GENERAL AGENCY FOR SPECIALIZED INVESTIGATION
GOVERNMENT REGULATORY AGENCY

In partnership with Canada

MERIT
A CESO AND WUSC PROGRAM

MINE WATER RESOURCES AND QUALITY MONITORING

FIELD MANUAL

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

Ulaanbaatar
September 2022

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The Mine Water Resources 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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ACRONYMS

ARD	Acid Rock Drainage
BOD	Biochemical Oxygen Demand
CLEM	Central Laboratory of Environment and Metrology
COD	Chemical Oxygen Demand
DEIA	Detailed Environmental Impact Assessment
DO	Dissolved Oxygen
EC	Electric Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GASI	General Agency for Specialized Inspection
GPS	Global Positioning System
IRIMHE	Information and Research Institute of Metrology , Hydrology and Environment
ISO	International Organization for Standardization
IWRM	Integrated Water Resources Management
KPI	Key Performance Indicator
LEM	Laboratory of Environment and Metrology
MDG	Millennium Development Goals
MERIT	Mongolia: Enhancing Resource Management through Institutional Transformation Project
MET	Ministry of Environment and Tourism
NAMEM	National Agency for Meteorology and Environmental Monitoring
NGO	Non-Governmental Organization
PAH	Polyaromatic hydrocarbons
REDOX	Reduction and Oxidation Potential
SS	Suspended Solids
SI	International System of Units
TDS	Total Dissolved Solids
TSF	Tailing Storage Facility
TSS	Total Suspended Solids
T^o	Temperature
WRM	Water Resources Management
WRSF	Water Resources Storage Facility
WWTP	Waste Water Treatment Plant

GLOSSARY

Acidic Drainage and Metals Leaching:	Related to oxidization of sulphide minerals common with base metals e.g. Cu, Pb, Zn and Fe.
Alkaline Effluents:	Associated with ore separation processes that use chemical additives to ensure an alkaline pH, sometimes as high as 10 or 11.
Aquifer:	An underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt). Aquifer holds and allows groundwater flow through spaces between the rocks [2].
Bank stability:	The potential to collapse or erode (e.g. steep banks and those with bare and/or crumbly soil are vulnerable to erosion) and any signs of past erosion. To be considered as erosion, the banks must be actively eroding through break down, soil sloughing, or false banks [3].
Bore well:	A deep, narrow well for water that is drilled into the ground and has a pipe fitted as a casing in the upper part of the borehole, typically equipped with a pump to draw the water to the surface [7].
Borehole:	A deep, narrow well for water that is drilled into the ground that is not equipped [7].
Centralized water supply:	The pipeline system for extraction, purification, and distribution of water; the action to provide consumers with pure water that meets the standard requirements by using the constructed facilities [9].
Channel alteration:	To obstruct, diminish, destroy, modify, or relocate a stream channel. Channel alterations change the stream morphology and then the flow condition, both morphological and hydrodynamic factors affect one another, and these factors affect the habitat [5].
Drainage Basin:	An area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel. The edge of the drainage basin is referred to as the watershed divide [9].
Drinking water:	High quality and safe water that is being used to provide the normal function of hygiene, to process foods and is directly drinkable [1].
Sediment deposition:	The extent of fine particle deposition in the riverbed. The water carries sediment (clay, silt, and sand) downriver until deposited on the riverbed. Sediments are deposited in areas where flow is reduced such as pools and bends in the river, or where flow is obstructed by objects such as fallen trees [3].
Embeddedness:	The extent to which coarse substrates are buried by silt, sand or mud on the stream bottom. To estimate the percent of embeddedness, observe the amount of silt and sand sediments overlying and surrounding the larger gravel and cobble size particles [10].
Eutrophication:	The process of aquatic overgrowth, followed by death, decay, and oxygen depletion. When agricultural and industrial runoff floods waterways with excess nutrients such as nitrogen and phosphorus, these nutrients often cause eutrophication [12].

Groundwater:	It exists below the earth's surface and can be present in the pore spaces and fractures of soils, surficial geological materials, and underlying bedrock. Groundwater is not subjected to losses by evaporation and the temperature of groundwater is very stable and does not fluctuate due to changes in air temperature [1].
Household water:	Adequate, high quality and safe water that is being used to provide a normal condition of hygiene and contagion protection of the population [1].
Hydrological cycle:	A continuous process of water circulation among the oceans, the atmosphere and land masses through evaporation, precipitation, surface runoff and groundwater percolation [2].
Hydrology:	The scientific study of the movement, distribution and management of water including the hydrological cycle, water resources and environmental watershed sustainability [2].
Hygienic zone:	The strip of land or buffer zone established to protect water resources from contamination [9].
Main distribution pipeline of water supply:	The pipeline system from the constructed facility of the water source to a branch pipeline [1].
Monitoring:	The continuous and systematic process of evaluating the physical, chemical, or biological attributes of a substance such as air, water or soil, to identify whether standards are being met and to track changes and trends over time. In the case of water, monitoring usually requires the collection of samples for detailed chemical or biological analysis and the collection of data from in situ measurements.
Mine footprint:	The core area of the mining operation where there is resources extraction and processing activity and all the infrastructure required for mine operations [30].
Non-centralized water supply:	The action to extract, transport, distribute and provide consumers with pure water that meets the standard requirements [9].
Pipeline system:	The facility to transport and distribute pure water to consumers and sewage facility to pump back and remove the wastewater [1].
Pool:	Water is slow and generally deeper than a riffle or run. Water surface is smooth with no turbulence. A general rule that can be used to distinguish a pool from a run or riffle is if two or more of the following conditions apply; the stream channel is wider, deeper, or slower than average [3].
Relief well:	Typically drilled to intersect a well that has experienced a blowout. It is used to reduce pore water pressures in confined aquifers or in stratified ground conditions. The relief well acts as a valve to relieve the water pressure and allow excess water to be diverted safely, without collapsing the stream or lake banks [7].
Riffle:	Higher gradient areas where the water is fast and turbulent, water depths are relatively shallow, and substrates are comprised of boulder, cobble, or gravel. Riffles generate high levels of oxygen [3].

Riparian vegetation:	The natural vegetated zone adjacent to the edge of a water body and is an important component of stream habitat in terms of shading and preventing erosion. Riparian vegetation is often subject to inundation at normal high flows, and is a source of input of nutrients such as woody debris and litter [11].
Riparian vegetative zone width:	It estimates the width of the vegetative zone adjacent to the stream. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when overgrazing, roads, fields, bare soil, rocks, or buildings are near the stream bank [3]**.**
Run:	The water may be moderately fast to slow but the water surface typically appears smooth with little or no surface turbulence. Generally, runs are deeper than a riffle and shallower than a pool [3].
Sedimentation:	It occurs when eroded material that is being transported by water, settles out of the water column onto the surface, as the water flow slows. While heavy particles settle out quickly the finer silts and clays tend to stay in suspension for days or weeks causing water to remain cloudy and discolored [10].
Shallow ground water:	Water in the first impermeable layer which is located beneath the ground surface.
Special and normal protective zone:	The strip of land or buffer zone established to protect a water source, discharge and resource from contamination and diminution [9].
Springs:	Locations where groundwater emerges naturally to the surface and flows over the surface [1].
Stream bed substrate:	The primary physical environmental variable affecting the taxa richness and density of macroinvertebrates and fish. Coarser streambed substrates (boulder, cobbles), submerged logs/snags, undercut banks indicate good habitat quality that is favorable for epifaunal colonization [8].
Stream order:	A measure of relative size of streams. A first-order stream is the smallest permanently flowing stream with no tributaries. The union of two first-order streams becomes a second-order stream; the union of two streams of second order becomes a third-order stream, and so on. First- through third-order streams are called headwater streams [6].
Surface water:	It exists above the earth's surface and accumulates in water bodies such as streams, rivers, wetlands, and lakes. The temperature of surface water varies with changes in air temperature and surface water is subject to losses from evaporation [4].

Velocity/depth regime:	Stream velocity, which increases as the volume of the water in the stream increases, determines the kinds of organisms that can live in the stream (some need fast-flowing areas; others need quiet pools). It also affects the amount of silt and sediment carried by the stream. Sediment introduced to quiet, slow-flowing streams will settle quickly to the stream bottom. Fast moving streams will keep sediment suspended longer in the water column. Lastly, fast-moving streams generally have higher levels of dissolved oxygen than slow streams because they are better aerated. Stream depths affect many other characteristics of a stream. For example, a stream flowing through a shallow channel will receive more sunlight throughout its water column and become warmer throughout. Also, deep water stays cooler for longer and tend to flow with greater velocity [10].
Water consumer:	The customer who uses water and water surroundings for beneficial purposes such as drinking and household use, agriculture, and livestock-farming [9].
Water distribution house:	The service outlet to which water is delivered by transportation vehicle for distribution to water consumers [1].
Water erosion:	The detachment and removal of soil and surficial material such as gravel, by water. The process may be natural or accelerated by human activity. The rate of erosion may be very slow to very rapid, depending on the soil, the local landscape, and weather conditions.
Water resource:	Surface and underground water that is being used and likely to be used in the future [9].
Water resources area:	The area covering lakes, ponds, salt marsh, rivers, streams, springs, permanent snow, glacier and their protection zone [9].
Water supply source:	Surface water or groundwater resources used to supply water by means of infrastructure such as; pump well, collector pipeline, water reservoir, pump station and water treatment facility [9].
Water table:	The upper surface of the groundwater zone of saturation [4].
Water user:	The organization, economic entity and citizen that use water and water surroundings in the manufacturing and services for profit purpose [9].

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FOREWORD

This field manual on Water Resources Monitoring is a practical reference for inspectors containing reliable, objective and timely information to understand and manage water resources impacted by mining. 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 over water resources.

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 water systems.

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 Generalized Agency for Specialized Inspection (GASI), the Ministry of Environment and Tourism (MET), the Water Agency, the River Basin Authorities, the Ministry of Mining and Heavy Industry 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 implemented 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.

The MERIT project focuses on building the capacity of national government ministries/agencies, as well as local government in the aimags and soums, to effectively implement the national government's extractive sector-related policies and regulations. Given the actual extractive activities essentially take place in the aimags, capacity building must consider the relationship between different levels of government and the various roles they play in managing the extractive sector for the benefit of all Mongolians. Therefore, MERIT provides technical support for strengthened environmental management and compliance enforcement, by working collaboratively with the Ministry of Environment and Tourism (MET), the General Agency for Specialized Inspection (GASI) and its branch offices, and Local Government in the aimags and soums.

The General Agency for Specialized Inspection (GASI) has identified the need for technical guidance on practical and affordable field-based monitoring tools and techniques to strengthen risk-based assessment for mine inspections. Water resources management is a significant component of environmental management for the extractive sector, and MERIT has committed to developing training programs and resources which will help build capacity in this specific area. As part of this work MERIT has developed a Mongolia-based Water Resources Monitoring Field Manual focused on water resources use and protection in placer gold, open-pit coal, and metal mines. This manual is focused on routine water resources management fieldwork at mines and provides background information on water resources management of the extractive sector in Mongolia, general guidance on conducting inspections related to mines and risks to water resources, and basic field inspection and measurement techniques. The manual provides step-by-step guidance on approaches to: planning, conducting and documenting inspections; identifying problem situations which are impacting or posing risk to water resources; water use monitoring; specifying mine effects and impact pathways for water resources; selection of sampling sites; and water quality sampling and measurement techniques for surface water, groundwater, mine water, and mine effluent.

This field manual strives to outline standard monitoring and measurement procedures applicable to the above mentioned three types of mining. Standardizing inspection and monitoring procedures across Mongolia recognizes the need for consistency in implementing national policies both across the various regions of the country and for different stakeholders in the extractive sector. This manual is one component of a multi-audience training program for environmental officers, state inspectors, and ecological police officers and rangers at the aimag and soum levels. Moreover, this manual is an educational resource that can be used by wider interested parties such as industry representatives, professional organizations, environmental NGOs and community groups.

All procedures in the manual are designed to be compliant with the Mongolian Law on Water (2012), the Law on Water Use Fee (1995) and the Law on Water Pollution Fee (2012), and applicable regulations and Mongolian water quality standards. The practical recommendations on calculating pollutant load fees are included with the description of various physical, chemical and bacteriological characteristics of drinking water. This is the first edition of this manual and there will no doubt be a need to edit and update it over time to ensure it reflects all new legislation and policies relevant to the extractive sector.

RATIONALE/CONTEXT

Mongolia faces severe water scarcity and quality crises both in rural and urban areas. As a result of climate change, hundreds of lakes and rivers have dried up, and there is significant desertification, especially in the steppe and Gobi-desert regions. Groundwater is the main source for household and drinking use, animal husbandry, and industrial consumption in Mongolia. Hence, the interception of water resources through mining activities is increasingly becoming an issue for decision-makers, water users, and planners, as well as for individual mines and the mining industry.

The extractive sector is the main source of economic growth in Mongolia and a major part of the economy. However, water supply and the demand gap is the key limiting factor for mine sector development. Mining companies are exposed to the risks related to the availability of water, particularly in the southern mine-intensive Gobi region.

The mining industry's use of and impacts on water can result in a range of environmental, social, and economic risks. Among the environmental problems arising due to mining activities, perhaps the most significant impact of mining is its effect on water resources. Mining influences the quality and quantity of water in the mine area and in its surroundings and changes hydrological and topographical conditions, sometimes drastically. Also, a mine is regarded by local communities and other users as an excessive water consumer or as detrimentally affecting water quality, and there can be conflict or discontentment as a result. Communities close to mine sites increasingly become concerned about their availability of water, security of their access to it, and the potential for water contamination.

Hence, the improvement of the industry's water management performance is a high priority for the Mongolian government. Responsible management of water by mining companies is a key ingredient in ensuring that their contribution to sustainable development is positive over the long term. The lack of comprehensive and practical tools for efficient mine water monitoring and inspection seems to be one of the main causes behind the inadequate water management practices in mining.

Given these challenges, MERIT recognizes the capacity strengthening needs of water management and governance, and offers this guidance document to provide consistency, certainty, and clarity on mine water monitoring requirements for both government and industry.

CHAPTER I
INTRODUCTION TO WATER RESOURCES AND MANAGEMENT

1.1 WATER RESOURCE

Most of the Earth's water exists in the oceans as salt water. Just 2.6 percent of all water on Earth is freshwater. The majority of freshwater is contained in icecaps and glaciers, and groundwater, whereas all lakes, rivers, and swamps combined account for only 0.3% of Earth's freshwater reserves (Figure 1), [13]. Annual water resources for Mongolia are estimated to be 500 km3 from lakes, 19.4 km3 from glaciers, 34.6 km3 from surface water and 10.8 km3 from groundwater [14]. The majority of all the freshwater resources are stored in the lakes and by far the largest is Lake Hovsgol that stores three quarters of this water volume (Figure 1). The groundwater resources of Mongolia are estimated at about 10.8 km3 and from this, the exploitable resource is 5.6 km3. Groundwater recharge is 40-60 mm/year in the Northern part of the country but 1mm/year in the Southern part [12]. Mongolia is one of 60 countries in the world with limited water resources [16].

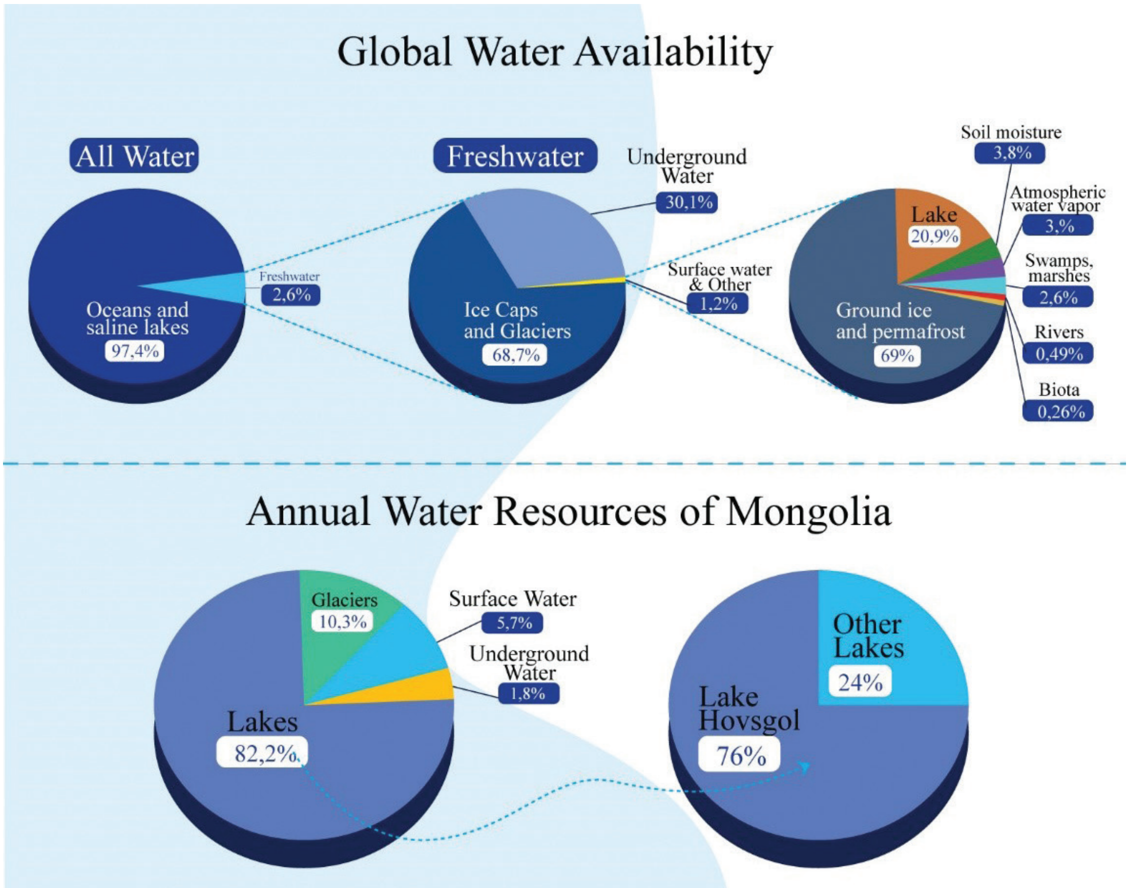


Figure 1. Global and Mongolian water resource

Mongolian socio-economic development is being threatened by degradation of water resources quality and quantity. According to all scenarios of water demand projections, the future water demand of Ulaanbaatar is expected to exceed the current water supply capacity before 2021. Additionally, due to the increased water demand from mining and industrial activities, the expected water demand could surpass the available resources in the high water-demand scenario before 2030 at the local level [16].

1.2 WATER QUALITY AND POLLUTION

Water quality is a measure of the suitability of water for a particular use based on the significant physical, chemical, and biological characteristics [9, 17]. Water quality standards are guidelines approved by the competent authority which define the acceptable limits for the concentration of various substances in water, to ensure that the chemical, physical and biological characteristics of the water do not adversely affect human health or the aquatic environment.

Typical water quality parameters include water quality physicochemical indicators such as temperature, conductivity, color, taste and odor, pH, electric conductivity (EC), suspended solids (SS), total dissolved solids (TDS), water temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD5), and chemical oxygen demand (COD), macro and micro elements; specific contaminants such as petroleum products, agricultural pesticides, toxic industrial chemicals, etc., and biological indicators such as bacteria (e.g., fecal & total coliform, E. coli.), parasitic protozoa (e.g., cryptosporidium, giardia) and blue-green algae (See key measurable parameters for monitoring compliance in Annex I) [18]. Variations in water quantity have important effects on water quality and hydrological data is important for interpreting water quality data. A full understanding of hydrology requires the collection of climate data. Information on precipitation, temperature, humidity, solar receipt, wind direction/speed, and soil moisture is useful to hydrologists for understanding hydrological cycles and forecasting trends in flow.

FACT 1. The most stringent guidelines are applied to drinking water quality. In Mongolia, water quality in more than 100 soums does not meet the drinking water quality standard since 60% of the soums have water with a too high TDS and 40% have high hardness [15].

Natural water quality is highly variable across different regions and throughout the year with different seasonal flow levels, natural seasonal cycles and changing climate conditions. Climatic, geomorphological, and geochemical conditions prevailing in the drainage basin and underlying aquifer chiefly influence a unique pattern of chemical and physical properties for each body of freshwater [7].

Due to the balance between dissolution and precipitation, mineral content, which is defined by the total of dissolved solids present, is an indispensable factor of the quality of any body of water (e.g. Table 1).

Table 1. Suitability of water-usage based on hardness and total dissolved solids [19].

Hardness in mg/l	Pozoknov's classification	EC µs/cm	Suitability for human, animals, and vegetation
Hardness<1.5	Very soft	0-480	Good water to use for drinking
(1.6-3.0)	Soft		
(3.1-6.0)	Slightly hard	480-1500	Good water for vegetation and animals
6.1-7	Hard	1500-6000	Impossible for human use
7.1 ≤ Hard	Very hard	6000 <	Not suitable for human and domestic animals

Water pollution is the contamination of the components of the natural waterways to such an extent that human health and normal environmental processes are adversely affected. It is largely caused by direct and indirect human activity (Figure 2).

Water quality and quantity data are important information sources used to assess drinking water safety or other beneficial uses, risks to ecosystem health, pollution impacts, water quality trends, planning water treatment systems, assessing implications of new development on current water quality, and developing water management plans [21]. Water quality and quantity data storage systems need careful consideration to ensure that all the relevant information is stored so that it maintains data accuracy and allows easy access for users. To manage water resources, governments must have thorough and up-to-date information on all available water resources.

FACT 2. The minimum amount of DO that is required for sustaining a variety of organisms is 5g/m^3. If temperature (T°) increases, the amount of DO will decrease. Coarse fish such as perch can live in water with T° of up 30°C and oxygen levels of only 3g/m^3. Salmon or trout die if oxygen level falls below 5g/m^3 or T° moves outside the narrow range of 5-20°C [20].

