in this standard.

ANNEX 10.1.3 PROCEDURES AND RELEVANT INFOGRAPHICS

Procedure for mine closure and reclamation of land disturbed by mine site, mine operation and processing plant and mine closure

Pursuant to Article 10.1.14 of the Minerals Law, *"Regulation on rehabilitation and closure of mines, quarries and concentrators shall be approved jointly with the state central administrative body in charge of environment", the legislative act for mine closure and rehabilitation has been formalized with the approval of joint order No. A / 181 of 2019.*

The procedure required the project proponent to develop three new documents: a preliminary mine closure plan, mine closure plan, and a detailed mine closure plan. These three documents are not defined in the Minerals Law or any other law, and only this regulation governs the affairs relating to the content, requirements, processing, delivery and control of these documents.

Box 2. Funding mining closure

Funding mining closure. The operation of the South Gobi Sands LLC (SGS) will end in 2037, according to mineral resources estimation which approved by Mineral Resources Professional Council under Ministry of Mining and Heavy Industry. According to the Minerals Law of Mongolia, the Mining closure plan shall be approved three years before the actual closure of the mining operations. However, the SGS has planned the closure activities in 2015-2016. In 2016, the SGS LLC has recruited professional team of advisors to properly project the budget for the mining closure plan. The total budget for the closure was estimated for 100 million USD. The SGS recognized the obligation to complete the closure mine areas and a suitable amount of financing has been set aside on a systematic basis that was adequate to fully reclaim the mine according to the responsibilities that the company had committed for the closure plan.

The company annually transfers 5 million USD approximately from the annual income to the special account aimed to exclusively designated for funding mining closure. In this case, the company can provide solid assurance that mining closure plan will be successfully completed on time without any financial risks.

Approval Procedure for Mine Closure Management Plan

Diagram 11. Approval procedure for mine closure management plan

ANNEX 10.1.4: LEGAL REGULATIONS REGARDING DEIA AND EMP

DEIA report: A business entity shall prepare DEIA based on BEIA results. The report shall consist of primarily basic field researches documents and assessment expert studies results. The report shall have four copies and shall be delivered to MET, project implementer, Governor's office of the soum or district where the project targeting to be implemented and one copy will remain to EIA conducted entity.

DEIA report shall include the followings issues[4] including::

- Baseline environmental condition where the project is planned to be implemented;
- Potential negative impact, magnitude, extent, consequences of the project and findings of studies;
- Recommendations for measures to mitigate and eliminate potential and major impacts of the project;
- Recommendations for methods and technology that reduce potential pollution that expected from the project and use of environmentally-friendly methods and technology for the project;
- Risk assessment of impacts on human health and environment of the proposed project, if BEIA is required;
- Mine closure activities, objectives, scope and indicators of rehabilitation and ex-situ (offset) conservation measures for petroleum, mining and radioactive minerals projects;
- Objectives, scope and indicators of EMP;
- Meeting minutes and proposals of consultations made with local authority and General Community Meeting of administrative area that will be impacted by the proposed project and;
- Other issues relevant to the historic and cultural sites and special nature of the project.

Legal regulations regarding the DEIA

Laws on Environmental Protection, on Minerals, on Water, on Air, on Forest, on Hunting, on Plant, on Chemical, Toxic and Dangerous substances, and on Environmental Impact Assessment are all serve as the key laws that are directed to regulate relations and activities associated with sustainable use of recoverable resources, environmental protection and impact assessment.

Specifically, Law on Environmental Impact Assessment which was passed on May 1, 2012 is the main law that directly regulates relations connected with the DEIA.

Regarding procedures and regulations associated with this report, there are several effective and applicable regulations, including:

- Regulation on Environmental Strategic and Accumulated Impacts;
- Regulation on Monitoring the Transactions through Accounts for Environmental Protection;
- Regulation on Development, Review, and Reporting of EMP;
- Regulation on Engaging Public Participation in EIA and;
- Methodology on EIA Development; and
- Regulations on Commission, Accreditation, Review, Adoption and Reporting of EIA etc.,

[4] Law on Environmental Impact Assessment, Clause 8.4;