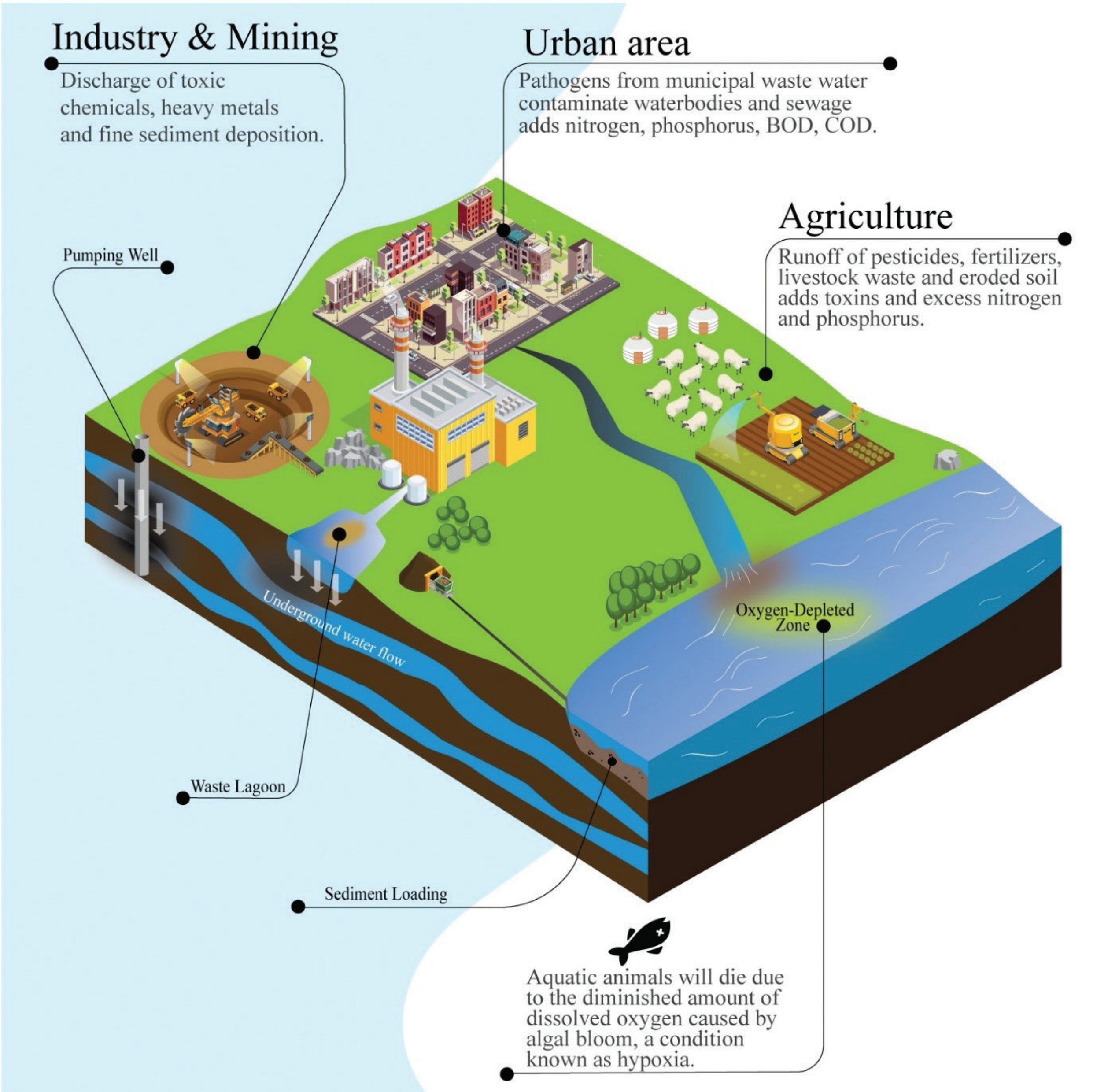


Figure 2. Water pollution source

Water quality monitoring is the continuous and systematic process of evaluating the physical, chemical and biological aspects of water quality to determine if standards are being met [1]. Water quality monitoring usually includes the regular collection of water samples for laboratory analysis and the collection of on-site field measurements at the time of sampling.

The actual collection of information at set locations and at regular intervals provides data which may be used to define current conditions, establish trends, and allow for comparison with water quality standards. The use of monitoring is incorporated in a water quality assessment to determine the condition of the water in relation to set standards, and to define longer term trends and cause-effect relationships which are important for planning water resources management initiatives.

1.3 WATER RESOURCES MANAGEMENT (WRM)

Effective water resources management for Mongolia is required to overcome water related challenges. Water resources can be managed and developed in a sustainable and balanced way with the help of the integrated water resources management approach which considers social, economic, and environmental interests. This method acknowledges the various competing interest groups, such as the sectors that use and abuse water and the needs of the environment.

FACT 3. Water resources management is coordinated across different sectors and interest groups, and at different scales, from local to international by an integrated approach. It emphasizes involvement in national policy and law-making processes, establishing good governance and creating valuable institutional and regulatory arrangements as routes to more equitable and sustainable decisions. A variety of tools, such as economic instruments, information and monitoring systems, social and environmental assessments, support this process [22].

Many completed and on-going water-related projects and programs have been implemented since the Water Resources Management activities started in the 1990s, with aid from NGOs, international organizations, and development agencies from donor countries [23].

The objectives, strategic goals, and required actions are defined by the National Water Program, which was passed by the Mongolian Parliament in May of 2010 (Figure 3). The actions are being implemented in two phases. The first phase was completed in June 2015 and the second phase, in June 2021. In the "Vision-2050" Mongolian long-term development policy documents, the goals are to establish a hierarchical fee system for water resources in 2021-2030; to increase the value of freshwater and protect water resources, strengthen Integrated Water Resources Management (IWRM), increase water accumulation and improve water supply and adequacy in 2031-2040; and ensure that natural and deliberately augmented natural water resources are used efficiently in 2041-2050 [24].

Figure 3. Summary of Integrated Water Resources Management

There are different responsibilities and priorities for WRM for different levels of government (Soum, Aimag, and National). Many ministries and government agencies are involved in the WRM and oversee the water policy and management associated with their division (Table 2).

FACT 4. A thorough understanding of stakeholders is needed for basin management. It should be clear who is involved in making decisions regarding water and land resources management in a basin and who will be influenced by said decisions. Then the methods of achieving the appropriate blend of stakeholders involved at suitable levels can be coordinated [23].

The IWRM implementation unit is a 21-water-basin administration including 29 water basins which were established by the Ministry of Nature, Environment, and Tourism in 2005 (Figure 4).

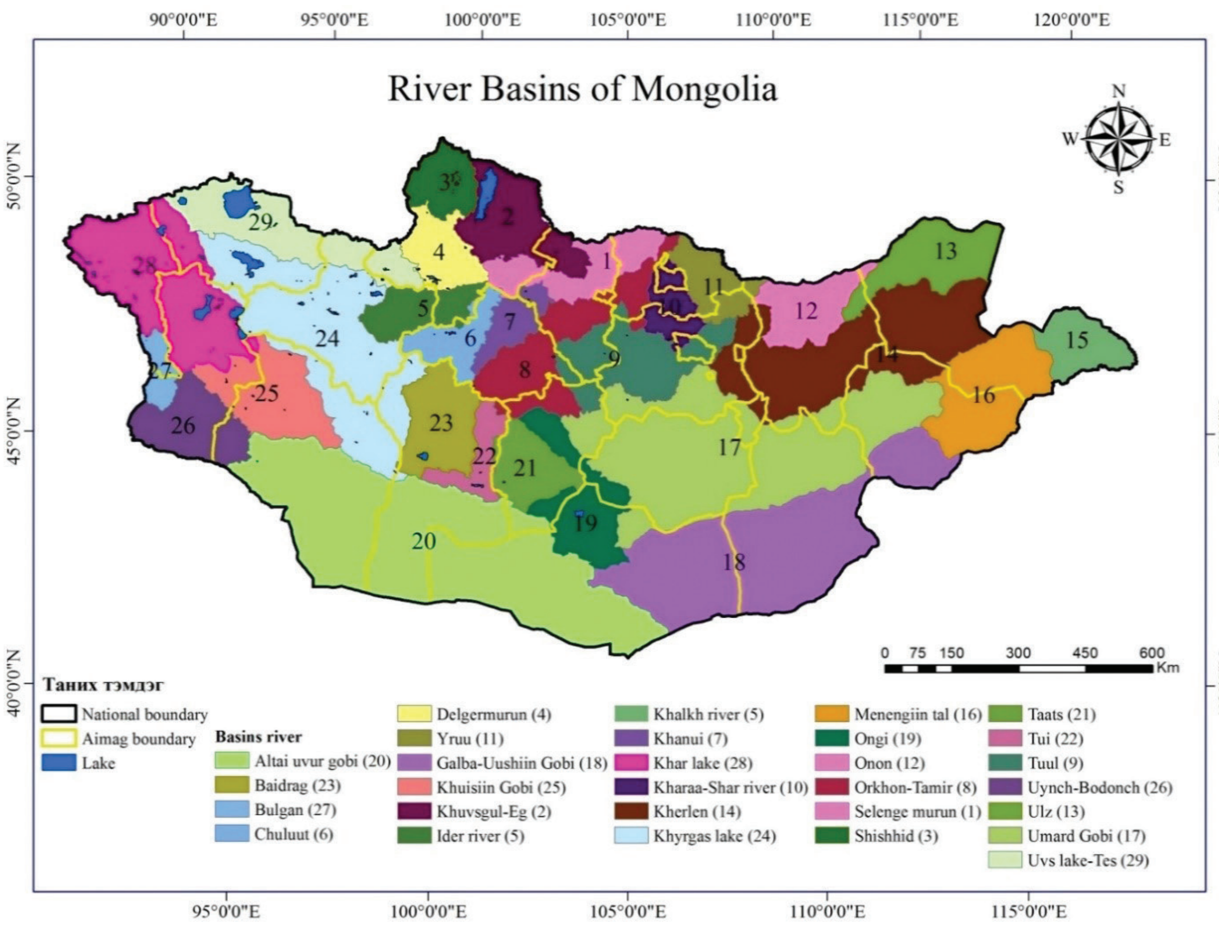


Figure 4. River basins of Mongolia

The progress of IWRM plans for the 29 water basins in Mongolia is directed by the national IWRM Plan. The basin administrations are responsible for local and inter-sector coordination, monitoring, and reporting to keep track of the implementation of the IWRM Plan.

CHAPTER II
ENVIRONMENTAL MANAGEMENT IN MONGOLIA

2.1 OVERVIEW OF LAWS AND REGULATIONS

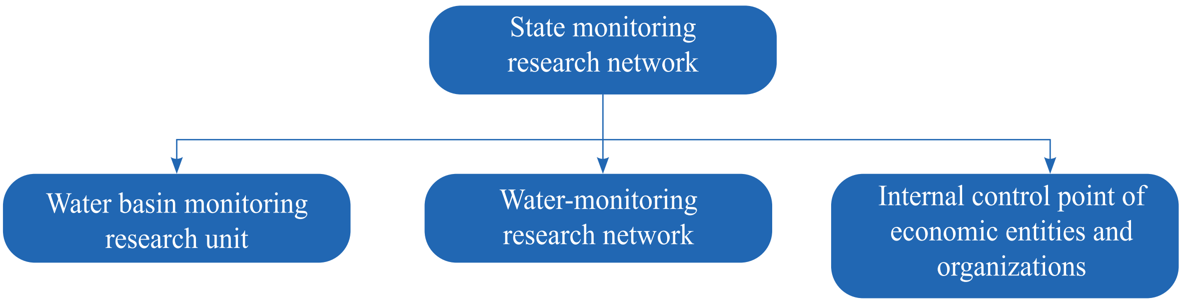
Since the mid -1990s, legal settings have improved substantially and the government issued 30 laws and about 200 legislative acts regulating the protection of the environment and the proper use of natural resources and environmental restoration [25]. In 2012, an overlap of 18 laws on Environmental Protection made amendments to 7 laws, revised 15 laws, and 2 new laws were enacted and approved. Since several minor changes were made. The following laws specifically regulate the effective use, protection and restoration of water resources, water use fees and water supply [26].

The Law of Mongolia on Water (2012) is one of the most important environmental laws in Mongolia and plays an integral role in the mining sector. However, the current legislation is poorly linked to the mining objectives. Five amendments have been made since 2012, including major penalties for violators in 2017, water pollution charges in 2019, and rights of the National Water Council and the State Administrative Central Organization in charge of water issues in 2020. The specific interaction and compatibility should be checked, and special attention must be paid to ambiguous cases.

RELATED ARTICLES OF THE WATER LAW [9]

Article 6. Water monitoring-research network

The State Administrative Central Organization in charge of nature and environment shall establish and maintain a water-monitoring research network. The water-monitoring research network shall consist of the above components of permanent functioning.



Article 21. License for water professional institution

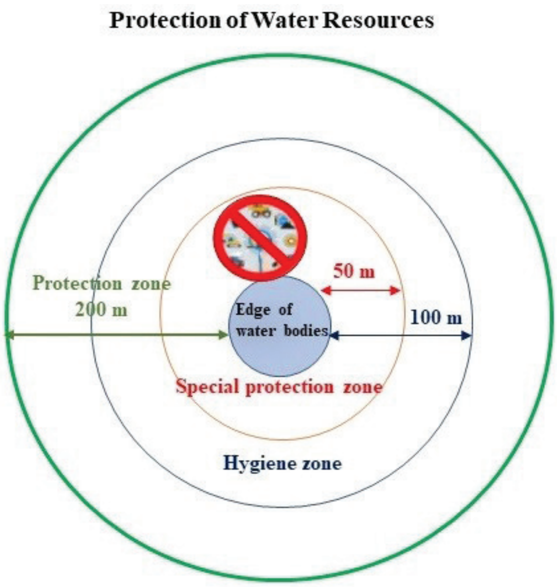
Water professional institutions shall execute water exploration and survey, the drilling of boreholes and the design and construction of water facilities equipped to introduce water efficiency technology, in addition to conduct water analysis and audits. License of professional institutions for water resources exploration and survey shall be issued only to those economic entities with domestic investment. Action guidelines and the role of the water professional institution shall be approved by the Cabinet member in charge of nature and environment.

A license for professional institutions can be:

- Issued by the State Administrative Central Organizations in charge of nature and environment for a period of five years
- Extended every five years if the institution fulfilled its duties properly.

Article 22. Protection of water resources

Special and ordinary protected and hygiene zones at water body areas and water sources will be established in order to protect against water depletion and pollution and to prevent flood and water disasters. In these special protected zones, many types of high risk industrial, agricultural and construction activities will be prohibited.



Article 25. Payment and compensation for water pollution and depletion

25.1. Water contaminator shall be responsible to supervise the volume and composition of wastewater and to remove the wastewater after meeting the standard requirement and to be liable to pay water contamination fee.

25.2. The environment inspector shall impose water pollution compensation on the basis of the conclusion of the accredited laboratory analysis in cases where the water contaminator removes wastewater, but fails to meet the standard requirement and the inspector shall oversee the settlement of payment. The amount of compensation shall be determined by increasing the water pollution fee by two to five times for each pollutant.

25.3. The member of the Government in charge of nature and environment shall approve the model contract specified in Article 17.1.13 of this Law and the procedure for calculating the amount of compensation in increments specified in Article 25.2.

25.4 Compensation for water pollution shall be paid by relevant citizens, business entities and organizations to the Environment and Climate Fund.

25.5. Citizens, business entities and organizations shall pay for water depletion fees in the amount of buildings and paved areas owned and used in cities and settlements.

25.6. The amount of water pollution and depletion fees shall be determined by law.

25.7. The fact that the guilty person has paid the compensation specified in Article 25.2 of this Law shall not serve as a ground to release him/her from liability specified in the Criminal Code or the Law on Violations in accordance with the relevant legislation.

Water utilization: Article 27 and 28. Issuing permission to water users

Permissions for well and hole drilling and digging of channels and canals are issued by the aimag capital city environment authority.

Applications to obtain a permit must include:

- ☐ Purpose and volume of water usage
- ☐ A copy of proof of land ownership, possession and use
- ☐ Information regarding the wells

Citizens, economic entities, and organizations submit their application for a permit → The aimag/capital/city environment authority registers the wells and holes in the water database → The aimag/capital/city environment authority issues well passports

Table 2. Authority for issuing permission to water users

Water use for energy, water transportation and utilization per day	Authority for evaluation and issuance of report	Wastewater discharge/day	Assessment authority	Licensing authority for approval
<50 m^3	Environmental authority of city and provinces	0-50 m^3	Water Basin administration (Water Agency if it contained hazardous pollutants)	Governors of province or the soum
50-100 m^3	Water Basin administration	> 50 m^3	Water Agency	Water Basin administration
100 m^3 <	Water Agency	*Source: Water Law 2012, article# 28.4 Water pollution fee, Article 4.2*		

Citizens, economic entities, and organizations need to submit the water usage request to a legal person, specified in 28.4 of the present law (Table 2). In case of the utilization of water for strategically important mineral deposits, the permit should be valid throughout the duration of the exploitation license.

Documents that need to be annexed to the water usage request:

- [ ] a map indicating the water source to be used and its location
- [ ] exploration and survey reports of water and mineral water resources
- [ ] quality, composition and conclusion on potential usable resources
- [ ] amount of water to be used per day and its purpose
- [ ] drawings and projections of water facilities
- [ ] production capacity, technical and economic indications and
- [ ] environmental impact assessment documents.

Article 31. Water usage fees

Water usage fees

- In the case of water usage exceeding the permit's volume, escalated rates up to 50 % may apply.
- The exact rate will be determined by the state administrative central organization and approved by the government.
- A fee is charged for the use of natural water.

2.2 OVERVIEW OF CURRENT WATER MONITORING PROGRAMS

The Ministry of Nature, Environment and Tourism is in charge of establishing and maintaining a water-monitoring research integrated network, approving the water-monitoring research program and providing professional management as indicated in the article 6.3, Water Law (Figure 5). The National Agency for Meteorology and Environmental Monitoring (NAMEM) is operating as a state environmental monitoring research network, for the purpose of carrying out regular observations, measurements, surveys, and research on water resources, and to provide evaluation of changes in water quality and quantity [9]. There is a Central Laboratory of Environment and Meteorology and a Center for Hydrometeorology and Environmental Monitoring which has local branches in the 21 aimags that act as water basin monitoring research units. Water-monitoring research results and data are deposited to the state water information database [27].

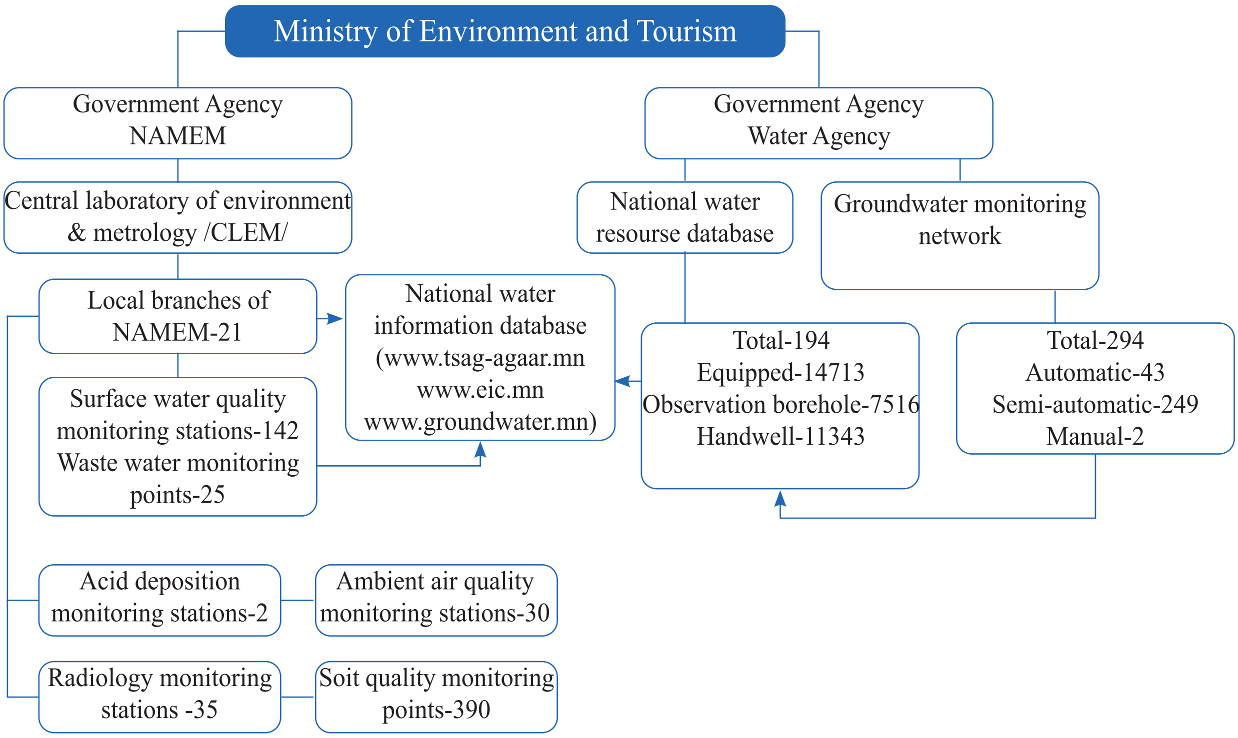


Figure 5. The structure of the water monitoring-research network

The surface water resources of Mongolia are monitored by NAMEM with a surface water monitoring network of 152 permanent gauging stations including 110 rivers and 16 lakes throughout Mongolia (Figure 6). The longest records go back to 1942. Water regime measurements are being recorded from 152 stations and water chemical samples are being taken from all 152 stations on a regular schedule. For biomonitoring, benthic and planktonic samples are taken each month from April to October from 64 of the 152 stations. The integrated groundwater monitoring network is being expanded every year with the state budget and private funds. Currently, 43 fully automatic, 249 semi-automatic, 2 manual, and a total of 294 water monitoring points are connected to a national network to monitor water level and quality [18]. A total of 194 groundwater deposits, 14713 bore wells, 7516 boreholes and 11343 hand wells were recorded in the groundwater database [29]. The state Central Administrative Organization (Water Agency) in charge of water issues shall provide integrated professional and methodological guidance to water users and consumers. It conducts water policy, is in charge of identification and inventory of available water resources for each use in the basin, water use assessment, controlling of the permits, river diversion, flow adjustment and reuse, and writing a statement on the water use project with natural waterways and construction of water facilities [9].

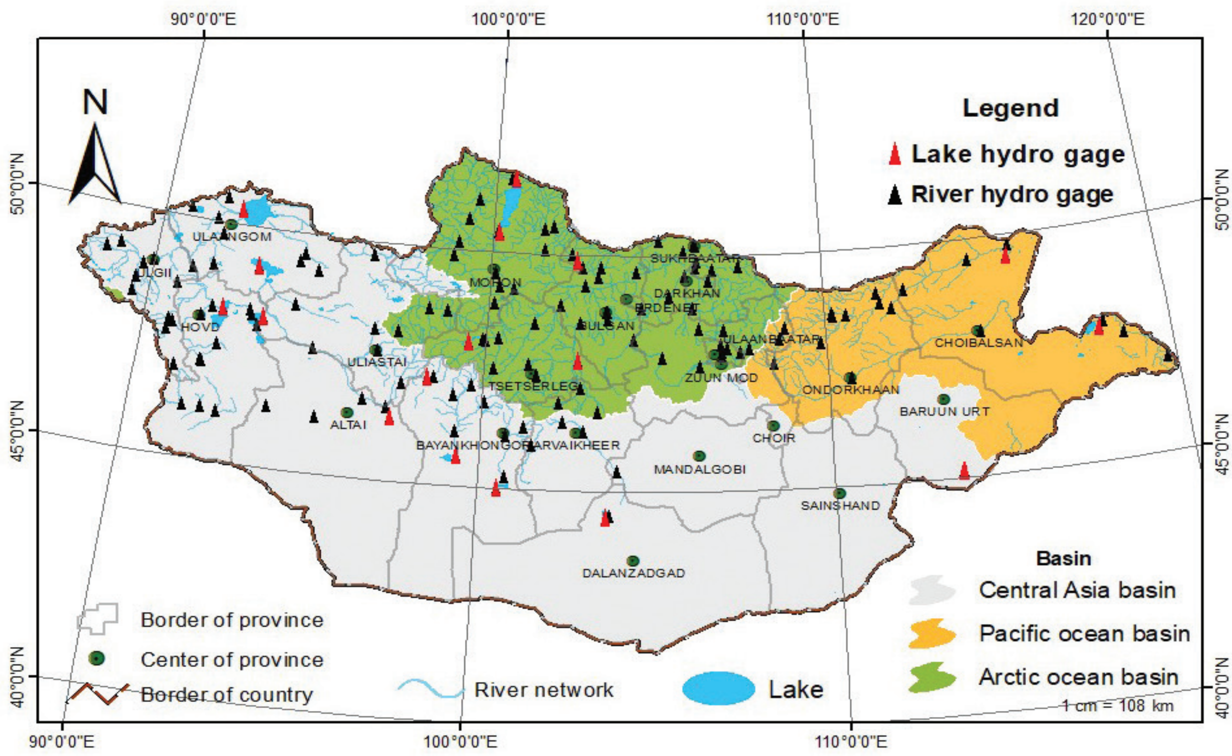


Figure 6. Surface water quality and quantity monitoring stations

Water quality parameters approved by order #A/02 of NAMEM in 2016 (Table 3) are used in a national water-monitoring research network [18].

Table 2. Water quality monitoring parameters of a national water quality program /order #A/02 of NAMEM, 2016/

Type of monitoring	Parameters	Implementation unit/Timeframe
Chemical Monitoring	pH, EC, COD-Mn, suspended solids, DO, BOD5, anion, cation, hardness, trace metals, biogenic elements, pesticides and other organic compounds, surface-active compounds.	Monthly sampling from the 152 stations and sent to local LEM (aimag).
Wastewater monitoring	pH, EC, suspended solids, BOD5, trace metals, NH4, NO2, NO3, PO4, surface-active compounds and total bacteria.	Ulaanbaatar-4, and wastewater monitoring 2 points in each aimag. Monthly sampling sent to local LEM (aimag).
Hydrological monitoring	Water level, discharge, water and air temperature, depth, velocity, cross-sectional area m2, ice phenomenon, ice snow depth, turbidity, discharge of suspended solids, evaporation, spring yield, flood estimate, water catchment area, slope degree.	Monthly samplings are taken every possible month (January-December) at 152 hydrological gauging stations. Local hydrological observer records raw parameters and sends to local LEM (aimag).
Biological monitoring	Benthic and plankton macro invertebrate diversity, and abundance, total number of bacteria, coli-titer, fecal coliform	Monthly sampling from April to October at 64 of the 12 stations and macroinvertebrate samples sent to the hydro-biological laboratory at IRIMHE. Surface water samples are sent to CLEM and drinking water samples are taken by GASI for bacteriological analysis.

CHAPTER III
WATER RESOURCES MONITORING FOR THE MINING SECTOR

3.1 MAIN WATER RESOURCES ISSUES IN MINING

The availability of adequate water resources is essential to support economic activities by providing the quantity and quality of water required to facilitate these activities [19]. The mining industry needs water for its industrial operations and settlements around the industry need to be provided with water for domestic purposes. Adequate water resources may be available in the immediate area of a mine or it may be necessary to transport water over long distances, e.g. to the Gobi. Mining, due to the size and nature of its operations, has the potential to severely impact its surroundings in more than one way. Procedures should be in place to ensure that the environmental impacts of the mining operations comply with water quality and ecological standards for surface water and groundwater.

Each type of mining (coal, placer, and metal hard rock) will pass through the four life stages: Exploration & Feasibility; Planning and Construction; Operations; and Closure (Figure 7). Water resources issues are relevant at all four life stages, and depending on the geographic location, water source availability, the methods of processing the natural resources (coal and minerals), etc., there will be different water resources management challenges at these stages. However, if water reserves are further from the mining area and the adequacy of the supply is questionable, then the risks of water shortages and environmental impacts are higher and there may be a need for more careful planning and possibly additional investment in infrastructure will be required. A decision should be made to conduct measurement at monitoring boreholes of the aquifer regime based on established procedures, and to deliver outcome reports of monitoring research work to the Water Authority and Environmental Department of the aimag each year.

In the operations phase, the greatest risks to water resources are when the highest demand is put on water usage and when resource extraction and processing pose the highest risks. If the mine has built its own treatment system for recycling the water, water usage will be better controlled and if water shortages are anticipated, more technical advantages will be required to compensate for the risks to mining operations from such shortages.

In the closure stage, the main problem is the tailing dams and wastewater treatment in all three types of mining. Therefore, it is important to ensure that ongoing changes in mining operations during the operational phase do not interfere with closure and reclamation plans.

Figure 7. Three types of mining and water resources issues

3.1.1 MINE WATER FOOTPRINT

The footprint of the mine is the core area of the mining operation where there is resource extraction activity and all the infrastructure required for mine operations [30]. Mining activity always has some level of impact on water resources and always poses some level of risks. Impacts and risks are greatest inside the mine footprint but are also relevant to the surrounding and downstream areas. Furthermore, hydro-chemical reactions and the use of water for operational processes can change chemical characteristics of water [30].

- The mine footprint should be limited to what is needed for efficient operations.
- Minimize ground disturbance when possible.
- Protect natural water bodies and sensitive areas with protective buffer zones of undisturbed natural vegetation.
- Ensure good site drainage to keep “clean” water away from mine footprint and to contain all on-site drainage within the mine footprint.
- Plan for changing operational requirements over the life of the mine.
- Ensure there is adequate suitable space to efficiently handle and store waste rock and process tailings.
- Careful location of high-risk activities.
- Plan to keep pollution impacts confined to the mine footprint and prevent off site and downstream migration.

FACT 5. Water footprint is the volume of fresh water used to produce a product summed over the various steps of the supply chain. Water footprint analysis goes on to quantify the volume of water required to produce a set amount of product (e.g. treatment of 1 ton of Cu and Au ore requires, 1050, 1250 liters of water, respectively), considers the type of water (green, blue, and gray) used and when and where the water is used. The green (rain) water includes impounded runoff water incorporated into the process, and the amount evaporated. The blue water (river, lake, underground) includes water incorporated to the process, the evaporated volume, and the volume diverted to another catchment area. The gray water (volume of polluted water) includes treated water recycled back into the production process, the evaporated volume, and treated water (site drainage water and treated effluents) released into natural water bodies [30].

Water use includes water supply for drinking water/sanitation for camp/office facilities and industrial water supply for mining and processing operations. There are significant impacts on the natural hydrological conditions inside the active footprint of a mine. *Figure 8* uses the example of a typical copper mine to outline the key components of the mine operations and how water resources are managed to improve efficiency, minimize pollution impacts, and accommodate other water uses in the surrounding area.

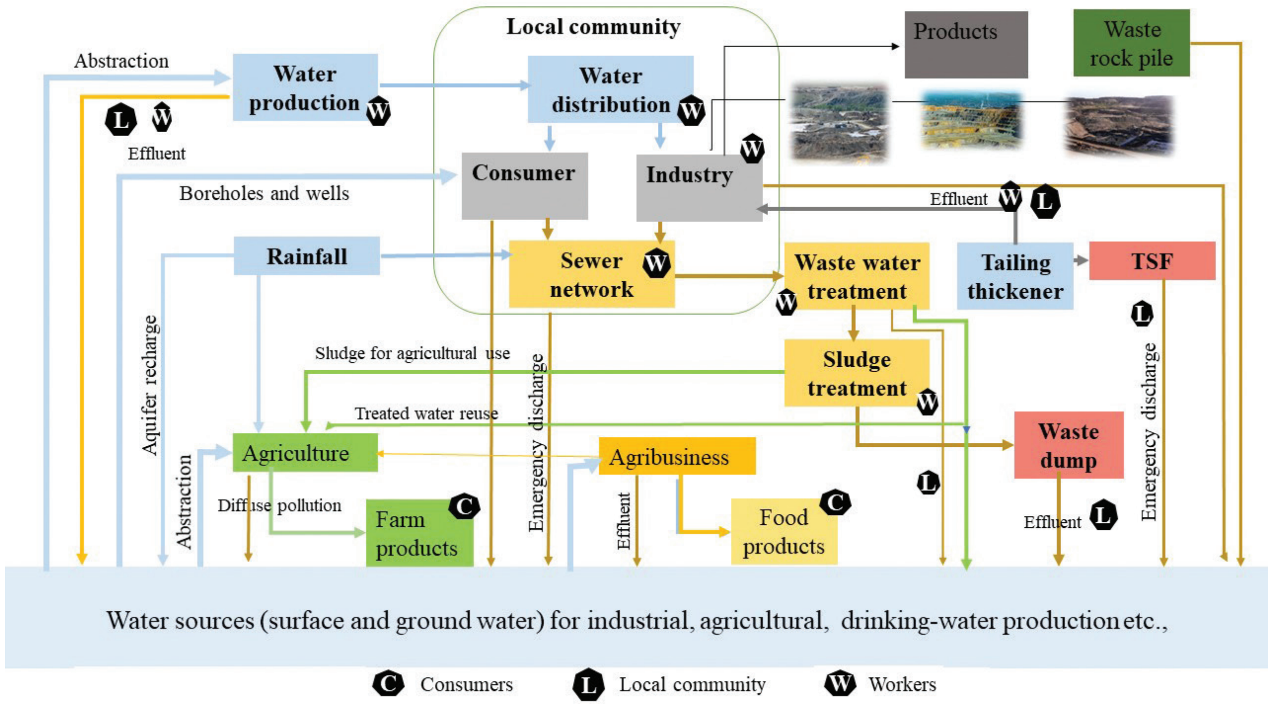


Figure 8. Flow diagram and footprint of water distribution system of mining area [38]

3.1.2 SITE DRAINAGE AND DEWATERING

Site drainage and dewatering operations can have a significant impact on natural hydrological conditions in the mine footprint and the surrounding area. Large volumes of water can be affected by sedimentation or impacted by other contaminants from the mine footprint. Water directed to settling ponds can have significant evaporation losses. Contaminated drainage waters can migrate off the mine footprint through surface or groundwater pathways.

Perimeter ditching around the mine footprint should direct "clean" water away from active mine areas.

Water from onsite drainage from within the mine footprint should be directed to settling ponds.

Water recycling programs reduce demand on water supply systems and reduce the net output of wastewater.

Mine operations should implement water recycling when possible:

- Water pumped by dewatering systems can be recycled for water supply.
- Water from onsite ditch drainage can be directed to settling ponds and recycled.
- Water used in various stages of mining and/or ore processing can be recovered and recycled back into the mining system after appropriate treatment.

Good site drainage keeps work areas relatively dry and stable during times of precipitation. High risk activities such as hazardous materials, fuels and solid wastes storage, storage lagoons for liquid wastes, etc. should be located well away from natural water bodies and sensitive areas. They are best located on level land with adequate room for good maintenance and operations practices, and room to intervene effectively in the event of leaks or spills. Mines should follow the main guidance listed below and should apply appropriate treatment technologies from those listed in Figure 18.

- Operational drainage plan for the mine to separate clean and affected water:
  Capture and divert surface water channels around the mine footprint before entrance to the mine, and capture and store surface run-off occurring within the mine footprint.
- Treatment of captured runoff before release to environment.
- Recycling opportunities to reduce use of fresh make-up water.
- Implementation of a Hazardous Material Management Plan.

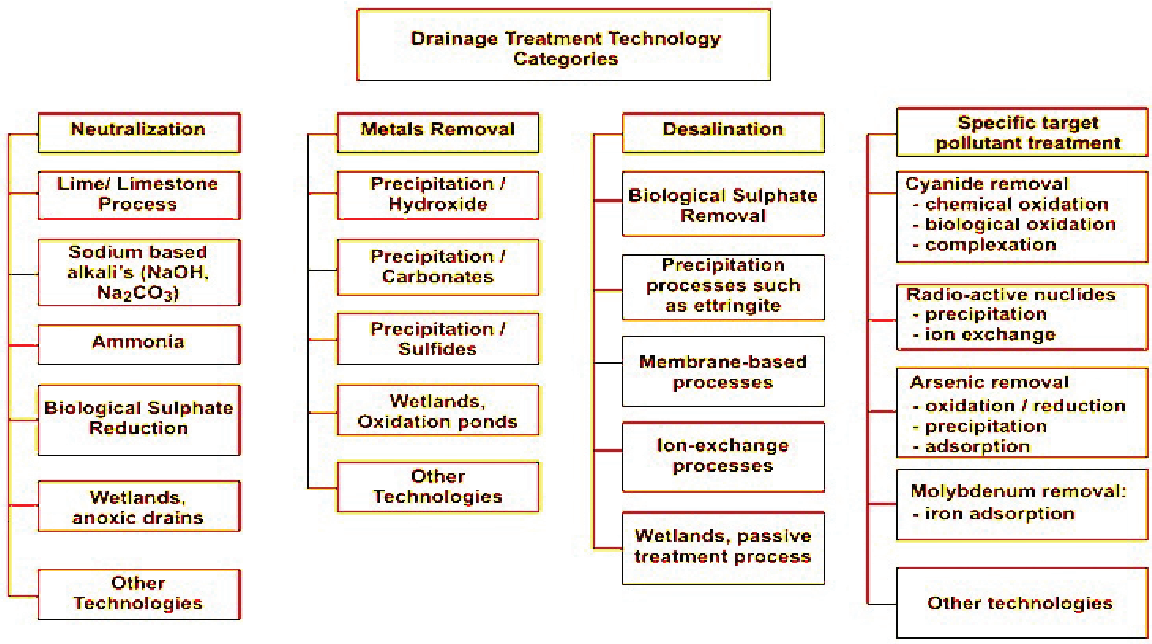


Figure 9. Drainage treatment technology categories [32]

3.1.3 INSPECTION CHECKLIST FOR POTENTIAL WATER RESOURCES ISSUES

- ☐ Inspect and assess the security of the potable water supply to determine if the supply has adequate volumes and quality of water for current and future use.

Securing good quality potable water for mine offices and camps can be challenging and costly. Water supplies can be depleted or be subject to water quality issues.

- ☐ Inspect and access the security of industrial water supplies to determine if there is adequate water for current and future use and if there are risks of shortage that might affect the mine operations or other users in the surrounding area.

  Mine operations require secure, long-term industrial water supply. Water demand for some mining operations is extremely high and can challenge the sustainable use of surface or groundwater supplies, particularly in areas subject to prolonged droughts. Water shortages or significant water quality problems can impact the financial viability of the mining operation. Regional water shortage issues can be further aggravated by mining operations and other water users can be negatively impacted.

- ☐ Assess the level of ongoing ground disturbance and erosion within the mine footprint and determine if there are any issues with excessive erosion and/or sedimentation.

  Due to the removal of vegetative cover and significant ground disturbance at mine sites, erosion and sedimentation are common during precipitation events or when water is pumped and diverted over soils and surficial materials.

- ☐ Inspect mine operations and infrastructure to identify issues or problems related to water resources.

  For example: inspect and identify leaking pipes, process plants, tailings ponds or treatment lagoons; identify uncontrolled acid mine drainage; and inspect to identify accidental leaks/spills of hazardous materials or waste which may be the source of pollution of the surface and groundwater within the mine footprint.

- ☐ Inspect and identify any surface water and groundwater pollution impacts that migrate outside the mine footprint.

- ☐ Inspect the operational efficiency of any treatment plant.

  Outputs of treatment plant effluent, even when fully compliant. are a source of low-level pollution which can be more significant during low flow and drought. Treatment plants can break down or have operational issues which affect operational efficiency. Complex operating systems for effluent and wastewater treatment can experience structural, mechanical, or operational problems causing the release of untreated or partially treated water to the environment. Engineered infrastructure and operating systems do not work 100 % efficient 100 % of the time.

- ☐ Extreme weather events and natural disasters can pose significant challenges for maintaining normal environmental management performance at mines. A detailed inspection should be carried out after all extreme weather events to assess the impacts of the event and identify any damage or problems related to the event.

- ☐ Inspect any water resources related records that a mining company is required to maintain on an ongoing basis as part of its Environmental Management Plan.

  Such as records of volumes of water pumped for dewatering, volumes of water extracted from water supply systems, volumes of wastewater being treated and discharged, base flow in any surface water body receiving discharge effluents, or any relevant aspect of water use or management which requires regular record keeping.

3.2 MINING WATER RESOURCES MANAGEMENT

In the field of water resources management, the mining sector is a vital stakeholder. The immediate availability of water supply is crucial to numerous activities in mining. Aquifers in close range of the mine can be seriously affected by the dewatering of open pits and underground mines. In the future, water demand from mining activities is expected to rise remarkably [15,16, 24]. In mining operations, water use is extremely inefficient, and water reuse is not adequately developed.

Mining activity can cause surface water or groundwater to become polluted. There will inevitably be some level of pollution and risks to water resources, even with the implementation of the best management practices. The deviation and rerouting of natural surface water drainage patterns can be necessary for mining activity. In many cases, wastewater is discharged without treatment [3,6]. An essential element of mining operations for decreasing the impact on water balances and quality for both surface and groundwater resources responsibly is good management practices. Throughout the life cycle and post-closure of a mine on both a local and regional scale, these practices are to be implemented. Water monitoring is included in the negotiations with authorities for a mining permit, and it is a legal requirement.

The first stage of the mining assessment and monitoring is focused on the initial, unmodified state of the water bodies by measuring surface and groundwater levels, flow rates, seasonal variations, and completing a full quantitative analysis of water quality. Also, all anticipated environmental impacts and risks should be identified (Figure 10).

In the operational stage, implementation of water level and water quality monitoring programs are required for surface water and groundwater through continuous sampling and analysis aimed at detecting possible changes in the water quality. It is also important to monitor treated water quality before releasing to receiving water. Continuous measurements of ground- and surface water levels and water quality are necessary for monitoring after mining ends and during the reclamation process.

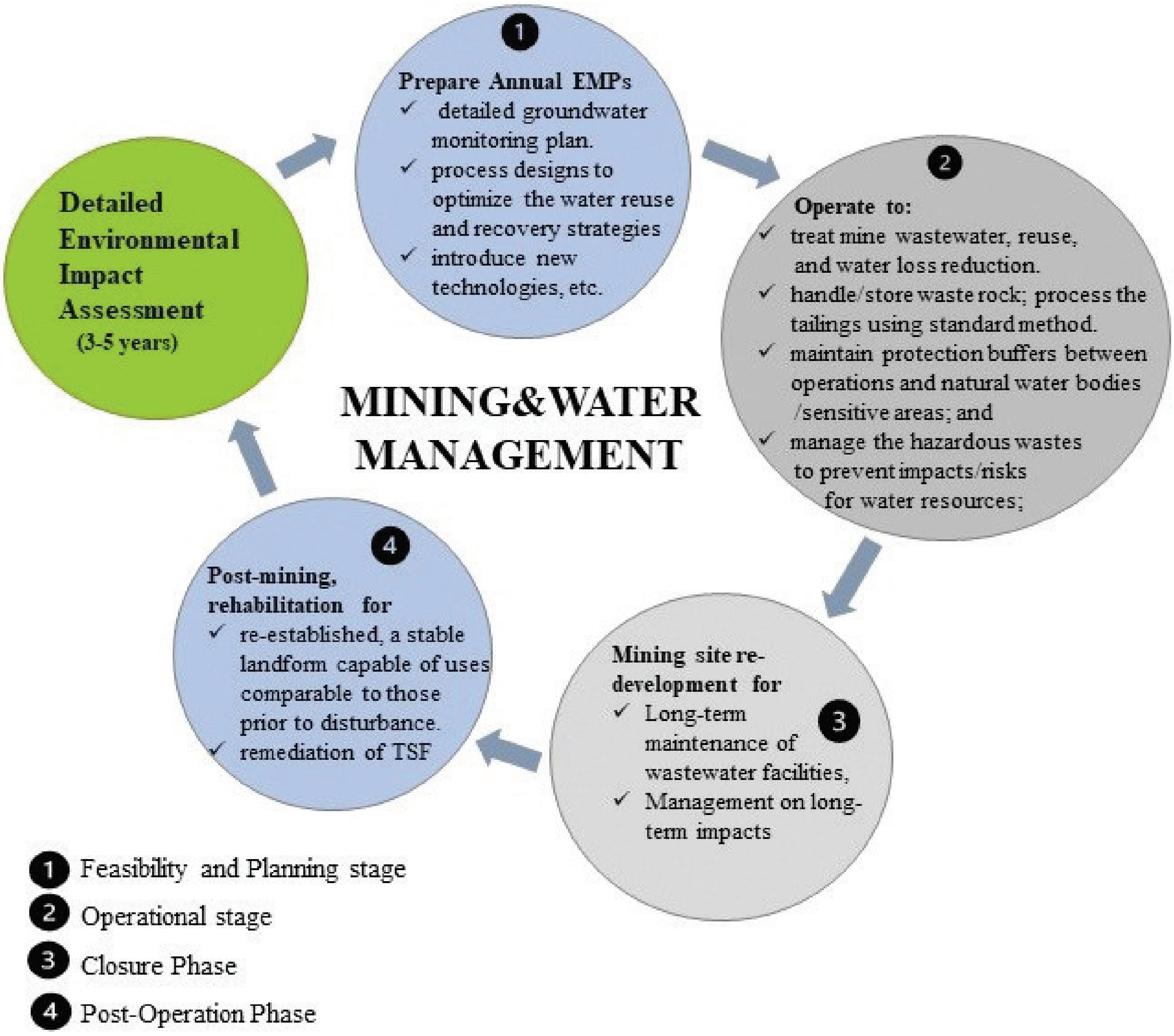


Figure 10. Mining&water management in four stages of mining

3.2.1 ROLE OF ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLANS

Environmental Impact Assessments (EIA) have two roles; legal, which is to ensure that development projects (mining) have minimal impact on the environment during their entire lifecycle; and educational, as it is equally important to educate everyone involved - both those professionally involved in the management of the project (mining staff members and various government officials, and staff tasked with regulating the project), as well as residents in the immediate area, and other land and water users in the surrounding area.

01
Environmental impacts and risks are minimized through careful planning and good environmental management practices.

02
Mines are subject to a detailed Environmental Impact Assessment (EIA) process prior to the construction of the mine.

03
Operating mines must develop and implement annual Environmental Management Plans (EMPs).

04
Individual permits or licenses may be required for certain key components of mine operations (water use, waste management, water treatment, hazardous materials and fuel storage).

An Environmental Impact Assessment (EIA) must be completed at the planning phase for all mines. EIAs include:

- Mines must develop annual Environmental Management Plans(EMP) for each year of operation.
- EMPs identify all environmental management initiatives related to mining operations including those focused on the protection of water resources.
- EMPS outline all planned monitoring programs including those for surface and groundwater.
- EMPs must be updated annually to adapt to operational changes at the mine as it progresses through the operational phase.

Environmental Management Plans (EMPs) are detailed plans outlining all initiatives aimed at controlling and reducing the impacts and risks defined in the environmental assessment process.

The EMPs outline the operational details of normal ongoing environmental management work as well as upgrades and improvements to environmental management infrastructure required to support ongoing and future operations.

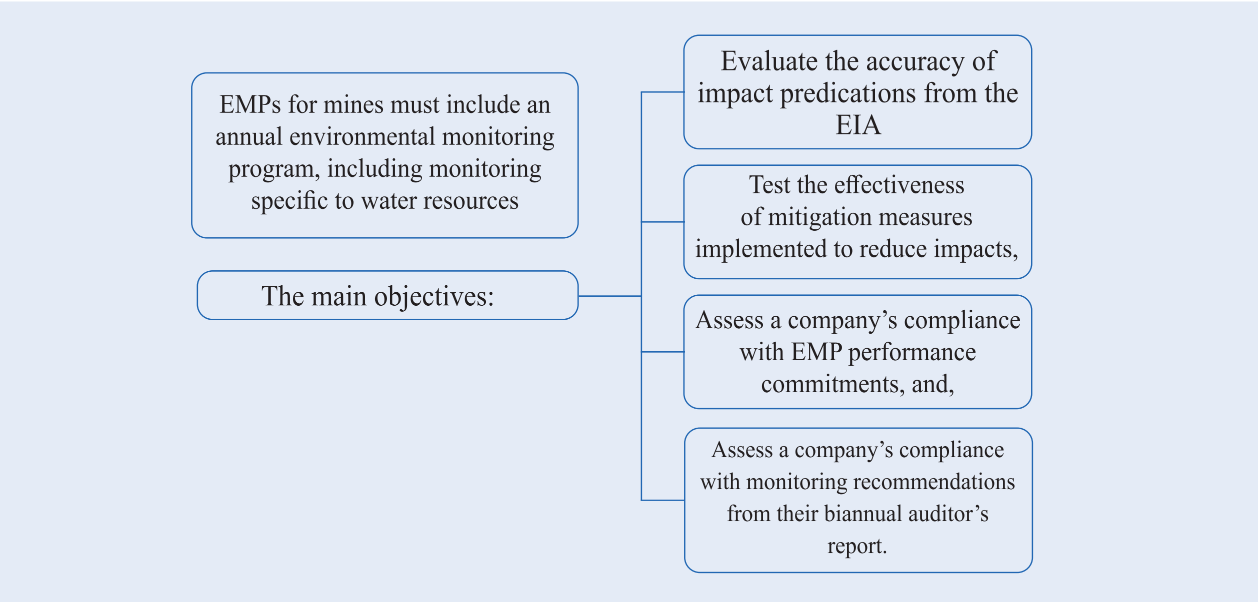
EMPs cover all aspects of water resources management such as water use, water recycling, wastewater treatment and pollution control measures aimed at protecting water quality.