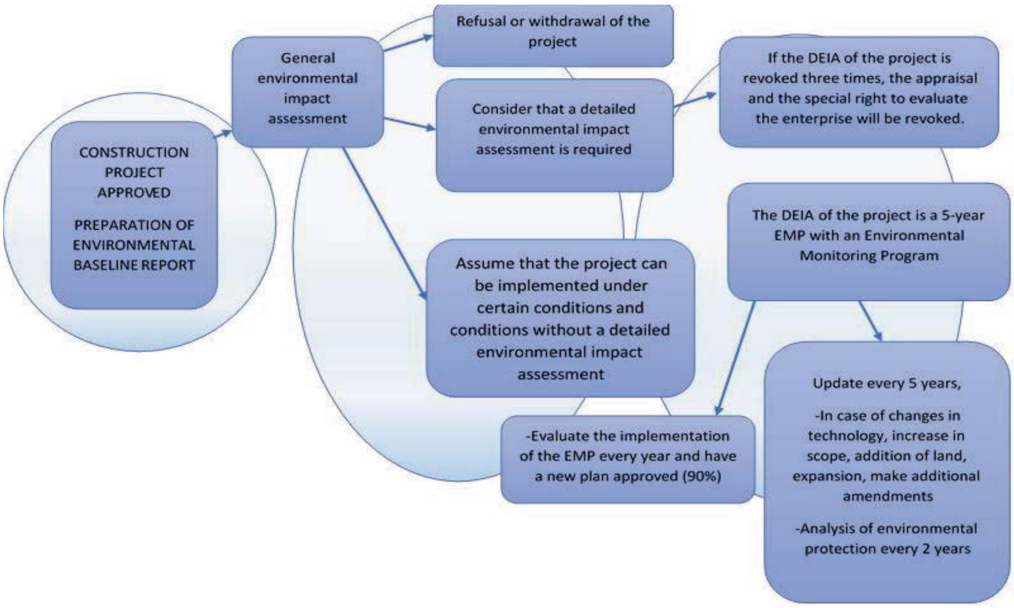


Diagram 12. GEIA and DEIA

EMP shall be a five-year plan or is to be revised and re-approved every 5 years if the project duration is longer.

Diagram 13. Environmental Management Plan

ANNEX 10.1.5: CASE STUDY 3 – INSPECTION OF ENVIRONMENTAL REHABILITATION

Case description

The State Environmental Inspector issued compensation act to business entity based on committed number of violations to perform general obligation stated in Article 35 of the Law on Minerals including approved design, mining and environmental management plans, absence of land and water use agreements and noncompliance of State inspectors requirements.

Repeated failure to comply with duties stated in the Article 35 of Minerals law of Mongolia; these duties included the following clauses:

- 35.3. A mining license holder shall keep the following documents at the mine:
- 35.3.1 certified copy of the mining license;
- 35.3.2 feasibility study on mineral mining and a mining plan reviewed by the relevant organization;
- 35.3.3 environmental impact assessment;
- 35.3.4 environmental management plan;
- 35.3.5 property leases and product sales agreements;
- 35.3.6 records establishing and marking the boundary of the mining area;
- 35.3.7 agreements on land and water use.
- 35.4 a mining license holder shall commence its mining activities after a commission appointed by the Government Ministry in charge of geology and mining accepts the mine.
- 35.5 The mining license holder shall exhaust all the mineral reserves. Itis prohibited to mine selecting the high-grade areas.

When imposing the compensation, the inspector estimated the ecological and economic valuation according to methodology approved by the Order No. A/156 dated May 27, 2010 of the Minister of Environment and Tourism of Mongolia.

The mining company has filed a lawsuit to the Administrative Court, claiming that the act of the state environmental inspector is illegal and the company does operate in compliance with the relevant laws.

The Court Decision

The Court resolved the dispute and has found that the act of the state environmental inspector to impose compensation was explicitly illegal.

The Court judgment followed below justifications:

1. The general grounds and procedures for conducting inspections specified in Article 5 of the Law on State Inspection have not been satisfied. The inspection was conducted without inspection directive thus violating Article 5.2 of the Law on State Inspection, which states that "scheduled and unscheduled inspections shall be conducted in accordance with the inspection directive approved by the authorized official ...".
2. The court confirmed that License holder committed a non-compliance of the law provision: "Obligation of the license holder to keep documents such as mining work plan specified in Article 35.3.2, environmental management plan specified in Article 35.3.4, land and water use agreement specified in Article 35.3.7 of the Minerals Law at the mine site". However, the offender (refers to the state environmental inspector) violated the provision on imposing a fine or compensation for damages, taking into account of the nature of the violation in case of non-fulfillment of this obligation.

Note: The court concluded this ground as "the compensation is imposed not considering the nature of the violation". In other words, the state inspector

- did not identify how the environmental protection legislation was violated, the act of the violation, the nature of the violation;
- did not fulfill the inspector's obligation to do so; and
- did not sufficiently identify the act violating Law on Environmental Protection.

3. It is true that the Article 10.12.2 of the Law on State Inspection contained provisions on exercising powers of the state general inspector and senior state inspector: "illegally earned income and property of business entities, organizations and citizens shall be taken to state revenue by issuing an act, as well as to resolve the issue of compensation for damage caused to others in accordance with relevant legislations. A state environmental inspector has issued an act with pursuant to Article 10.13 of the same law, stating that a state inspector of the soum shall exercise this power in a soum where no senior state inspector is available. The court found that the conviction is associated with fulfilling of this Article of the law WITHOUT identifying what **illegal activity** committed by the business entity, and WITHOUT identifying the **illegal income** or property earned by the business entity.
4. The Inspector shall calculate the ecological and economic assessment in accordance with the methodology approved by the Order No. A / 155 of the Minister of Environment and Tourism dated May 27, 2010. Amount of damage to the environment, damage to the subsoil, damage to surface water, damage to the atmosphere, damage to vegetation, damage to soil, damage to the environment caused by mine damage, Article 49.5.1 of the Environmental Protection Law It is also incorrect to decide to compensate for the damage caused to the subsoil by calculating the amount of damage calculated by the methodology for calculating the environmental damage in the amount equal to twice.

   The Inspector's act was repealed for the reason that amount of damage caused by the business entity to the environment and natural deposit is not accurately estimated according to the relevant laws, regulations and methodologies where the amount of damage should have been estimated as follows:

   Article 49 of Law on Environmental Protection, it is required to:

   - Determine in detail what kind of damage has been caused to the environment and natural resources, and if so, which category of damage has been caused to the environment;
   - Engage a professional licensed company to develop an EIA to estimate the amount of damage caused; and
   - Estimate the amount of damage to the environment depending on if the damage is categorized as subsoil damage or soil damage. The estimation shall be based on the benchmark rates approved by the Minister in charge of environmental affairs.

(The dispute is a real-life example and is resolved by the court decision that has been made available to public via the website shuukh.mn. The names of the parties to the dispute were anonymized in the case narrative, as it may adversely affect the reputation of those parties.)

COMPANY

We insist the act of the inspector is illegal and the company operates in compliance with the laws.

JUDGE

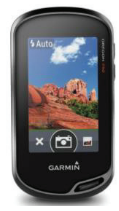
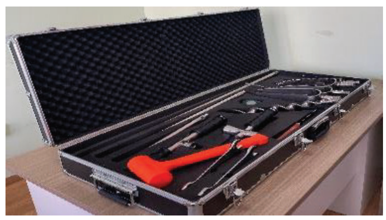
Ordered to repeal the Inspector's act due to
i) inspection is conducted without the inspection directive,
ii) have not taken account of the nature of the violation,
iii) issued act without identifying specific illegal activity and income by the company,
iv) damage loss was not estimated by the professional licensed company.

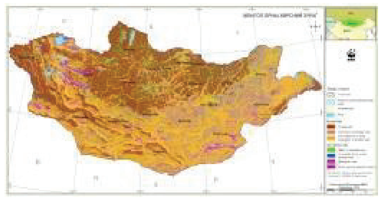
INSPECTOR

I have imposed compensation act to this entity due to
i) repeated failure comply with Minerals Law of Mongolia,
ii) conducted operations without proper documentations and agreements
iii) failure of fulfilling my requirements.

Photo 48. Legal case study

10.2 LIST OF EQUIPMENT AND TOOLS

No.	Багаж хэрэгсэл	Товч тайлбар	Зураг
1.	Inclinometer	An inclinometer or clinometer is an instrument used for measuring angles of slope	
2.	Soil pH testing tool	Measuring soil pH and moisture; Soil acid and alkaline environment to measure; and Measuring range: pH 1 – 10; Operating temperature: 5 - 45°C (41 - 1113°F) / ATC; Stick sample measuring tool into the soil and read from the screen the measurement results.	
3	GPS is widely used for surveying. By receiving radio signals from the satellites, a GPS is able to calculate exact location on the planet and records the location in coordinates.	It records the location in coordinates; Check the markshader measurements; and Estimate the area size.	
4.	The sampling instrument/tool	The sampling instrument of the soil should take a sample from shallow depth below the surface; Measurement of topsoil and compacted soil density;	
5.	A drone (UAV) is a flying robot that can be remotely controlled or fly autonomously through software-controlled flight equipment	Monitoring the stability of tailings dams and topsoil stockpiles, stripping areas, and open pits; View, photograph and videotape the overall site layout; Security monitoring; and Estimate plant cover.	
6.	Soil compaction tester	Soil compaction meters (often called penetrometers) are used to determine the density of soil and other material.	

7.	Photo camera	A camera is an optical instrument used to record images.	
8	Weight scale	Weighting scales are used to measure the weight of vegetation yield.	
9.	Dust particle measuring device	Selection mode 0.01-20 mg / m3 or 0.1-200 mg / m3 depending on the level of contamination High sensitivity measurement (0.01 mg / m3) Ability to monitor battery level on the screen Additional memory can be installed	
10.	Soil sampling tool kit for laboratory testing	Soil container, labels, marker, box and other required small items	 
11.	Big scale soil map	Soil map is a geographical representation showing diversity of soil types and/or soil properties in the area of interest	
12.	Shovel	This tool is used to determine thickness and moisture of the fertile soil layer.	
13.	Tape meter	A tape measure or measuring tape is a flexible ruler used to measure size or distance.	

14.	Ramensky net	Ramensky grid or net is used to determine yield of vegetation	
15.	Plant identification document, photo reference book	Comprehensive plants reference book	
16.	Ruler	A ruler is a device used for measuring length	
17.	Scissors	Heavy duty scissor will be used to cut plants for purpose of monitoring the vegetation yield.	

Ex. The tool is included as a sample. Therefore, it is possible to carry any instrument capable of measuring the parameters required for the step-by-step control.