EMPs outline hydrological and water quality monitoring programs for water use, drinking and industrial water quality, effectiveness of treatment processes, and pollution impacts to surface and groundwater, etc.

Over the life of the operational mine, on-site activities evolve and change as new extraction areas are developed and mine infrastructure is modified to meet changing operational needs. EMPs are updated annually to address ongoing changes in mining operations. Implementation of EMPs is normally supported through dedicated annual budgets.

3.2.2 CHECKING ENVIRONMENTAL MANAGEMENT DOCUMENTS

All mining companies follow a general water management plan, but not all companies focus significant attention to water resources management activities for both surface water and groundwater, covering issues such as: sustainable industrial water supply; safety of drinking water supply; site drainage/dewatering and containment of impacted waters; treatment and recycling of water to reduce demand and wastewater output; efficient operation of water treatment systems ranging from simple settling ponds through to advanced water treatment plant; operation of interception ditches to contain leachate from waste materials or tailings; maintaining protection buffers or separation distances between operations and natural water bodies or sensitive areas; water level/flow and water quality monitoring programs for surface water and groundwater; management of hazardous materials, fuels, and waste material to prevent impacts/risks to water resources; and monitoring of treated water quality before release to receiving water.



Not all mines have the same issues and challenges regarding water resources management. Therefore, the significance of any of the above identified issues will vary between mines depending on the type of mining and processing involved, and the specific site conditions where the mine is located. Environmental inspectors and other government staff responsible for regulating mines should be very familiar with the infrastructure and detailed operational procedures for each of the mines they are responsible for and should keep up to date as the mine's operations evolve over its operating life. These inspectors and staff should pay particular attention to the details of EMPs as they are updated annually.

3.3 WATER QUALITY AND QUANTITY MONITORING PROGRAMS

The design and implementation of water quality and quantity monitoring programs is a key component of environmental management of water resources for the mining sector.

Water quality monitoring programs for mines should specify:

- sample locations in surface water bodies or groundwater monitoring wells,
- sampling frequency including the timing of regular samples and the need for extreme event or special samples (for example during peak flows or drought),
- parameters of concern, routine sampling parameters and special samples,
- the laboratory doing the analysis and the testing methods to be used, the type of "in situ" field measurements that will be made,
- the responsible person and the budget available, and the reporting method for the data collected and
- key performance indicators (KPIs) - Each different type of mining has its own KPIs which are based on the processing, treatment types and chemicals used, and these KPIs should be included in the parameters of concern.

Water quality and water quantity monitoring programs within the mine footprint are very important tools which allow for the evaluation of environmental management performance of specific mining projects (projects with environmental assessment). These monitoring programs evaluate the accuracy of impact predictions, test the effectiveness of mitigation measures implemented by the project, and assess performance in meeting the requirements of the mine's Environmental Management Plan and auditor's reports. Data from monitoring programs should be reviewed carefully and analyzed overtime to track changes which may indicate the need for additional environmental management initiatives.

3.3.1 BASELINE WATER QUALITY DATA AND PARAMETERS TO BE MEASURED

Water quality analysis carried out for mining operations generally encompass three main geochemical groupings: comprehensive analysis; heavy metal ion analysis; and chemical analysis based on the metal processing [17].

Prior to mine development, baseline water quality samples should be collected using the checklist below.

- ☐ Upstream and downstream of the mine footprint to characterize background water chemistry. Surface water sampling sites should provide representative samples of standing water or flowing water.
- ☐ Sample significant surface water bodies and groundwater monitoring wells are drilled at various appropriate locations around the mine footprint and must be drilled to depths required to access water under variable water table and aquifer conditions
- ☐ Baseline monitoring sites established prior to mine development can be maintained during the active mining phase.
- ☐ During active mining, baseline surface water and groundwater sampling sites should be

established at locations upstream/upgradient from potential impacts from mining activity (see the location from the Figure 8 and Figure 11) as well as within the mine footprint where some impacts are anticipated. Consider sampling sites such as:

  - o upstream of the mine workings,
  - o along the process stream including supernatant water from the Tailings Storage Facility (TSF),
  - o downstream of each of the mine facilities (WRSF, TSF, plant, etc.),
  - o collection ponds around the mine footprint,
  - o at the compliance point at the margins of the mine claim, and
  - o within the receiving environment.

- ☐ Water quality networks at mines usually combine surface water sampling sites and groundwater monitoring wells.
  - o Groundwater monitoring wells are installed upstream of impacted areas to collect baseline water quality samples of "clean" water.
  - o Groundwater monitoring wells are installed in areas where the risk of impacts to groundwater quality are anticipated such as: downgradient from active mining areas, tailings and waste rock storage facilities, ore processing facilities and waste treatment plants or lagoons. Wells should also be installed in areas where offsite migration of contaminated water is anticipated.
  - o Groundwater wells which are installed for dewatering operations can also be used for the collection of water quality samples.
  - o Additional groundwater monitoring wells may need to be established during mining operations to determine the extent of aquifer contamination and the direction and rate of contaminant migration.
- ☐ Water quality from baseline sites is used to establish a benchmark for making comparisons with water quality data at impacted sampling sites.

Water quality monitoring includes: the collection of samples of water to be analyzed at a laboratory and the use of handheld water quality monitoring probes and instruments to make field measurements.

Hydrological measurements at mines

- Mines should log all water use and keep daily records of pumping and recycling.
- Volumes of process water used at various locations in the mine should be logged as well as the volume of effluent output from all processing and treatment systems.
- Flow measurements in adjacent streams and rivers should be measured under various hydrological conditions and it is important to ensure that minimum base flows are maintained for discharging effluents (5 X rule).
- Elevation of the water table in monitoring wells should be measured regularly to track changes in aquifers and to determine if groundwater resources are being depleted.

CHAPTER IV
ON-SITE MONITORING AND RISK ASSESSMENT OF WATER QUALITY AND QUANTITY

Fieldwork is practical work conducted by a researcher in the natural environment, rather than in a laboratory or office. Good fieldwork requires the standardization of both field procedures and the documentation of data collected in the field. Standardized fieldwork procedures are often documented in field manuals or procedures and policy manuals.

The use of standard field sheets or field records helps to ensure that data is collected consistently and in a format which can be readily entered into databases or other information management systems (see Annex 2).

The main goal of field work is the collection of information (data) which can be stored and analyzed.

- Fieldwork often involves repeat visits to regular sites to monitor and evaluate changes over time.
- Fieldwork can also be used to share information between stakeholders and to promote the interests and goals of the organization doing the field work.

WRM Fieldwork in Relation to Mines

- Collection of baseline hydrological and water quality data prior to mine development.
- Collection of data to assess the viability of mine operations and to predict potential impacts on the water resources of the area from the mining activity.
- Ongoing hydrological and water quality monitoring during the active mining phase to determine the level of impacts and the effectiveness of mitigation measures.
- Compliance monitoring to inspect operations and maintenance activity and identify issues and problems in relation to specific permits, licenses or operations in general.
- Careful planning of fieldwork is important to ensure that the time in the field is utilized efficiently and effectively and that the data collected meets the intended requirements. When planning a field trip, there are several factors to consider.

Mapping and Georeferenced Data

Locations of significant observations can be indicated on working maps while in the field and the locations of photos taken or samples collected can also be noted on the working map. When conducting field work at new locations, it is important to collect the location information (latitude and longitude) of significant observations, photos taken, samples collected, etc. Location data can be determined using a handheld GPS or a GPS App on a smartphone.

Access to up-to-date mapping resources combined with good map reading skills is a strong asset for anyone working in the field. Satellite imagery such as google earth can be a very useful tool for field work and sections of imagery can be printed off when planning and taken along as reference material. When taking photos, it is important to record the exact location the photo was taken at, as well as the approximate direction which the photo points toward. The direction can be estimated to the nearest 45 degrees, so; north, north-east, east, south-east, south, south-west, west or north-west. With the exact coordinates and approximate direction any field worker should be able to visit a site and take a picture which can be compared with previous pictures.

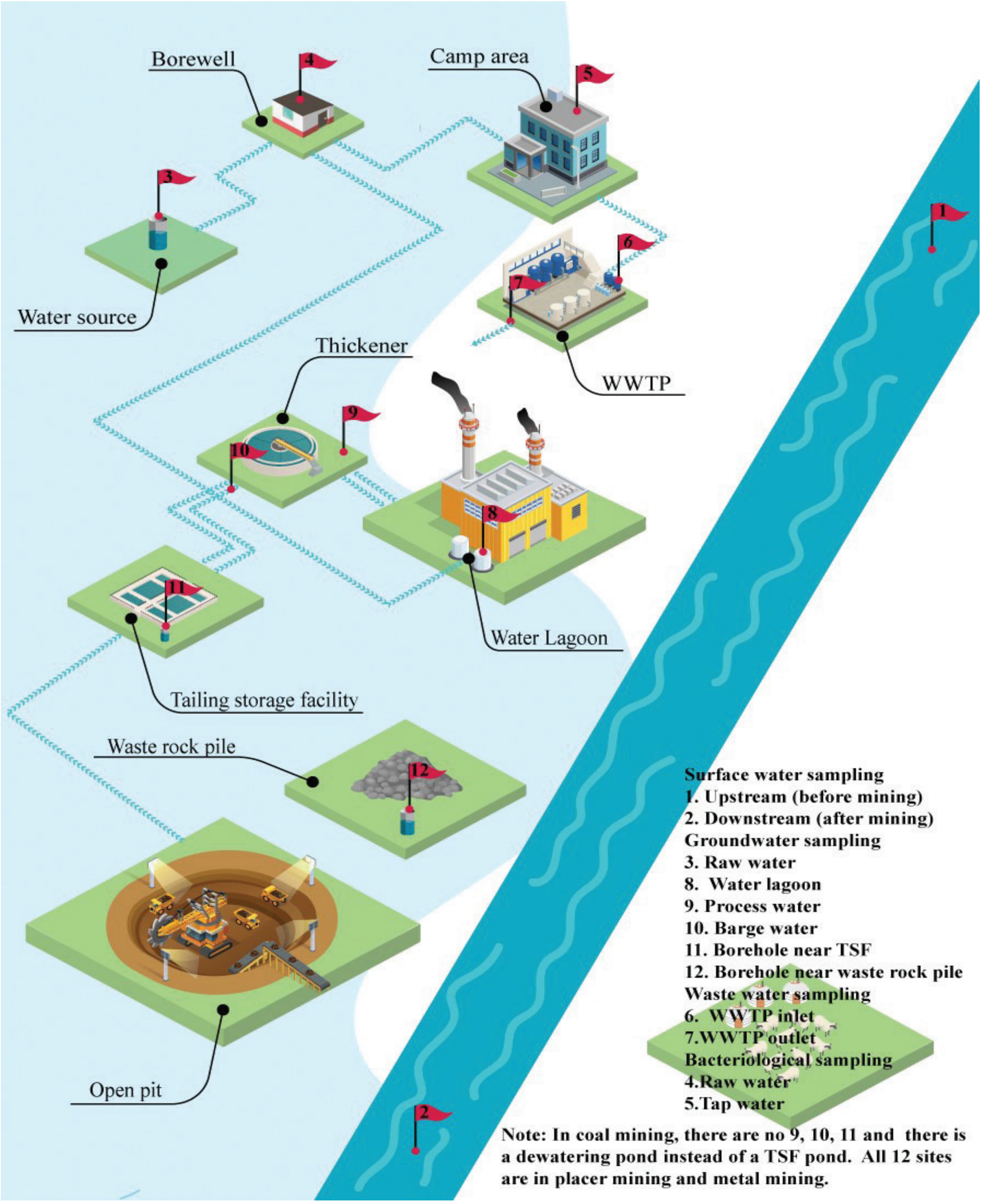


Figure 11. Mining water sampling sites/facilities

4.1 MONITORING OF GROUNDWATER QUANTITY AND QUALITY

4.1.1 INSPECTION OBJECTIVE:

Inspection of whether there is an impact of the mining operations on groundwater quality and quantity to determine if the operation is compliant with the EMP and all relevant regulatory requirements related to groundwater.

4.1.2 SUMMARY OUTLINE

Groundwater quality and quantity issues

1. Over consumption (indicated by water usage license) of the groundwater can cause further regional water shortages and other water users can be negatively impacted.
2. Typical mines include large-scale surface facilities such as: open pits, spoil piles, coal stockpiles, waste rock piles, wash plants and coal fines ponds, processing plants and tailings storage facilities (TSF), which all have the potential to impact surface water runoff causing subsequent groundwater quality problems.
3. Issues with the structural integrity of dams, reservoirs, tailings storage areas, acid rock storage facilities, etc., can lead to leaks and uncontrolled migration of contaminated water.
4. Chemical weathering of waste rock in the pit walls, waste rock facilities and tailings can lead to Acid Rock Drainage (ARD) and leaching of metals and other elements which can be released to the groundwater.
5. Scaling of the pipes.
6. Biological fouling of pipes and corrosion of mine infrastructure.

Measurable parameter

1. Water level of boreholes and borewells
2. Water meter (rate-of-flow and volume)
3. Acidic Drainage (pH, SO_4^{2-}) and Metals Leaching (trace metals)
4. Alkaline Effluents (pH)
5. Mineralization
6. Cyanide
7. Ammonia
8. Suspended Solids and TSS
9. Thiosalts
10. Base metals which are targeted for mining
11. Polyaromatic hydrocarbons (PAHs).
12. Corrosion (mpy)
13. Scaling potential
14. Biofouling (bacteria amount)

Field measurement technique & data review: water quality

1. Collect water samples at designated sampling points (groundwater monitoring wells, dewatering wells, water supply wells etc.).
2. Record field measurements of pH, SS, TDS, REDOX, T°C, turbidity, or other significant parameters at designated points.

3. Meet with responsible staff from the environmental department of the mine to review laboratory test results of anion, cation, metals, and PAHs etc. from recent samples collected by both government inspectors and the mining company.

Sampling location of the facilities

Details of the groundwater sampling and measurement programs carried out by mining companies are normally outlined in the annual Environmental Management Plan for the mine. Possible sampling sites can be at the lagoon (source water), process water (related to main mining processes; issue#5-7), barge water (recycling wastewater from mining operation), TSF (wastewater in pond including dewatered water from ground), borehole near the TSF (issue#2 and 3), and borehole near the waste rock pile (issue#3 and 4), (see in Figure 11: 3,8,9, 10, 11, and 12)

1. Groundwater monitoring wells are drilled at various locations around the mine footprint and must be drilled to depths required to access water under variable water table and aquifer conditions. For example: groundwater monitoring wells are installed upstream of impacted areas to collect baseline water quality samples of "clean" water. (Reference site)
2. Groundwater monitoring wells are installed in areas where the risk of impacts to groundwater quality are anticipated, such as: downgradient from active mining areas, tailings and waste rock storage facilities, ore processing facilities and waste treatment plants or lagoons.
3. Sampling wells should represent the point of interest in issues and the diameter of the well tube should be adequate to take samples.

Sampling frequency

Taken during scheduled and unscheduled inspections.

Performance criteria

Compliance with commitments in

1. MNS 4943-2015 effluent treated wastewater. (max. content of polluting substances in the wastewater released to open nature/monitoring requirements/during operation (Table 25).
2. MNS 4586:1998 Water quality parameter. General requirement
3. MNS (ISO) 5667-11:2000 Water quality. Sampling. Part 11. Guidance on groundwater sampling and wastewater and water treatment facility sludge sampling procedure
4. Mine Environmental management plan of the year: water quality monitoring plan
5. Lab analyzes results of the previous year and pre-mining reference data.

4.1.3 ASSESSMENT OF GROUNDWATER POLLUTION

The evaluation of groundwater quality and quantity is based on the results of measurements and analyzed samples from existing boreholes in the vicinity of potential pollution sources. Analyzed samples assess the level of pollutants in groundwater within the mine footprint. Repeated sampling at the same sites over time shows changes in pollution levels over the life of the mine. Also, as the mine operations evolve over time, the addition of new groundwater monitoring wells helps define any changes in the area or zones of groundwater pollution, and the risk of offsite migration of polluted groundwater.

4.1.4 LIST OF REQUIRED EQUIPMENT AND TOOLS

Water bottle /Nalgene/

Бэйлер /Bailer

1. 1L Nalgene bottle
2. Bailer
3. Preservation reagents if necessary
4. Permanent pen
5. Coolers and Icepacks
6. Custody chain sheets with pad (Table 7).

4.1.5 FIELD GUIDE FOR GROUNDWATER SAMPLING

The collection of groundwater samples by inspectors allows for the independent assessment of any pollution impacts on groundwater, which can be used to verify results from samples collected by the mining company. Below is a step-by-step approach to assist inspectors with the collection of groundwater samples.

1. Prior to collecting samples from a groundwater monitoring well, the well should be purged of stagnant water by bailing out 3-5 times the volume of the well. Wells can also be purged using manual or electric pumps.
2. Rinse the bailer, water scoop, and sample bottle with sample water and open the valves.
3. Take sample with hand bailer which fills with water when lowered into the well.
4. If necessary, preserve samples as soon as possible. Preservatives: 1 ml concentrated H_2SO_4/L for biogenic element, 1 ml HNO_3/ L -trace metals, 1 ml Chloroform /L for samples store longer durations.
5. Rinse the inside of each lid with sample water, cap the bottle immediately, and place the sample in a cooler.
6. Measure the following parameters on site: pH, Tem, EC, REDOX, Turbidity, TDS.
7. Fill datasheet and custody chain. Write the sample number, date, time and location on the bottle label.

4.1.6 KEY MEASURABLE PARAMETERS ON-SITE

pH, EC, SS, TDS, TºC, REDOX, and Turbidity (see in Annex I)

4.1.7 LIST OF REQUIRED EQUIPMENT AND TOOLS

1. Water quality multi-meter
2. Turbidity meter
3. DO meter
4. pH tester/or litmus paper
5. Custody chain (Table 10).

Multimeter:pH, Temperature, EC, TDS, ORP

Dissolved oxygen meter, oxygen saturation %, water temperature meter

Water turbidity meter

4.1.8 FIELD GUIDE OF ANALYTICAL TECHNIQUE

Use manuals of the equipment and follow the steps. Examples are shown below.

I. **Multiparameter-meter** is an electronic measuring device that measure parameters: pH, REDOX, EC, T0C on-site easily (33)
   1. Fill the cell cup
   2. Push a parameter key
   3. Take the reading (pH, REDOX, EC, T0C)

II. **Dissolved oxygen meter is** measured with a remote sensor that also contains a thermistor for measuring air temperature. Filling the electrolyte container prior to initial use. Fill the electrolyte with **new electrolyte.** Screw the electrolyte container back onto the electrolyte holder and probe handle. Lightly tap the probe to remove air bubbles.
   1. For first time use or after long periods of non-use, calibrate the instrument using the procedure below.
      1.1 Connect the oxygen probe plug to the probe input socket.
      1.2 Switch ON the meter by pressing the **Power/ESC** button.
      1.3 The lower display should indicate the %O2 unit symbol and a temperature value.
      1.4 The upper display will begin fluctuating. Wait approximately 3 minutes for the upper display to stabilize.

1.5. Press the **HOLD** button and the display will show the HOLD icon.

1.6 Press the **REC** button. The display will show "CAL" flashing and the meter display will begin counting down from 30 to zero; the meter will then display the END icon.

1.7 The upper display will show a value approximately 20.9 or 20.8 (typical concentration of oxygen in air)

2. Taking measurements

   2.1. Press and hold the Function button for at least 2 seconds to change from %O2 to mg/L or from mg/L to %O2. For DO measurements select mg/L (milligrams per liter).

   2.2. Immerse the probe in the solution under test. For optimum automatic temperature compensation, immerse the probe to a depth of at least 4" (10 cm).

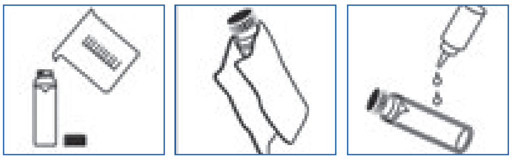
   2.3. Wait until the display stabilizes.

   2.4. The velocity of the liquid coming into contact with the probe must be at least 0.6 to 1 ft./min (0.2 to 0.3 m/s). If the solution is standing, stir the solution with the probe or use an agitator.

   2.5. Rinse the probe with clean water after each use and cover the probe head with the probe head protective cover

III. Turbidity meter is an electronic measuring device that measures turbidity [33]

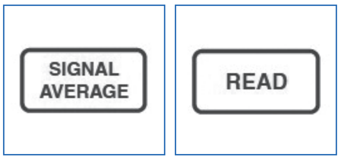
1. Fill a sample cell to the line (about 15 ml). Cap the cell.
2. Wipe the cell with a soft tissue to remove water spots and fingerprints.
3. Apply a thin film of silicon oil. Wipe the cell with a soft tissue to obtain an even film over the entire surface.



4. Turn on the instrument. Place the instrument on a flat, sturdy surface.
5. Insert the sample cell in the instrument compartment and so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment. Close the lid.
6. Select manual or automatic range selection by pressing the **RANGE** key. The display will show **AUTO RNG** when the instrument is in automatic range selection.

7. Select signal averaging mode by pressing the **SIGNAL AVERAGE** key. The display will show **SIG AVG** when the instrument is using signal averaging.

8. Press **READ**. Take the turbidity reading after the lamp symbol turns off.

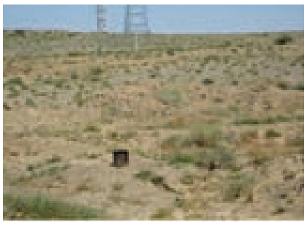


4.1.9 TYPES OF WELLS

Groundwater Monitoring Wells

- Groundwater monitoring wells are drilled down to a depth necessary to access the underlying aquifer.
- Groundwater monitoring wells can be used to measure the depth to water and for collecting water samples.


1.Observation borehole

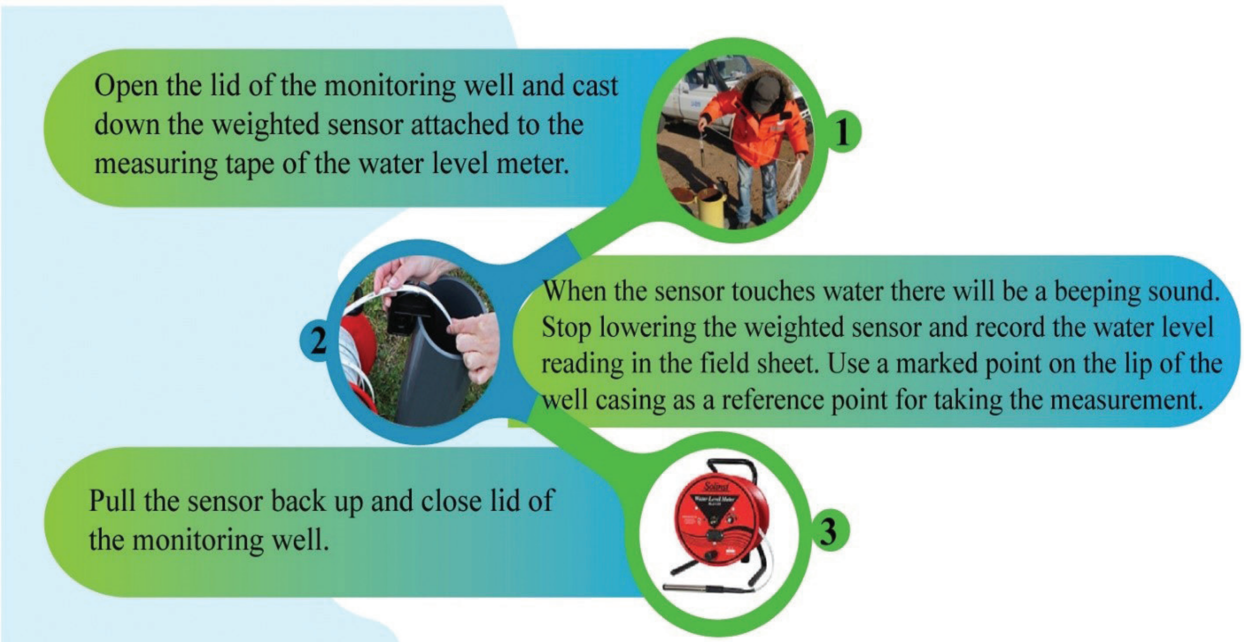

2. Supply well


3. Dewatering well


4. Equipped supply well

4.1.10 FIELD GUIDE OF MEASURING GROUNDWATER LEVEL

Mines which rely on groundwater supply sources and/or groundwater dewatering systems should carry out groundwater level monitoring and flow monitoring for water use and dewatering.



4.1.11 LIST OF REQUIRED EQUIPMENT AND TOOLS

1. Groundwater level meter
2. Field sheet (Annex II: Table 7)

4.1.12 LIST OF DOCUMENTS TO BE OBTAINED FROM THE COMPANY:

#	Primary document	Particular section
1.	🗁 Environmental management plan of the current year: water quality monitoring plan	Water related issues and risk assessment
2.	🗁 Water level measurements of the previous year and pre-mining reference data.	Borehole and borewell measurement results

4.2 CHECKING THE WATERMETER AND TAKING THE READINGS

4.2.1 INSPECTION OBJECTIVE:

Check compliance with the Water Use Metering Procedure (Annex to Order A/156 of the Minister of Environment and Green Development, 2013).

4.2.2 SUMMARY OUTLINE

Watermeter and water usage issues

The installation of a water meter in accordance with this regulation clearly shows how much water is used and consumed in each plant process of the mine. However, the following conflicts are common.

1. Losses of water in distribution systems and/or unmeasured flow are difficult to account for accuracy, and must be estimated.
2. Water meter is out of date or not certified
3. The line valve to which the water meter is connected is closed
4. Meters are not fully installed at all customer levels

Field measurement technique

1. Scheme of the water system,
2. Records confirming meter readings
3. Camera
4. Datasheet (Table 9).

Sampling/checking location

Metering is required both at source level and user level. Metering at source level involves measuring the water flows impounded, conveyed, and distributed to various components of the mine. Metering at the user level involves measuring all water use at and within the various components (mining operations, processing operations, camp facilities, waste treatment systems, etc.) of an operating mine, including water recycling facilities.

Performance criteria

- Compliance with commitments in Law on Water; Article 31. Water usage fees:
- Based on Article 10.1.3 of Law on Water; Order: Procedure for metering water use and consumption.
- MNS 2662:2002- Cold water meter checking techniques
- MNS OIML R 49-1:2012- Technical requirement of drinking water and hot water meter.
- ISO4064 standardized electrical tool installation.

4.2.3 FIELD GUIDE FOR WATERMETER CHECKING AND TAKING THE WATER VOLUME

Watermeters measure the rate of flow of water through a pipe and are calibrated to calculate the volume of water which passes the meter at various flow rates. Watermeters can use digital technology to record and display this information, or they can have mechanical dials which display the information on an ongoing basis.

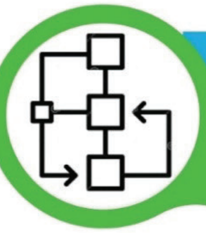
Watermeters can be installed in any pipe with flowing water and are typically installed at water sources to monitor production levels and water use from groundwater wells, and water use from surface water sources. In addition to monitoring water use from sources, watermeters are used to measure the volumes of water distributed to various components of an operating mine and for process control systems within refining operations, wastewater treatment plants and water recycling systems. Mining companies rely on watermeters for optimizing efficient water use and for tracking production costs. Watermeters are also valuable tools for identifying water losses through leaks and unauthorized water use. Water use data from watermeters is also used by government regulators in relation to the terms and conditions of water use licenses and it can also be useful for calculating pollution taxes.

Note: There are two types of losses- real and apparent losses. Water loss through leakage of storage tanks, distribution systems, and service connections (including overflow) are examples of real loss. Unauthorized water uses, such as unauthorized connections and theft, and meter and record inaccuracies are examples of apparent loss. Authorized unmetered uses can represent lost revenue, and they can also be considered a special type of lost water, therefore they should be estimated carefully. Preparing a plan outlining steps necessary for further identification and reduction of water losses within a reasonable time is recommended if the unaccounted or unmeasured water loss is beyond the permissible limit [34].

The plan for reducing water losses should be updated if unmeasured water loss greater than the permissible limit continues to show on future annual inspection. Areas where data is lacking should be identified and addressed after the first audit. Greater accuracy and reduction of water losses should be provided by subsequent audits. Operators can also learn a simple tip for well maintenance if these photos are provided at the end of your inspection report. They can monitor their average mining water usage by comparing the meter readings for the first few months and be alerted to any unexpected surges that may indicate a leak in the plumbing system.

Typically government inspectors visit mines at regular intervals and are able to collect data on water use from watermeters while they are at the mine. The following 7-step procedure outlines a method for using a camera to record watermeter data and assess if there are leaks.

1

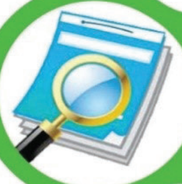


Meet the person who is taking the water volume reading monthly. Take the flowchart and water balance over the mining, or over individual units of the process.

2

Make a tour to the main source of the mining water.

3

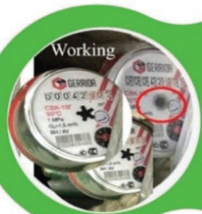


While you are at the borewell, check the well passport, additional documents, the watermeter seal, and whether it is tested and licenced by the authorized organization of metrology.

4

Take the screen photo of watermeter.
If watermeter is not running go to step 5.
If watermeter is running go to step 6.

5

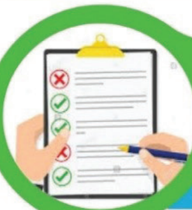


Take 3 photos of the watermeter,showing that no waterlines are leaking, assuming you didn't find any. The 1st photo, which demonstrates that the water is not running, is your baseline photo.The 2nd photo shows that the water is running. If the valve is closed, turn it on. The 3rd photo, which is your proof photo, shows that the water is not running, there are no leaks and the watermeter is working properly.

6

Take the reading first, then take the 3 photos again. But first, you should close the valves and turn off all water flow. 2nd and 3rd photos are showing that the watermeter is not running, confirms that there are no hidden and undiscovered water leaks in the system. If 2nd and 3rd photo is showing the running mode. If you have all valves and faucets off in the system and meter is still turning, it is an indication that a leak is present.

7



Using this method, check the other wells and rework water balance. If needed, take the measurement of volume of water for water pollution tax (it will depend on the water quality data).

4.3 MONITORING OF GROUNDWATER IMPACTS FROM WASTEWATER AND TREATED WATER SYSTEMS

4.3.1 INSPECTION OBJECTIVE:

Inspection of whether there is an impact on groundwater resources in the mine footprint and surrounding area from the operation of wastewater treatment and storage facilities and to ensure compliance with regulatory requirements.

4.3.2 SUMMARY OUTLINE

Groundwater quality and quantity issue

1. Issues with the structural integrity of dams, reservoirs, treatment lagoons, tailings storage areas, Acid Rock Storage facilities, etc., can lead to leaks and uncontrolled migration of contaminated water which can pollute groundwater resources both within the mine footprint and the surrounding area,
2. Monitoring of the water quality within water treatment systems and at outlets from these systems allows for the assessment of its efficiency and effectiveness, and helps define risks to groundwater associated with any leaks or other system failures, and
3. Pollution of groundwater resources from leaking or poorly operating treatment systems can impact groundwater quality causing additional problems with physico-chemical scaling, biological fouling and/or corrosion of water pipes if this groundwater is being used for process water at the mine.

Measurable parameter

1. Suspended Solids and TSS
2. BOD
3. COD
4. Polyaromatic hydrocarbons (PAHs).
5. Water meter (rate-of-flow and volume)
6. Biofouling (bacteria amount)

Field measurement technique

On site measurements of pH, SS, TDS, REDOX, TºC, turbidity, mild and yellow metal corrosion rates and corrosion coupon results (monthly)
Water quality data environmental department of the mining company

Sampling location of the facilities

Inlet and outlet of the Waste Water Treatment Plants (WWTP), Tailings Storage Facilities (TSFs), any wastewater in a ponded area, including dewatered groundwater or recycling water, and any other mine infrastructure where impacted water is stored or processed (see in Figure 11: 6 and 7).

Sampling frequency

Scheduled and unscheduled inspections (Table 22). It may be appropriate to coincide sampling with extreme hydrological events such as during high flows and flood events or during drought and low flow conditions.

Performance criteria

Compliance with commitments in

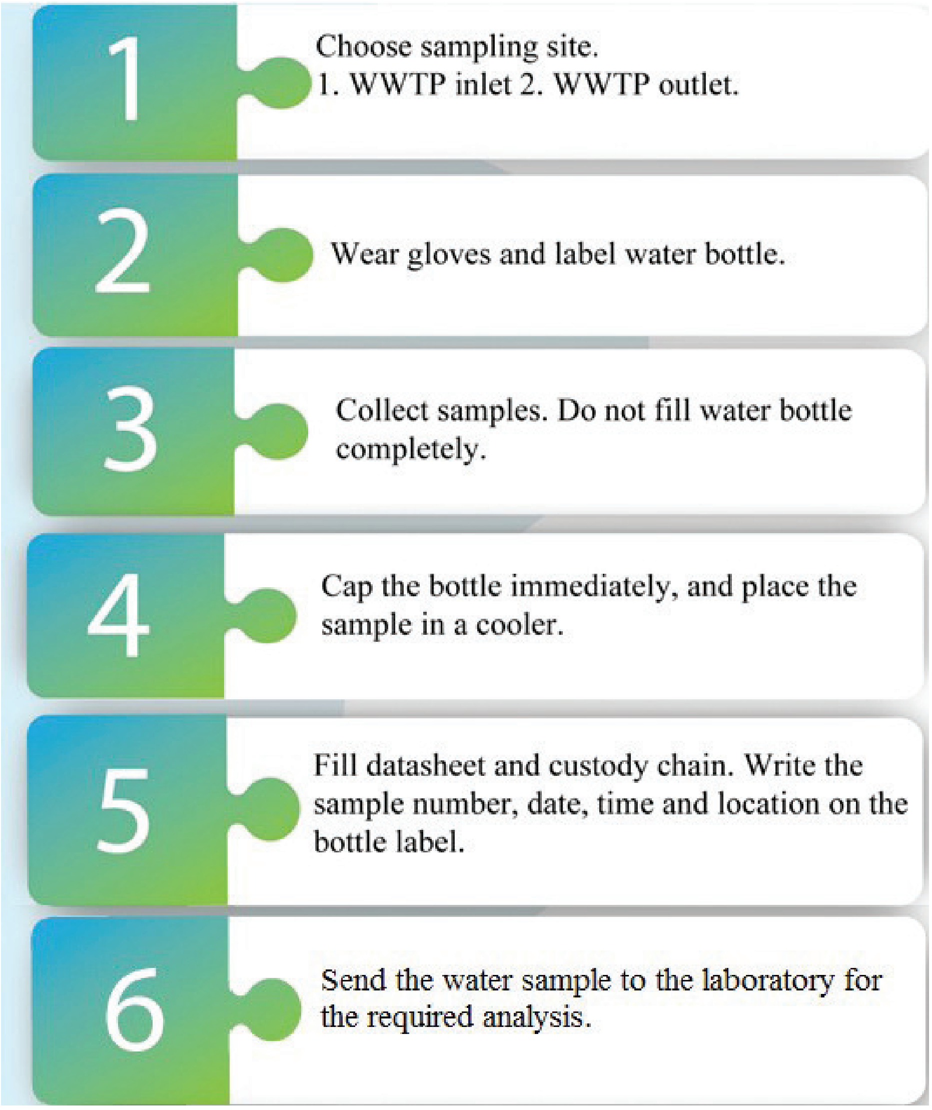
1. MNS 4943-2015 effluent treated wastewater. (max. content of polluting substances in the wastewater released to open nature/monitoring requirements/during operation)
2. MNS 6963-2015 Environment. Water quality. Sewage and supply wastewater. General requirement.

4.3.3 DESCRIPTION

Wastewater is liquid waste from domestic use and production. Industrial wastewater is also wastewater with various chemical compositions from production and services.

4.3.4 FIELD GUIDE FOR WASTEWATER SAMPLING

Once appropriate sampling sites have been identified, the step-by-step approach outlined below should assist inspectors to carry out sampling of wastewater.



4.3.5 LIST OF REQUIRED EQUIPMENT AND TOOLS


Water bottle


Water scoop


Rubber glove

1. Water bottle (glass)
2. Preservation reagents if necessary
3. Permanent pen
4. Coolers and Icepacks
5. Custody chain sheets with pad (Table 12).

4.3.6 KEY MEASURABLE PARAMETERS ON-SITE

pH, EC, SS, TDS, TºC, COD, BOD5 and Turbidity (see definitions in Annex I)

4.3.7 LIST OF DOCUMENTS TO BE OBTAINED FROM THE COMPANY:

#	Primary document	Particular section
1.	Environmental management plan of the current year: water quality monitoring plan	Water related issues and risk assessment
2.	Lab analyzes results of the previous year and pre-mining reference data.	Laboratory test result of water quality indicators

4.4 MONITORING OF DRINKING WATER QUALITY

4.4.1 INSPECTION OBJECTIVE:

Inspection of whether there is any pathogenic contamination in potable water for mine offices and camps to ensure quality of drinking water is compliant with regulatory requirements.

4.4.2 SUMMARY OUTLINE

Drinking water quality issues

1. Unsafe drinking water supply and distribution system
2. Lack of, or poor drinking water treatment system

Measurable parameter

1. Bacterial, viral, and protozoan contamination (Total bacteria, coliform, patogen)

Field measurement technique

1. Bacteriological sampling
2. Review of laboratory test results from previous bacteriological samples with staff of the environmental department of the mine.
3. Review water quality data from bacteriological samples collected by staff of environmental department of the mine and obtain a copy of the data

Sampling location

Raw water and tap water (random) see in the (Figure 11).

Sampling frequency

Centralized water supply: once a week

Performance criteria

Compliance with commitments in:

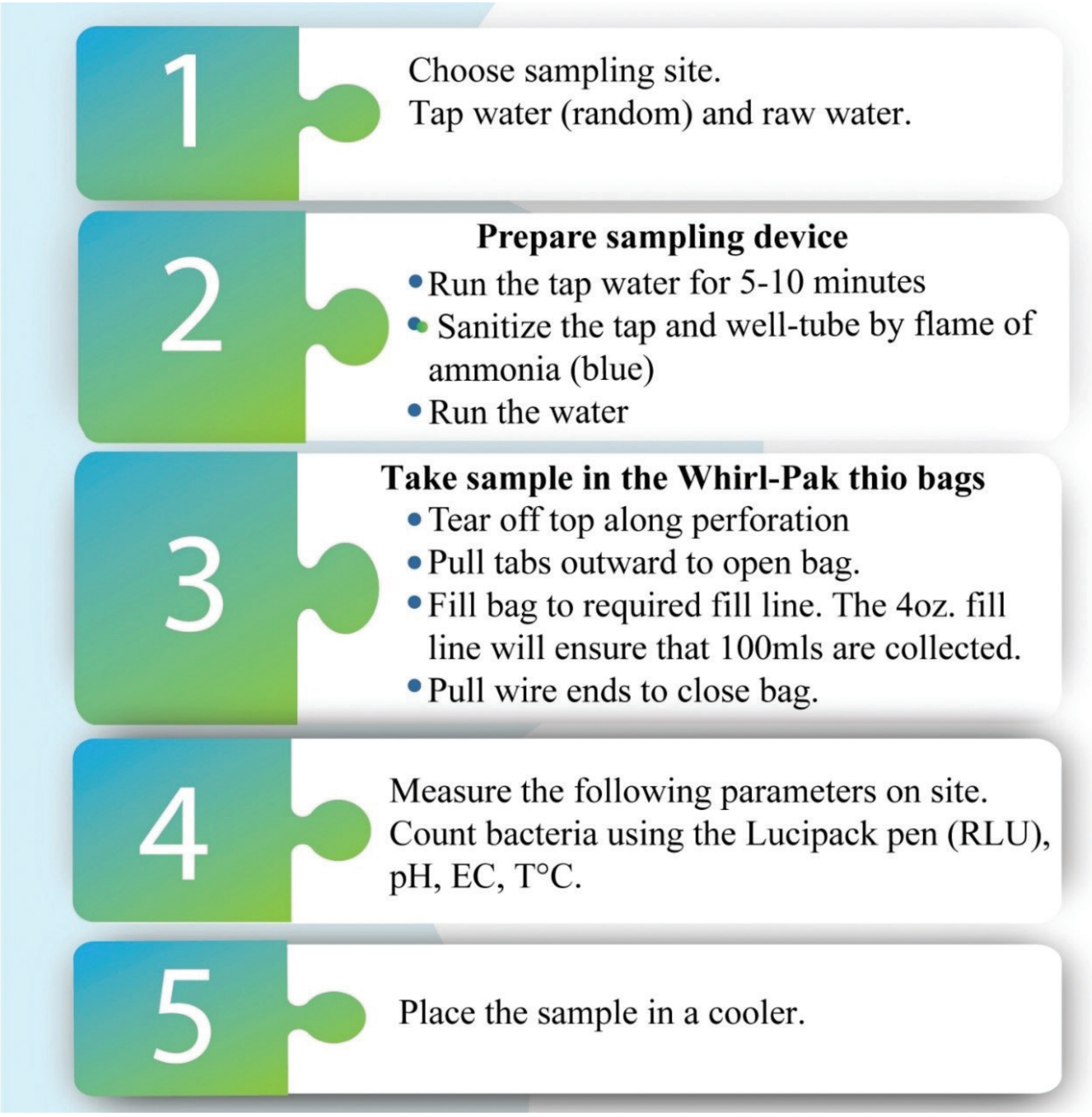
1. MNS0900:2018 Environment. Health Protection. Safety. Drinking water. Hygienical requirements, assessment of the quality and safety.
2. Mine Environmental management plan of the current year: water quality monitoring plan
3. Lab analyzes results.

4.4.3 DEFINITION

Monitoring of drinking water is to ensure the hygiene, quality and safety of drinking and domestic water.

4.4.4 FIELD GUIDE FOR BACTERIOLOGICAL SAMPLING

Once appropriate sampling sites have been identified for a specific mine site (mines may have more than one potable water supply), the step-by-step approach outlined below should assist inspectors to carry out sampling of drinking water.



4.4.5 FIELD GUIDE OF ANALYTICAL TECHNIQUE

1. Turn on the Lumitester
2. Remove the sampling stick from the main body (casing)
3. Soak the sampling stick about 3 cm from the tip of the sampling stick into water or other liquid samples and shake gently. Make sure no bubbles remain within the sampling stick's comb.
4. Pull out the sampling stick slowly and straight up from the sample
5. Return the sampling stick to the main body (casing) and push it all the way into the main body. Push firmly onto LuciPac Pen casing and agitate.
6. Allow the leftover luminescent reagent to thoroughly dissolve.
7. Insert the LuciPac Pen into the Lumitester to measure the results
8. Take the reading (Table 11).

4.4.6 LIST OF REQUIRED EQUIPMENT AND TOOLS

1. Whirl-Pak thio bag
2. Lucipac pen and lumitester
3. Sterilizer (Lighter with cotton wetted by ammonia/ surgical ethanol)
4. Permanent pen
5. Coolers and Icepacks
6. Custody chain sheets with pad (Table 10) and (Table 11).

4.5 MONITORING OF SURFACE WATER QUALITY

4.5.1 INSPECTION OBJECTIVE:

Inspection of whether there is an impact of the mining operations on surface water quality and compliance with regulatory requirements.

4.5.2 SUMMARY OUTLINE

Surface water quality issues

1. The placer mining process requires using significant volumes of water and resulting wastewater is heavily sedimented and can have significant pollution impacts if it leaves the mine site untreated.
2. The dewatering process can have a significant impact on surface water quality if there are high concentrations of trace metals contained in acidic water. In addition, nutrients (P and N) may cause eutrophication to surface water.
3. Effluents from both waste rock and tailings can cause problems such as acid mine drainage and elevated metals.
4. Extensive ground disturbance inside the mine footprint means there will be active erosion and sedimentation during precipitation and runoff events.
5. Spills or leaks of petroleum products and other stored hazardous materials can cause contamination of surface waters.

Measurable parameter

1. pH, SS, TDS, DO, TºC, turbidity
2. Stream discharge
3. Sedimentation (sediment deposition, embeddedness) and erosion (degree of bank erosion)
4. Aquatic organisms (algae and macroinvertebrates) response

Field measurement technique

1. Water sampling
2. Measurements of pH, SS, TDS, DO, TºC, turbidity
3. Laboratory test result of anion, cation, and metals
4. Obtaining water quality data from the environmental department of the mine

Sampling location

Upstream and downstream of the mine.

Possible sampling sites can be at the lagoon (source water), process water (related to main mining processes; issue#5-7), barge water (recycling wastewater from mining operation), TSF (wastewater in pond including dewatered water from ground), borehole near the TSF (issue#2 and 3), borehole near the waste rock pile (issue#3 and 4), (see in the Figure 11: 3,8,9, 10, 11, and 12) and, at specific locations with known infrastructure maintenance problems which are impacting, or have potential to impact, surface water bodies.

Sampling frequency

Scheduled and unscheduled inspections.

Performance criteria

Compliance with commitments in:

- MNS 0900: 2018 Environment. Health Protection. Safety. Drinking water. Hygienical requirements, assessment of the quality and safety.
- MNS 4943-2015 effluent treated wastewater. (max. content of polluting substances in the wastewater released to open nature/monitoring requirements/during operation)
- MNS 4047:88 Environmental protection. Hydrosphere.
- Mine Environmental management plan of the year: water quality monitoring plan
- Lab analyzes results of the previous year and pre-mining reference data.

4.5.3 DEFINITION

Assessment of surface water quality considers its physical, chemical, and biological characteristics. Assessing surface water quality relies on the measurement of some general water quality parameters directly in the field using handheld water quality meters, and the collection of water samples which are sent to an analytical laboratory for detailed analysis of various chemical parameters. The results of field measurements and laboratory results can be compared to water quality standards to see how well water quality compares to the goals which standards set for. In addition these results are useful for tracking water quality trends over time.

4.5.4 FIELD GUIDE FOR SURFACE WATER

A. SURFACE WATER SAMPLING AND MEASUREMENT

1. Once sampling location has been chosen, rinse the sample bottle three times by the sample water.
2. Approach your sampling location from downstream, disturbing the bottom sediment as little as possible. Always face upstream to collect your samples, to avoid any stirred-up mud from the streambed getting in your sample.
3. Collect samples near the center of the rivers and in lakes collect sample far enough away from the shoreline so that there is no interference from wave action stirring up sediments. Collect samples 0.3 m below the surface. Fill sample bottle gently to avoid turbulence and air bubbles.
4. If necessary, preserve samples as soon as possible. Preservatives: 1 ml concentrated H_2SO_4/L for biogenic element, 1 ml HNO_3/ L -trace metals, 1 ml Chloroform /L for samples store longer durations.
5. Rinse the inside of each lid with sample water from the sample bottle, cap the bottle immediately, and place the sample in a cooler.
6. Measure the following parameters on site: pH, Tem, EC, DO, Turbidity, and TDS.
7. Fill datasheet and custody chain. Write the sample number, date, time and location on the bottle label.

List of required equipment and tools

1. 1L Nalgene bottle
2. Preservation reagents if necessary
3. Permanent pen
4. Coolers and Icepacks
5. Custody chain sheets with pad (Annex II and Table 10)

Key measurable parameters on-site

pH, EC, SS, TDS, TºC, DO, and Turbidity (see definitions from the Annex I). Compare with the values in *Table 27.*

Field guide of analytical technique

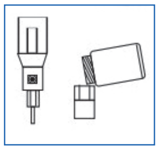
Field staff should be familiar with the handheld water monitoring meters that they are using and should read and use the field equipment manuals that are specific to the exact type and brand that they are using. These manuals should be studied prior to going into the field as they will give a clear step-by-step direction on how to use the meters. Examples of typical equipment analytical technique are shown below [33].

I. A multi-meter is an electronic measuring device that measures in situ parameters such as: pH, REDOX, EC, and T0C, on-site easily.

1. Fill the cell cup
2. Push a **PARAMETER KEY**
3. Take the reading (pH, EC, T0C)

II. A DO meter is an electronic measuring device that measures DO.

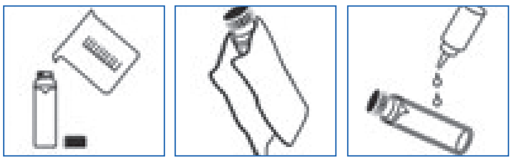
1. Place the tip of the probe into the sample deep enough that the silver dot on the shaft (thermistor for temperature compensation) is submerged, but not the handle. The handle is not waterproof.



2. Gently stir the probe in the water.
3. Take the reading of dissolved oxygen concentration.

III. A turbidity meter is an electronic measuring device that measures turbidity.

1. Fill a sample cell to the line (about 15 ml). Cap the cell.
2. Wipe the cell with a soft tissue to remove water spots and fingerprints.
3. Apply a thin film of silicon oil. Wipe the cell with a soft tissue to obtain an even film over the entire surface.



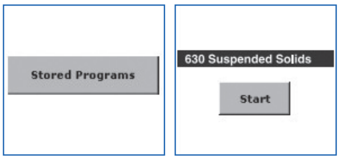
4. Turn on the instrument. Place the instrument on a flat, sturdy surface.
5. Insert the sample cell in the instrument compartment and so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment. Close the lid.

6. Select manual or automatic range selection by pressing the **RANGE** key. The display will show **AUTO RNG** when the instrument is in automatic range selection.

7. Select signal averaging mode by pressing the **SIGNAL AVERAGE** key. The display will show **SIG AVG** when the instrument is using signal averaging.
8. Press **READ**. Take the turbidity reading after the lamp symbol turns off.

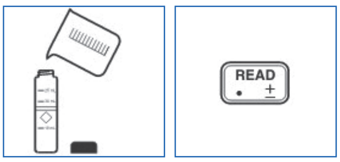
IV. A colorimeter is used to measure the concentration of a known solute in a given solution based on absorption of a particular wavelength of light [35].

1. Press STORED PROGRAMS.
2. Select the test.
3. Take 500ml of the sample and shake well for two minutes.



4. Fill a sample cell with 10 ml of deionized water (the blank)
5. Place the vial in the cell holder. Tightly cover the sample cell with the instrument cap.
6. Press ZERO key then remove the vial.

7. Take 500ml of the sample and shake well for two minutes. Then, immediately pour 10 ml of the blended sample in the vial and put into the sample cell.
8. Press **READ**. Take the SS reading.



List of required equipment and tools

Multimeter:pH, Temperature, EC, TDS, ORP

Dissolved oxygen meter, oxygen saturation %, water temperature meter

Turbidity meter

Colorimeter

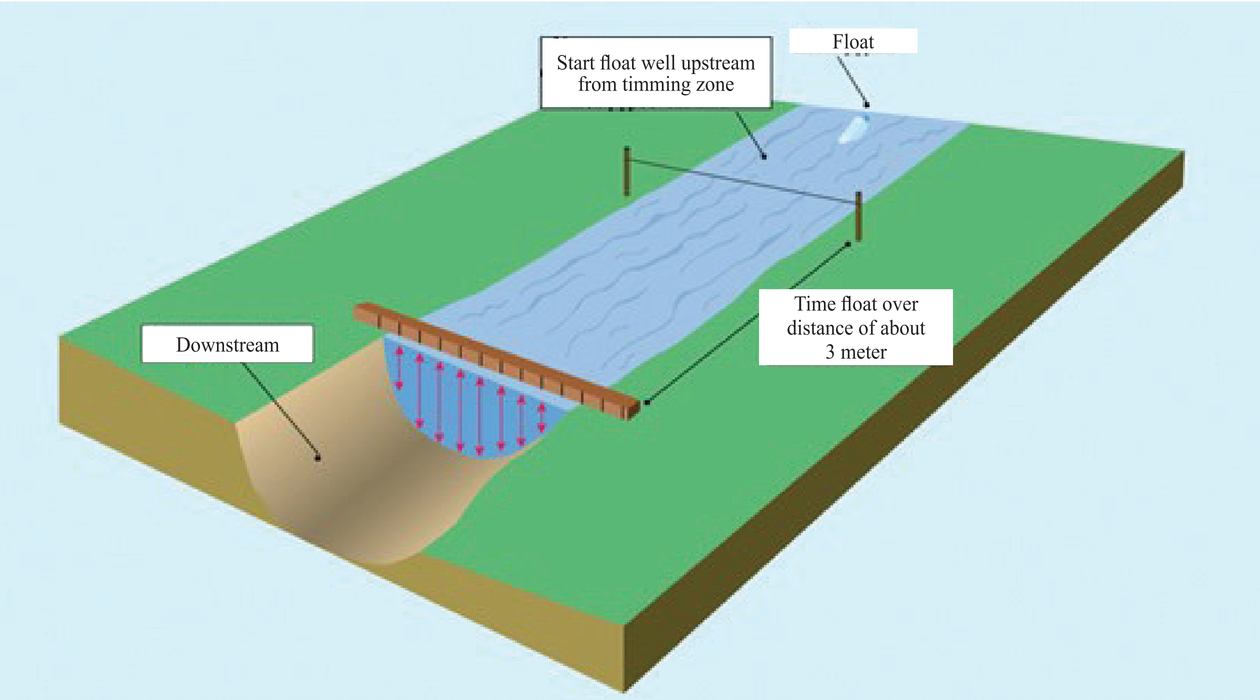
1. Water quality multi-meter
2. Turbidity meter
3. DO meter
4. Colorimeter
5. pH tester/or litmus paper
6. Field Datasheet (Table 7)

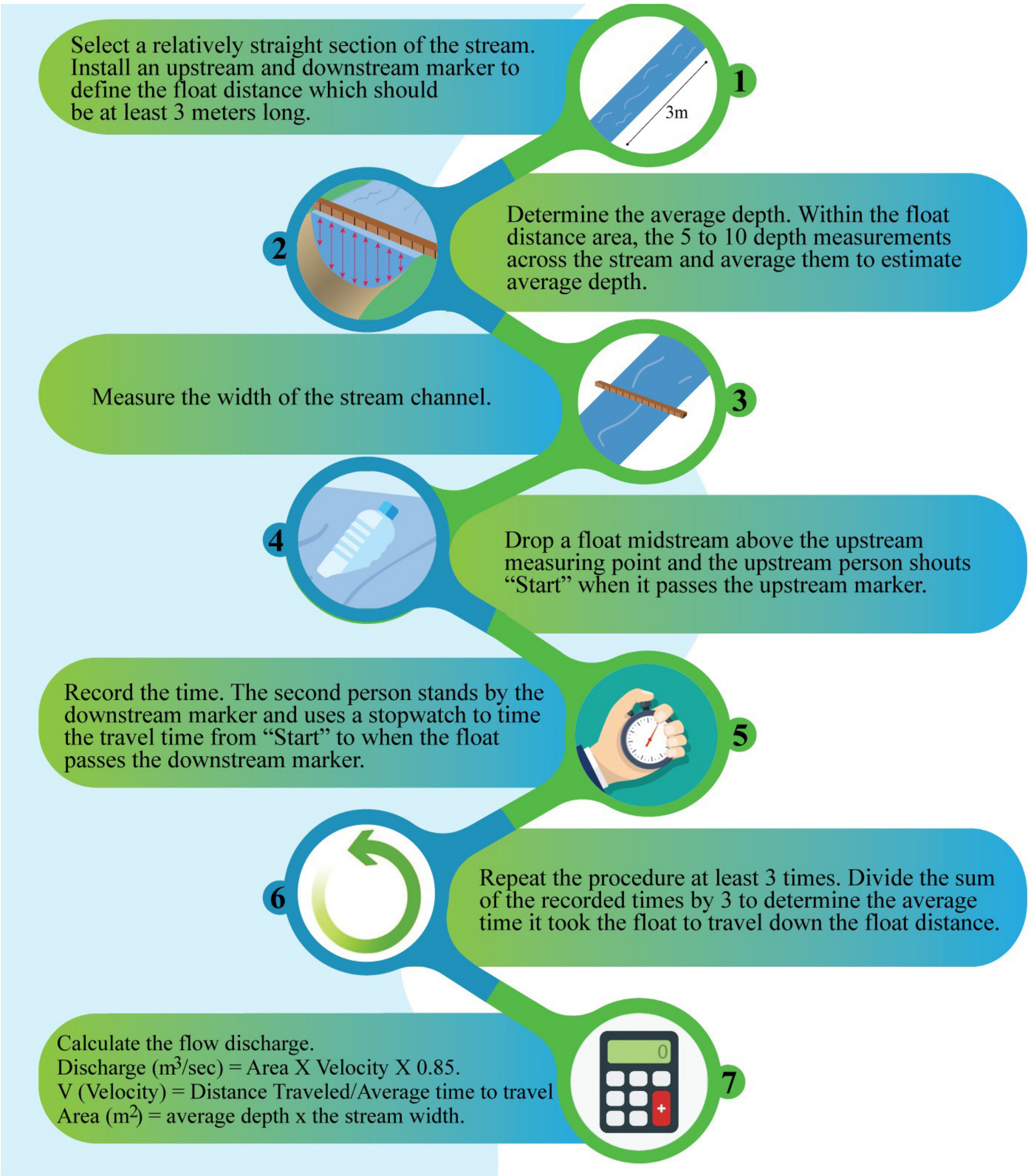
B. STREAM DISCHARGE MEASUREMENT

Definition

Discharge is the volume of water moving down a stream or river per unit of time, commonly expressed in cubic meters per second. If there is no hydrological gauge at the site for measuring stream flow (or nearby, for estimating stream flow), the float method can be used in smaller rivers and streams that are safe to wade, calculating stream flow from the average current velocity in the stream and the cross-sectional area of the water. Surface velocities are typically higher than average overall channel velocity. To account for this, we take the surface velocity measured, and multiply it by .85, to adjust the overall velocity to be more representative of the slower velocities under the surface [10].

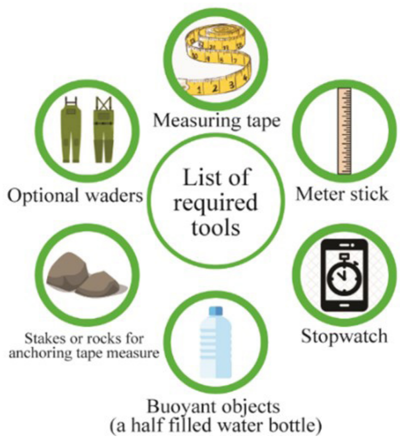
I. Field guide for estimating stream discharge





I. List of required equipment and tools

1. Measuring tape
2. Meter stick
3. Stopwatch
4. Buoyant object
5. Stakes or rocks for anchoring
6. Wader
7. Flow worksheet *(Annex II, Table 8)*



C. PHYSICAL HABITAT ASSESSMENT

Definition

Habitat visual assessment is an easy-to-use approach for identifying and assessing the elements of a stream habitat.

I. Field guide for habitat assessment

Habitat assessment is based on visual observations of ten different parameters: stream bed substrate, embeddedness, sediment deposition, riffle frequency, channel flow rate, velocity/depth regime, channel alteration, bank stability, riparian vegetation, and riparian vegetation zone width within 50 m reach of the water's edge, reflecting conditions from good to poor [5]. Check the appropriate categories based on your visual estimate of each parameter at the physical habitat assessment sheet (Annex II: Table 13-14), assign a score for each parameter and then calculate total habitat score.

1. Select study site and set transect within 50 m reach. Record site details such as site name, site code, and record latitude, longitude, elevation, date, and investigator.
2. Starting at the downstream end of your study area, walk in a zig-zag pattern up the length of the study area. Looking over the entire reach, estimate percentage of available substrate type in the riverbed while walking.
3. Check if coarse substrates are overlain with fine sediment by inserting your fingers into the substrate while walking zigzag. Estimate the percentage of embeddedness and sediment deposition (sand, silt) within the reach.

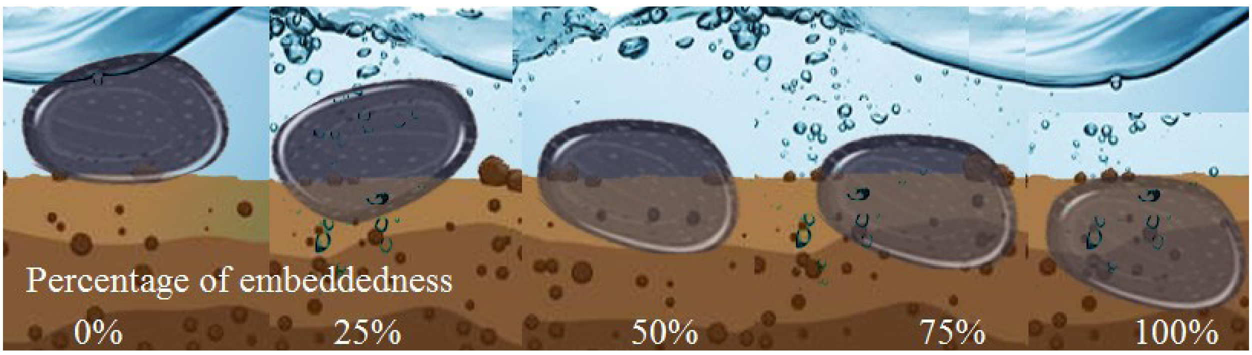


Figure 12. An embeddedness rating of 0% corresponds to very little or no fine sediments surrounding coarse substrates. Coarse substrate material completely covered with sediment is considered 100% embedded.

4 Estimate stream velocity and depth in riffle, run, pool habitats, and observe frequency of riffle within the reach. For this parameter, “slow” is less than 0.3 m/s, “fast” is greater than 0.3 m/s and “deep” is greater than 0.5 m.

5 Visually estimate the percentage of channel flow status that channel is filled with water and degree of substrate explosion.

6 Visually estimate how much of the study reach is straightened, deepened, or widened, and how severely the flow and channel form are modified by other alterations such as artificial lining of the bank, culverts, or weirs, etc.

7 Visually estimate the percentage of the stream bank that is actively eroding or have the potential to be eroded in both left and right banks.

8 Visually estimate the percentage of natural vegetation coverage on each bank at ~0, 6, 12, and 18 meters from stream bank in randomly tossed Ramensky net (1 m2 frame) and take an average estimate.

9 Visually estimate the width of riparian vegetative zone by measuring the perpendicular distance from edge of the stream bank on each side of the stream to the in-land edges of the buffer and any stop banks or natural landward margins to the floodplain.

10 Calculate total habitat score by summing scores of each parameter. Good habitat=60-80, Fair=40-59, poor=0-39.

11 After assessment is completed, take a detailed photograph facing both upstream and downstream of study site. If there are any characteristics of interest such as channelization, severe erosion or a healthy riparian area note in photograph.

II. List of required equipment and tools

1. Measuring tape
2. Meter stick
3. GPS
4. Ramensky net
5. Habitat assessment sheet (Table 13 and Table 14)
6. Wader
7. Camera

III. List of documents to be obtained from the company:

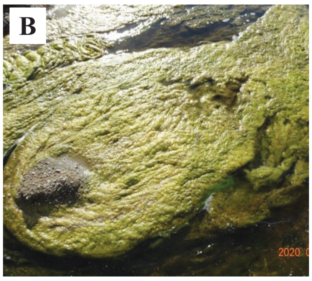
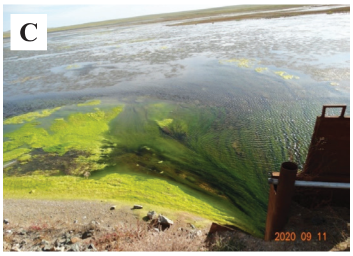
#		Primary document	Particular section
1.	🗁	Environmental management plan of the current year: water quality monitoring plan	Water related issues and risk assessment
2.	🗁	Lab analyzes results of the previous year and pre-mining reference data.	Laboratory test result of water quality indicators
3.	🗁	DEIA and EMP commitments	Annual Water quality monitoring plan

D. ALGAE ASSESSMENT

Definition

The water quality of a particular environment is indicated by the presence or absence of specific aquatic organisms such as micro-organisms, algae, macroinvertebrates, and fish. Aquatic organisms respond to pollution differently depending on the genera and species. The slimy coating can be found on rocks and other stable substrates in streams and rivers. It consists mainly of algae, but the term also includes fungal and bacterial matter, and varies greatly in appearance from a thin brownish or greenish film, to thick dark-colored "mats" to masses of streaming green or brown filaments. Algal bloom can occur due to large quantities of nutrients such as nitrogen, and phosphorus in the water [37].

I. Field guide for algae assessment [37]

Date: Sampling location code:	
Site name: Investigator name:	
Observe algae colonization within 50m reach of where habitat assessment was made and assess habitat quality.	**Score**
1. Amount of algae in river	
a. amount of algae is very small, not easy to detect	1
b. Notable amount of algae present on the rocks in the bottom and along the shore	2
c. Abundant algae growth can be found on the rocks in the bottom and along the shore	2
d. Filamentous algae body accumulated on the surface of water	2
 A. Filamentous algae  B. Blue-green algae	
2. Please observe the green algae colonies	
a. Green clumps and short hairs (up to 5-8 cm) on the bottom rocks	1
b. Green hairs (up to 10 cm and longer) on the bottom rocks.	2
c. Since green filaments grow much longer, most of their body flows on the surface of water and some separated parts accumulated in the slow running parts of the river.	2
d. Green filaments in the ponds along the river and slow running parts look like "cotton candy" mass.	2
e. Filaments are slimy and not able to collect many filaments by hand, only few.	3
f. Filaments are not slimy and able to easily collect filaments by hand	
 C. Slimy filaments of green algae layer  D. Blue green bloom, forms a thick on the water surface	
3. If water looks green as a consequence of blue-green bloom (explore this in the slow running part of river and ponds along the river)	
a. There are olive or brown green lines on the water surface	6
b. Only water surface looks green	7
c. Water column looks green	8
d. Leather-like green or dirty green layer on the water surface	10

4. Brownish biomass on the bottom rocks (this biomass mostly caused by diatoms). Pick 10 rocks that are at least 4 cm wide from different parts of the stream.	
a. There is not a notable mucilaginous cover on the rocks in the river bottom when you touch it	1
b. There is a notable mucilaginous cover on the rocks in the river bottom when you touch it. You are able to get brown mass if you scrape the rock with a spoon.	1 3-4
c. There is a brown color mass of up to 0,5 mm thickness on the rock.	5-6
d. There is a brown color mass of 0,5 -3 mm thickness on the rock.	7-8
e. There is a brown color mass of more than 3 mm thickness on the rock.	

E. Thin layer (<0.5mm),

F. Medium layer (0.5-3mm)

G. Thick layer (>3mm)

5. Calculate total score: 5-10 - water quality is very good 11-15 – water quality is good 15-20 – water quality is showing signs of deterioration >20 water quality is poor	

II. LIST OF REQUIRED EQUIPMENT AND TOOLS

1. Ruler
2. Forceps
3. Wader
4. Gloves

4.6 FIELD SAFETY TIPS AND DATA MANAGEMENT

4.6.1 DATA MANAGEMENT

A standard method of documenting a field inspection is to complete a field sheet or field record form while onsite in the field. If all staff are using the same field sheets, it helps to standardize the types of information collected in the field.

It is important that field sheets are completed in the field during the inspection process and before leaving the site so that all relevant information is included while fresh in the memory.

Field Sheets (Annex II) are an official record of a site visit and should be kept as a permanent record. Field sheets can also be typed up into a more formal format upon return to the office and key data can be extracted from them for input into databases or for tabulating annual statistics on inspections.

4.7 VISUAL INSPECTION OF THE MINE WATER INFRASTRUCTURES

4.7.1 INSPECTION OBJECTIVE:

Inspection of whether there are any new or ongoing problems that require immediate attention and action regarding water quality and quantity to ensure regulatory compliance. Conduct visual inspections while visiting mining facilities to take water samples (indicated in Figure 11).

4.7.2 SUMMARY OUTLINE

Infrastructure issues

1. Leaking dams or tailings ponds which have excess water emerging at the base or at some other site.
2. Overtopping reservoirs, tailings or settling ponds which do not have adequate storage capacity.
3. Inadequate site drainage with excess water accumulation and ponding in inappropriate areas.
4. Collapsed or blocked ditches or water diversions.
5. Significant erosion and sedimentation may indicate site drainage conditions are inadequate.
6. Excessive ground disturbance in sensitive areas or proximity to water bodies.

Measurable parameter

1. Leakage
2. Overtopping
3. Excess water accumulation
4. Damage

Field measurement technique

1. Onsite visual inspection
2. Water sampling (leaking water or other issues)
3. Review laboratory test result of anion, cation, metals, PAHs, from previous samples (leaking water or other issues) with responsible staff from the mine
4. Review new water quality data for recent samples collected by the mine environmental department and get copies of all data.

Inspection locations at the facilities

Typical mine facilities such as: open pits, spoil piles, coal stockpiles, waste rock piles, wash plants and coal fines ponds, processing plants and tailings storage facilities (TSF), any other significant mine infrastructure with a water resources component, and sensitive areas near natural water bodies.

Inspection frequency
Scheduled and unscheduled inspections;
It may be appropriate to coincide inspections (and any required sampling) with extreme hydrological events such as during high flows and flood events or during drought and low flow conditions.

Performance criteria
Compliance with commitments in
1. MNS 4943-2015 effluent treated wastewater. (max. content of polluting
2. substances in the wastewater released to open nature/monitoring requirements/during operation)
3. MNS 4047:88 Environmental protection. Hydrosphere.
4. Mine Environmental management plan of the current year: water quality monitoring plan
5. Lab analyzes results of the previous year and pre-mining reference data.
6. Risk assessment of the required facilities

4.7.3 GENERAL PROCEDURES FOR VISUAL INSPECTIONS

Visual inspections allow for the assessment of current operation conditions and the review of progress towards solving previously identified problems. They are also an opportunity for identifying newly emerging problems and issues while they are relatively minor and before they become more significant and challenging to resolve.

4.7.4 FIELD GUIDE CHECKLIST FOR VISUAL INSPECTION

This checklist identifies priority issues and gives some guidance to assist inspectors to carry out field inspection on mining facilities as follows:

- ☐ Look for leaks at the toe of dams and ensure interception ditches are working.
- ☐ Inspect the pond to ensure it is not overtopping.
- ☐ Inspect excess water accumulation and ponding in inappropriate areas.
- ☐ Ensure separation buffers are intact and not impacted by leaks, erosion, sedimentation, excessive ground disturbance, or other problems.
- ☐ Inspect dams, tailings storage facilities, waste rock storage piles, and other mines infrastructure with significant rock and gravel slopes, to ensure they are in good repair with no slumping or excessive erosion.
- ☐ Check if there are any collapsed or blocked ditches or water diversions.
- ☐ Look for evidence of significant erosion and sedimentation which may indicate site drainage conditions are inadequate.
- ☐ Document problems or issues with photographs, notes on field sheets, and the collection of exact location details with a sketch or mapped information showing the area of concern.
- ☐ Recommend action measures based on the risk management plan of the mine for any conditions which indicate substandard infrastructure or the need for maintenance and repairs.

4.7.5 LIST OF REQUIRED EQUIPMENT AND TOOLS

1. GPS
2. Camera
3. Field notebook
4. Permanent pen

4.7.6 LIST OF DOCUMENTS TO BE OBTAINED FROM THE COMPANY:

#		Primary document	Particular section
1.	🗁	Environmental management plan of the current year: water quality monitoring plan	Water related issues and risk assessment
2.	🗁	Risk assessment of the mine facilities	

4.8 ON-SITE RISK ASSESSMENT OF WATER RESOURCES (QUALITY & QUANTITY)

4.8.1 ASSESSMENT OBJECTIVE:

Assessment of whether there is an impact of the mining operations on water quality and quantity and if the mine meets regulatory compliance. Generally, the following processes are carried out to ensure regulatory compliance:

- Companies and governments continually monitor the mining operation to test environmental performance, demonstrate compliance with environmental legislation, refine operational practices, and safeguard the interests of both the mining company and the surrounding community.
- Inspections of mine sites are carried out by government staff on a regular basis to ensure that mining companies are practicing due diligence in implementing their Environmental Management Plans and the terms and conditions of various permits and licenses.
- Inspections offer the opportunity to identify deficiencies and problems with mine operations and infrastructure and to identify unacceptable levels of pollution [38] or high-risk situations that may lead to incidents or problems if left unresolved [23].

Specifically, inspectors, environmental rangers, and eco-police should use the below methods to look for risks and recommend on-site actions. Below are some examples.

4.8.2 ASSESSMENT OF PROCESS WATER AND WASTE WATER TREATMENT PLANTS (WWTP) AT MINES

Inspectors should record available quantitative information about the waste stream(s), such as flow rates and the design capacity of each treatment element. It is also helpful to understand the variability of the system under different natural conditions and operational scenarios (e.g. variability of load, both in terms of quantity and concentration, during heavy rain or flooding). The following is a step-by-step approach to assist inspectors to carry out field inspection on **process water** and wastewater:

1

Map the WWTP system and processing water

- Domestic water distribution map
- Process water flow diagram
- WWTP scheme
- Tailing storage facility map

2

Characterize the wastewater fractions

- Identify potential hazards (see table)
- The source(s) of the waste.
- The main composition of the waste (see step 4 too).
- The potential for accidentally mixed components of the waste

3

Identify potential exposure groups

W (Workers): A person who is responsible for maintaining, cleaning, operating, or the and processing water operators, QA/QC specialist

L (Local Community): Anyone who is living near to, or downstream from, the sanitation technology or farm on which the material is used and may be passively affected.

C (Consumers): Anyone who consumes or uses products

4

Gather compliance and contextual information

- MNS0900:2005,
- MNS6561:2015,
- MNS4943:2015,
- MNS6734:2018.
- WHO guidance for soil contaminates

5

- Verify system mapping and actions and recomendations

	Waste components									
	Potential biological hazards					Potential chemical hazards		Potential physical hazards		
	Viruses	Bacteria	Protozoa	Helminths	Vector related diseases	Toxic chemicals	Heavy metals	Sharp objects	Inorganic material	Malodours
Diluted excrete (human or animal)	+	+	+	+						+
Urine (human or animal)	+	+	+	+						+
Domestic wastewater	+	+	+	+	+			+	+	+
Stormwater	+	+	+	+	+	+	+	+		
River water	+	+	+	+	+	+	+			
Industrial wastewater						+	+			

Mapping the WWTP system and Process water

Each mine has a WWTP system and a process water system and its description and maps should, therefore, be specific. The method chosen for mapping will depend on the scale and complexity of the system. For some small-scale mining, it may be useful to map using a system flow diagram which tracks the path off all fractions of the waste. Where the WWTP system boundary covers a community/catchment, a geographical map may be more helpful. WWTP system and process water flow diagrams can be a simple engineering schematic joining the various components (Figure 13), or a system process diagram which uses standard process flow symbols (Figure 8). In larger systems, it may be more appropriate to generate a simplified schematic, referencing more detailed process flow information held in other technical drawings. It is important to ensure that the mapping is accurate and not simply a desk-based exercise. For this reason, site visits should be conducted both as part of the mapping exercise and for collecting information required in the following next steps.

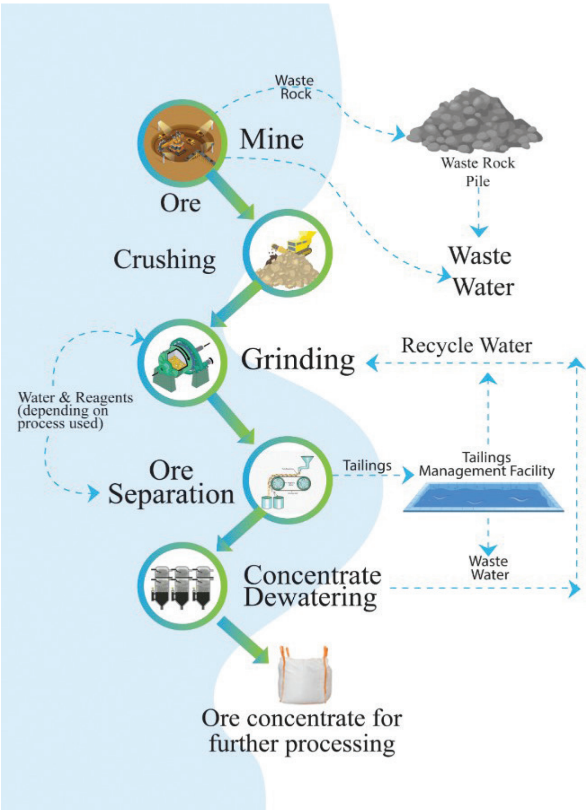


Figure 13. Typical metal mining water processing diagram and needed information for system map

- Include all sources of wastewater – both point and non-point sources such as runoff.
- Ensure the fate of all used and disposed parts of the waste stream have been accounted for (e.g. use or disposal for processing, domestic usage, soils, surface or groundwater, air).
- Identify all significant existing potential barriers– e.g. detention ponds, septic tanks.
- Include flow rates where known.
- Include capacity or design loading of components where known (e.g. treatment plant flow or loading limits, transfer system capacities).
- Include drinking-water sources where this is relevant to the system or could be affected by the sanitation system [23]

4.8.3 GUIDANCE NOTE FOR TREATMENT OF WASTEWATER AND PROCESS WATER

A wide range of treatment technologies and processes are available for removing and reducing contaminants in process wastewater [32] (Figure 9). To avoid high pollution fees, treat wastewater and recycle.

- ☐ Typical treatment plants process liquid wastes through a series of stages where reagents are added to precipitate out various contaminants and concentrate them in a waste sludge or fines which can then be managed for long term waste storage.
- ☐ Rivers receiving treated effluent must have a minimum volume at least 5 times greater than the volume of the effluent.
- ☐ Liquid waste from mine processing facilities must be treated and contaminate levels lowered to acceptable limits before discharge into receiving waters.
- ☐ Site drainage water and water pumped from dewatering sites has low-level contamination from sedimentation and can be treated in simple settling ponds.
- ☐ Water pumped from dewatering wells is often clean and usable for water supply or it can be moved offsite with no risk to natural surface or groundwater.
- ☐ Recycled waters must only be treated to the quality level required by the process they will be fed back into. Often this only means allowing heavier sediments to settle out prior to reuse.

Effluent from treatment plans should have significantly lower levels of contaminants than the waste stream being treated, and if required standards are met the effluent can be released to receiving waters (Table 24, Table 25).

4.8.4 ASSESSMENT ON MONITORING OF TAILINGS STORAGE FACILITY (TSF)

This inspection is to evaluate the performance of the tailings facilities.

Step1. Check the operating manual for the Tailing Storage Facility. The operating manual should cover all pertinent information with respect to operation, rehabilitation, and closure, including sufficient details to enable mine management and operational personnel to readily understand and implement the operational requirements. It also includes requirements for monitoring and auditing and form inspection checklists.

Step 2. Check the monitoring programs including geotechnical observations, water quality monitoring and water balance.

Geotechnical observations: standard forms for recording and reporting observations from visual inspections and data obtained from geotechnical monitoring systems such as to check the condition of the embankments, liners, pipelines, and water control facilities. Observations will be recorded in a field note. Special attention will be given to any toe and bank erosion, distinct changes in vegetation growth, plugged pipelines or drains, and the actual operation of any monitoring instrumentation. For example, in metal mines, monitoring systems will be installed downstream (outside) of the northern and southern embankments of each tailings storage cell, downstream of all the embankments of the Water Holding Dam and downstream of the seepage collection trench. If seepage is detected, a series of bores will be installed to recover any water, which is below the quality of the existing groundwater.

Water quality monitoring: Monitoring of surface waters and groundwater wells below the tailing storage will be conducted throughout the life of the project to assure early detection of any contaminant leakage. The groundwater monitoring program around the tailings will be designed to measure any changes in existing groundwater conditions downgradient of the tailing storage. Monitoring wells will be used in combination with piezometric wells to measure pore pressures within the actual embankment of the tailings.

Water Balance: Monitoring of the water balance will serve to indicate if any significant and unexplained water losses or gains in this system are occurring. Such losses or gains could indicate seepage or other problems along the closed-circuit water supply system.

The information needed to construct an annual water balance will include: Precipitation data, runoff volumes, tailings levels, tailings density and evaporation

Additional monitoring measures:

If necessary, to implement some additional measures, the following work will be done during the exploitation of the deposit

- To determine on weekly basis the mud composition and target (it depends the mine type) concentrations of the tailing waste in the pipeline
- To determine on weekly basis the temperature of the tailing waste in the pipeline
- To determine on weekly basis the grain size of the tailing waste in the pipeline
- Measure on quarterly basis the wall thickness of the pipeline for tailing waste drainage and implement necessary measures

Step 3. Check the risk assessments and possible issues of TSF depending on the mining activity stage. Here is shown the example of tailing facility issues and some possible actions for all three mines.

Table 4. TSF Water Issues and Actions

No:	Issues	Common actions
1.	Water quality	*In planning phase*
		Design drainage around boundary of pits, process plant, tailings storage.
		Design sediment control structures.
		Construction phase
		Collect any water from the construction area and dispose into the wastewater pond.
		Precipitation falling on the construction site will be collected in temporary infiltration basins or sediment control structures to remove sediment, thus minimizing impacts to underground water.
		Test peripheral drainage.
		To detoxify the tailings of soluble trace metals so there is no risk of groundwater contamination.
		Trace metals in tailings will be neutralized so that any water entering the groundwater system is benign.
		Operation phase
		Collect any water from the area of the mine, processing plant, warehouses and other constructions, and access roads to above-mentioned buildings immediately and pump the collected water into the process.
		Maintain, monitor and provide safe conditions in the sediment pond according to regulations and standards.
		Maintain, monitor and provide safe conditions at the tailing storage according to the regulations and standards.
		Disinfect drinking water by chlorine dosing.
		Regular testing for mercury, arsenic and other metal contamination.
		Reclamation & Closure phase
		The vegetation cover returned to open surfaces as soon as practical after exposure or completion of use.
		Sediment control structures will keep turbid water from entering surface streams.
		Sediment control structures will be removed after vegetation has controlled erosion.
2	Water resource: Extract water daily during winter and less through other seasons.	*In planning phase*
		Identify and supervise the boreholes to be exploited.
		Revise abstraction strategy pumping infrastructure and peak capacity.
		Match screen diameters, yields and pumps.
		Construction phase
		Equip boreholes according to the requirement.
		Implement variable rate (step) testing during installation.
		Construct storage tank, pipeline and other hydro-technical engineering facilities according to the requirements.
		Operational phase
		Rational use of water resources through management/control.
		Regular monitoring and assessment of water balance.
		Determine borefield management and pumping schedules by balancing abstraction over the aquifer and management of drawdown.
		Reclamation & Closure
		Return surface drainage to its original channels.
		Return boreholes to the soum.

3	Flooding and failure of dams	*In planning phase* Consider the possible flood event in designing the flood protection channels. The tailings disposal pipeline will consist of two parallel lines (one line in operation and the other one for reserve) contained inside a bund. Design to be capable of draining waste per day (or how much m^3/h). To distribute the tailing waste regularly all over the area of the tailing storage, a pipeline will be designed along the ridge of the dam.
		Construction phase Build the flood protection channels on both sides of the tailing storage, and along the dam. Build and protect the monitoring wells at tailings storage. Test the security of flood protection channels of the tailing storage.
		Operation period Distribute tailings regularly around storage by using periodic change of standpipes. Keep water level on the tailing storage low. At the thaw, store excess water from the tailing storage in the water holding dam. Use returned tailing water in the process in preference to all other water.
		Reclamation & Closure phase Leave the flood protection channel in operation whilst the storage area is being rehabilitated. Cover the surface of the reclaimed storage area to contain flooding rains. Install overflow drain in reclaimed storage as an added precaution.
4	Mine Dewatering and Borefield	*In planning phase* A water management plan to be completed to enable the effective management of water issues.
		Operation phase Operate the dewatering system in a manner that ensures the water table is at a level beneath advancing pit faces to enable the operation to remain in a sufficiently dry state;
		Operate the bore fields on a demand basis determined by the levels in the process water and raw water ponds. Control the system by level gauges with feedback to operators.
		Monitoring: Acid Mine Drainage
5	Ice lenses within the tailing storage	*In planning phase* Design raises for winter use.
		Construction phase Build to have a minimum freeboard of 1 m at the end of winter.
		Operation period Regular monitoring and appropriate maintenance of ice event. Heat the tailings.
		Reclamation & Closure phase Reclamation cannot start until ice is thawed and water separated.

6	Water erosion: Runoff during spring snowmelt, occasional summer rainstorms, cause seasonal flooding within the valley;	*In planning phase* Measures to intercept, divert, or otherwise reduce the stormwater runoff from exposed soil surfaces, tailing storage and waste rock dumps. Vegetative and other soil stabilization measures. Sediment control structure (e.g., detention/retention basins) to treat surface runoff prior to discharge to surface water bodies.
		Construction phase Construct to design: 1. Drainage and catchment below the plant site and waste dump. 2. Drainage around tailing storage.
		Operation Minimize area of disturbance, restrict entry of runoff to the site, encourage infiltration, manage water leaving the site. Control erosion in the mine using the following principles: -200 final slope on waste dumps, -catch berms every 20 vertical meters on dumps, -collect water flow for controlled discharge. All erosion control and sediment containment facilities will receive proper maintenance during their design life.
		Reclamation & Closure After completion of the project, continue to maintain the flood protection and wastewater collection and discharge system until the end of rehabilitation of all affected areas. Post closure monitoring.

Step 4. If they have problems, recommend some new technologies in Figure 9.

Step 5. Take the samples for controlling the quality of wastewater and penetration.

Step 6. Look at the changes of some key variables before mining and now.

Step 7. Write the notes and conclusions of TSF performances.

4.9 CALCULATION OF WATER POLLUTION FEE

According to Article 3.1.32 of the Law on Water, "water pollution fee" means a fee to be paid in discharge or disposal of water with a content that meets the treated water standard.

According to Article 3.1.33, "water pollution compensation" means the payment to be made in case of removal and disposal of water with a content exceeding the treated water standard [9].

4.9.1 ASSESSMENT OBJECTIVE:

Assessment of whether the impacts of mining operations on water quality have caused higher concentration in wastewater than the permitted levels of national standards to ensure regulatory compliance and if necessary to allow for the calculation of pollution fee. The calculation of pollution fee also provides the opportunity to evaluate water use and therefore to check that water usage amounts and fees are accurate.

4.9.2 WATER POLLUTION FEE CALCULATION PARAMETER

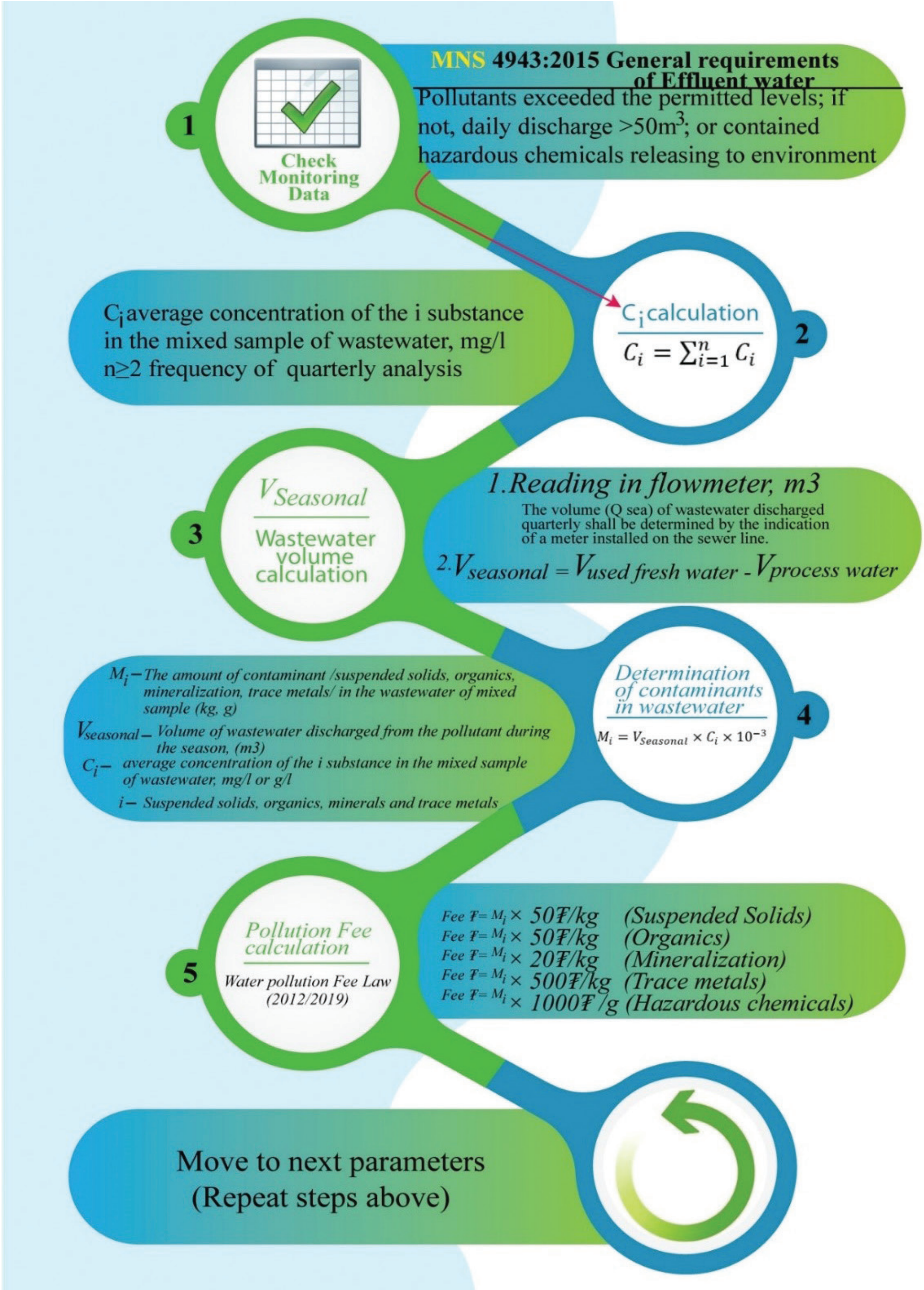
According to Article 25.1 of the Water Law, if the quality of wastewater meets the requirements of the standard, the water pollution fee shall be paid, and if it does not meet the standard requirements, the water pollution compensation shall be increased by 2-5 times depending on the amount of pollutants in the wastewater.

If less than 50 m3 of wastewater is generated per day, charges will be charged by standard. If wastewater containing more than 50 m3 of hazardous pollutants are released to the environment per day, charges will be charged for each type of pollutant [9, 43].

The amount of payment is determined by the type of water pollutant [43]. For example; if the total suspended solids is to be calculated directly from the suspended solids, the types of organic substances shall include COD , BOD, fats, organic phosphorus and nitrogen, as well as petroleum products, minerals including anions, cations, heavy metals and hazardous pollutants as shown in the table below. See annex 3.5 for a list of hazardous chemicals/contaminants (Table 28).

Pollutants	Unit	Payment range /₮/	
		min	max
Suspended Solids	kg	50	1000
Organics	kg	50	1000
Minerals	kg	20	400
Trace metals	kg	500	10000
Hazardous chemicals	g	1000	10000

If the mine treats and recycles wastewater for industrial and service purposes and if it is found that the wastewater is treated to the standard level of wastewater using the wastewater treatment plant, it is exempted from payment for three years from the date of installation and use of the wastewater (Article 8 of the Water Law) [9, 43]. Payment will be calculated according to the following step-by-step instructions.



4.9.3 CALCULATION EXAMPLES

Here are the examples used by the published materials and annual environmental management reports of three mines.

Table 5. Non--incremental calculation of water pollution compensation [43]

Steps	Coal mining	Metal mining	Placer mining
Check monitoring data and find higher concentrations than the permitted level (Table 25) MNS 4943:2015)	Dam water mineralization was higher than the standard (1000 mg/l), and arsenic concentration in dam water was higher than the 0.01 mg/l as permitted level.	Most of the lab data was under the detection limit of the equipment. B, Se, Sr concentrations were higher than the standards 0.5, 0.02 and 2, respectively in TSF water	Most of the mining companies are not measuring the downside of the streams. There was no data. So we used published material for this case. SS, Fe, Al and As concentrations were higher than the standard, 30, 1, 0.5 and 0.01, respectively.
Concentration calculation, mg/l	1784.1 =anion+cation As=37.1 µg/l=0.037 mg/l	B (мг/л) / Se мг/л / Sr мг/л 0.778 / 0.038 / 8.2 0.734 / 0.083 / 11.0 0.919 / 0.1 / 12.4 1.533 / 0.086 / 13.9 **Ci=0.991** / **0.08** / **11.4**	SS =39 mg/l Fe= 12.7 mg/l Al=11.9 mg/l As=0.01mg/l
Wastewater volume calculation, m^3	3038166 m^3 water leaked from open pit	80466 m^3 water leaked from the open pit and TSF	The water will be used in the Screens a total of 619900 m^3
Determination of contaminant in wastewater, kg	Mineralization (kg)=3038166 l*1784mg/l*10^{-3}= 5420088 kg As=3038166m^3*0.037mg/l*10-3=112.4kg	B (kg)=80466m3*0.991mg/l*10^{-3}= 80 kg Se (kg)=80466m3*0.08mg/l*10^{-3}= 6.2 kg B (kg)=80466m3*11.4mg/l*10^{-3}= 916 kg	SS =619900 m3*39mg/l*10^{-3}=24176 kg Fe =619900m3*12.7mg/l*10^{-3}= 7873 kg Al=619900m3*11.9mg/l*10^{-3}= 7377 kg As=619900m3*0.01mg/l*10^{-3}= 6 kg
Pollution fee calculation	Mineralization=5420088 kg*20=108401762₮ As=112.4kg*100 0g*1000₮=112400000₮	B=80 kg*500=40000₮ Se=6.2 kg*500=3087₮ Sr=916kg*1000=916105₮	SS=24176kg*50=1208805₮ Fe=7873 kg*500=3936365₮ Al=7377 kg*500=3688405₮ As=6kg*1000g*1000=600000₮

4.9.4 POTENTIAL DATA SOURCES

In the first instance, environmental authorities should be contacted for information on potential data sources (e.g. existing environmental monitoring program) on chemical concentrations in different media (e.g. wastewater, river water). In addition, existing WWTPs may have ongoing monitoring activities that can provide valuable data on chemical hazards. Industrial entities or published references [39] may also be consulted where industrial waste is of concern. In case of poor data availability, the collection and analysis of environmental samples that are obtained from specific waste fractions or environmental media may be warranted.

CHAPTER V
CASE STUDIES OF TARGETED AREAS

5.1 COAL MINING

Coal Mining and Water Issues

How to perform the site inspections?
What are the main problems with water in coal mining?

OVERVIEW

A coal mine drainage ranges widely in composition from acidic to alkaline, typically with high concentration of sulfate (SO_4^{2-}), iron (Fe), manganese (Mn) and aluminum (Al) as well as some common elements like calcium (Ca), sodium (Na), potassium (K) and magnesium (Mg), which can seriously degrade the aquatic habitat and the quality of water supplies because of toxicity, corrosion, scale and other effects from dissolved constituents [35]. Therefore, the biggest environmental threats posed by surface coalmines are water resource pollution and decline, acid rock drainage, and land degradation. Acid mine drainage occurs when pyrite and sulfide minerals contact water and oxygen in air. Understanding of the physical and chemical processes that take place during the mining, processing, and use of coal can help to identify, minimize, and/or mitigate undesirable environmental impacts [37].

This study will help us understand coal mining that is not limited to surface and ground water and average annual precipitation is 160 mm.

"**Problem:** For 3 years spent excavating a 650m long, 550m wide and 96m deep mine, the amount of water infiltrated into the mine is estimated to be 22,347 m^3/day or 931 m^3/hour. In this case, the mine is using six boreholes and one sump. Furthermore, two more ponds will connect to small natural lakes.

There is potential for contamination of groundwater with acid runoff. For example, external mine stockpiles can cause acid-base imbalances, which can affect surface and groundwater, causing pollution and acidic runoff."

MERIT| a case study on coal mining related water issues

APPROACH

- **Testing Content of Natural Water in coal mining:** Taking water samples from boreholes and lakes. Other chemical targets to analyze according to MNS 4943:2015, Effluent standard
- **Risk assessment**: Potential risk-Acid discharge
- **Occasional cause:** Heavy rains and spring floods
- **Worst possible consequence:** The absorption of heavy metals into the soil and surface water due to acid runoff.
- **Protective measures:** Regular monitoring; to organize training for employees; reduction of sulfide minerals in waste; increase the content of minerals that neutralize acidity; reduce process of water leaching and infiltration; control of bacterial and biogeochemical processes; drainage ditches to be constructed to reduce the risk of flooding.
- **Signal recurrence:** Once in 15 years
- **Improvement of the water management system**
- **Looking for possible technology for land injection of water**

RESULTS

6.3

pH of surface and groundwater samples ranges between 6.3 and 8.31, which is almost belonging to the average standard ranges 6.5–8.5.

639 mg/l

Cl ion in sump water was higher than the standard, 350 mg/l

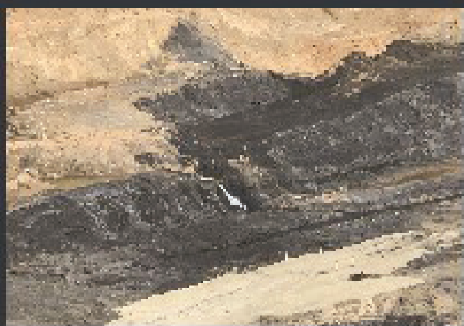
37.1µg/l

Arsenic (As) in sump water was higher than the standard, 10 µg/l

CONCLUSION

Monitoring data of underground and surface water concluded that the COD, NO_2, NH_4^+, Cl^- and SO_4^{2-} in the water is higher than specified the standard. Nitrite (NO_2) and chloride (Cl^-) are indicators of nutrient pollution, and sulfate (SO_4^{2-}) is formed in water because of dissolution of sulfur compounds in soil and rocks and biochemical processes that take place there. Ammonium (NH_4^+) is formed because of the decomposition of microorganisms and indicates biological or animal manure contamination. This means that the lake downstream of the pumped water from the open pit is being polluted with nutrients.

Additionally, continuous monitoring of trace metals and ARD tests in the pumped water and borehole near the surface soil/waste rock pile is required.



MERIT| A case study on coal mining related water issues

5.2 PLACER MINING

Placer mining and River water quality

(Environmental management plan and literature review)

How to perform mining water quality inspection using the documents?

1. Review the EMP of the placer mine, focusing on what are the main effects of this mine on the environment? Are the water quality and quantity monitoring methods accurate?
2. Research case studies: Looking at published research articles on habitat assessment.
3. Learn how to assess possible issues.
4. What are the actions we request from the mine?

In the EMP, it states:
"The water from the industrial tailings pond will be wastewater with a negative impact.In the case of the mine's concentrator, the process water will be collected in a recirculation reservoir and reused in the process. **Technological waste disposal method:** The traditional method of disposal is to directly dispose waste to tailing reservoir.

Vegetation and topsoil from the pond area will be removed and later used for reclamation and infertility rehabilitation. The bottom of the circulating reservoir will be covered with a protective layer and will consist of a layer of compacted natural clay (fine-grained stone and clay to prevent water infiltration) and polyethylene film The washed sand from the gravity concentrate is deposited in the tailings pond, the resulting liquid is pumped out and used back for technological purposes.
Although the plant does not discharge wastewater into soil or water sources, care must be taken to avoid any leakage".

Habitat assessment of Tuul River

Impact to the downstream (Baikal Lake)

Suspended river concentrations are much higher than the dissolved concentrations. The placer gold mining at the Zaamar site has increased the total riverine mass flows of Al, As, Cu, Fe, Mn, Pb and Zn by 44.300, 30.1, 65.7, 47.800, 1.480, 76.0 and 65.0 tonnes per year respectively [38].

MERIT | A Case Study | Placer mining and River water quality

Why we needed to do the case study?

In the EMP,

-There was no water leakage to the Tuul River due to the protection layer and design of the pond.

-No leakage from the storage facility or pond.

-No explained information about the wells controlling the ground water quality and penetration of the water pond and screening.

-Tuul River system is the main source of drinking water for herders and livestock downstream

What we have learned from measurement?

Sediment (key parameter) in Rivers

*Stream total load: Total amount of sediment

- Bed load. -Coarse particles moving along the bottom of the river channel, less than 10% of the total load

*Suspended load

- Accounts for about 90% of its total load and makes the river look muddy

*Dissolved load

- Carried in chemical solutions, such as HCO3-, SO42-, Ca2+ Na+, Mg2+

*Stream competence and capacity

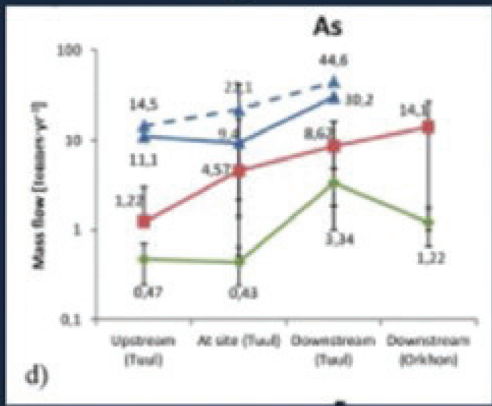
Competence

- Largest particle a river may transport

Capacity

- Total load by mass or weight of sediment that a river carries in a period of time

Results that Speak Volumes



- Using the literature review for decision-making and to understand the real impact of mining activities.
- Using long-term data
- Using the easy visual habitat assessment
- Learning how to use the data
- Request impact mitigation actions from the mining companies.

" The Selenge River Basin, which drains into Lake Baikal, should be recognized as one of the world's most impacted areas with heavy metals, and it contributes to dissolved Fe (1%) and Pb (3%) of the world flux".

Josefin Thorslund et al; Gold mining impact on riverine heavy metal transport in a sparsely monitored region: upper Lake Baikal Basin case, 2012

MERIT | A Case Study | Placer mining and River water quality

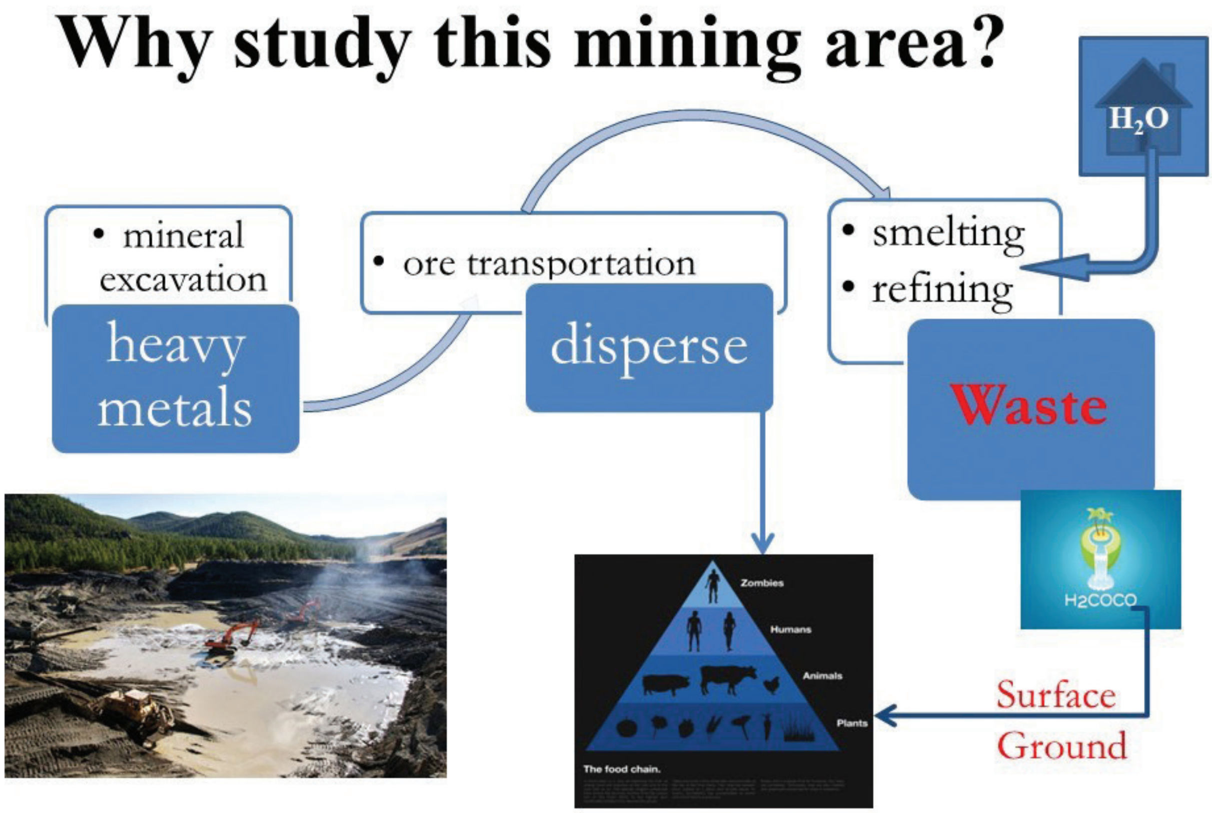
5.3 METAL MINING

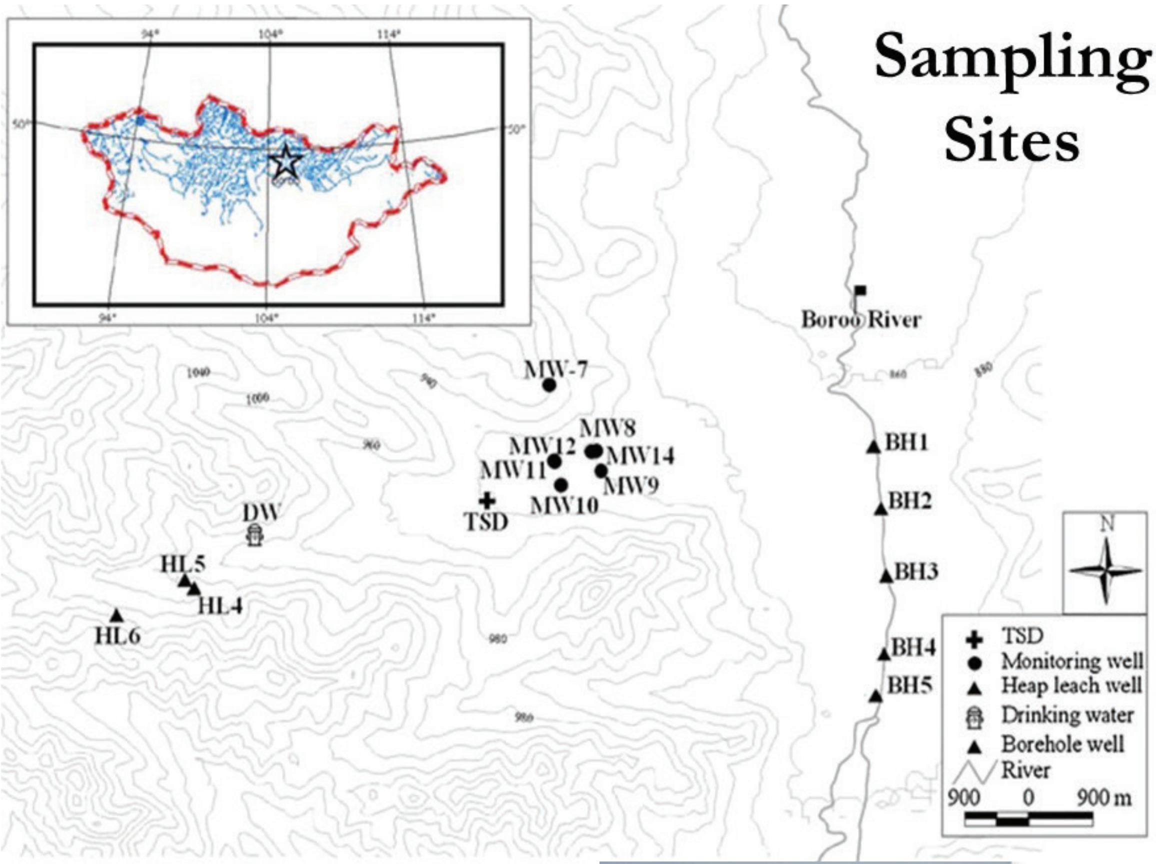
Geochemical distribution of trace element concentrations in the vicinity of Boroo gold mine, Selenge Province, Mongolia [41].

- To assess levels of trace metals in water, waste, and soils due to mining.

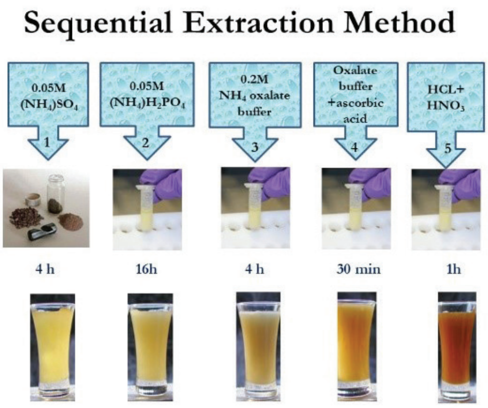
To understand risks to humans **Research purpose**

- And water supply.

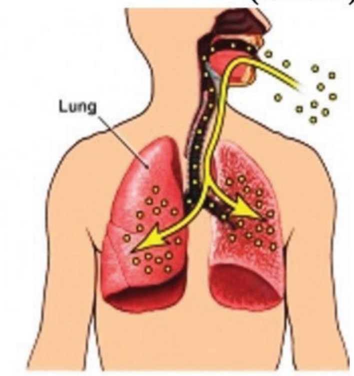



Sampling
Sites
Boroo River
MW-7
MW8
MW12
MW14
MW11
MW9
MW10
TSD
DW
HL5
HL4
HL6
BH1
BH2
BH3
BH4
BH5
N
TSD
Monitoring well
Heap leach well
Drinking water
Borehole well
River
900 0 900 m


Sequential Extraction Results
Non-specific
Specially sorbed
Amorphous Fe oxides
Crystalline Fe oxides
Residual
mg/kg 7.4 64.4 716.8 14.9 2856
<1% ~3% 12-18% minor 78-82%
The recovery of total 3660 mg/kg of arsenic is 93.4%


Sequential Extraction Method
0.05M (NH4)SO4
0.05M (NH4)H2PO4
0.2M NH4 oxalate buffer
Oxalate buffer +ascorbic acid
HCL+ HNO3
1 2 3 4 5
4 h 16h 4 h 30 min 1h

Simple Bioavailability Extraction Test (SBET)

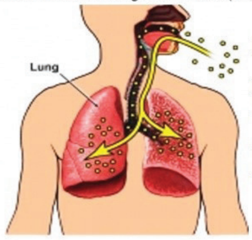


Synthetic stomach fluid pH=1.5

SBET Results

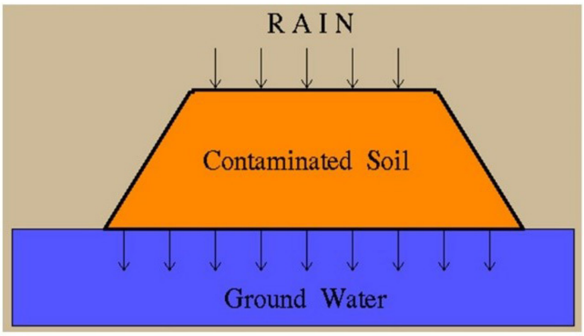
	As (mg/kg)
Summer sediment	288.2 (6.5%)
Mongolia soil standard [a]	6.0

[a] MNS 5850:2008 Mongolian standard (2008)



Mine workers may potentially take up these toxic elements through normal work activities.

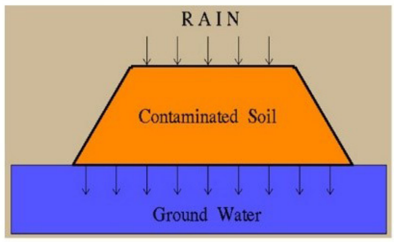
Leaching Experiment



Leaching Experiment Test Results

	As (mg/l)	pH
Sediment	1.3 (0.3%)	9.5
[a] Standard	0.01	6.5-8.5

[a] WHO water guideline (2006)



ANNEX I. WATER QUALITY PARAMETERS [42]

pH: expressed in terms of the amount of hydrogen ions, indicates the acidity or alkalinity of the aquatic environment. A pH range of 1 to 14 indicates strong acidity at pH 1 and strong alkalinity at 14 pH. The natural aquatic environment pH is weakly acidic to weakly alkaline (6.5-8.5), usually close to neutral, and this value is equivalent to the drinking water standard. Strong acidic and alkaline pH values are commonly observed in industrial water. In some cases, the water pH of mines and ore mills is close to 1. Changes in the pH of water cause other chemical changes that indirectly affect life in the aquatic environment. For example, low pH increases the solubility of some heavy metals. This allows heavy metals to be easily absorbed by aquatic organisms.

Electric Conductivity (EC): measures water's ability to conduct electricity due to the presence or absence of certain ions. While pure water conducts electricity poorly, water that has certain chemicals or elements in it, and at varying amounts—including sodium, magnesium, calcium, and chloride—is a better conductor of electricity. Because the electrical current is transported by the ions in solution, the conductivity increases as the concentration of ions increases. The SI unit of conductivity is Siemens per meter (S/m). EC is easily measured in situ using a hand held meter and regular monitoring of EC can give an indication of pollution events when there is an unusual spike in EC.

Total Dissolved Solids (TDS): refer to any minerals, salts, metals, cation, or anion dissolved in water. Total dissolved solids comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter that are dissolved in water. TDS (mg/l) =EC (µs/cm) *2/3

Water temperature: changes in water temperature have extreme biological effects on the life cycles of aquatic organisms. In general, as the temperature of water increases, the amount of oxygen dissolved in the water decreases and there is a tendency for pollutants to increase. Water temperature affects the rate of chemical reactions in general and many water quality parameters are temperature dependent.

Dissolved Oxygen (DO): Aerobic aquatic organisms require oxygen to survive, the same as do terrestrial organisms. There are two sources of oxygen dissolved in water: (1) equilibration of atmospheric oxygen with the water, and (2) production of oxygen by aquatic plants through photosynthesis. If photosynthesis contributes more oxygen to the water, DO will become supersaturated with oxygen. On the other hand, if aquatic organisms consume oxygen at a rate faster than it can be replaced, DO levels are reduced. When ≤ 4 ppm, the water DO is hypoxic. This is the bare minimum DO concentration required for diverse aquatic life. If all the oxygen is consumed, DO = 0, and the water is anoxic. When this happens, there is a complete change in the chemistry and biology of the water. Only anaerobic organisms can survive, and the chemistry changes from oxidizing to reducing. Hypoxia or anoxia results when the water contains oxygen-demanding substances. These are generally organic compounds that are consumed by aquatic microorganisms. Consumption, i.e. respiration, requires oxygen, which the organisms derive from the water. As the concentration of oxygen-demanding substances increases, the DO decreases.

Suspended solids (SS): refers to small solid particles which remain in suspension in water as a colloid or due to the motion of the water, suspended solids can be removed by the sedimentation because of their comparatively large size. It is used as one indicator of water quality. Total Suspended Solids (TSS) is the filterable solids in a water sample. Samples are filtered through a glass fiber filter. The filters are dried and weighed to determine the amount of total suspended solids in mg/l of sample; (on the outflow for functioning wastewater treatment plants this is usually up to 25 mg/l).

Biochemical Oxygen Demand (BOD5): is a test used to measure the concentration of biodegradable organic matter present in a sample of water. The BOD is measured by culturing a water sample in oxygenated dilution medium at 20ºC for 5 days. It can be used to infer the general quality of the water and its degree of pollution by biodegradable organic matter. It is used in water quality management and assessment, Ecology and environmental science. BOD is not an accurate quantitative test and should be considered as providing an indicator of the quality of a water body; water from households has an average value of usually 300 - 400 mg/l, treated water has this value less than 30 mg/l.

Chemical Oxygen Demand (COD): test is commonly used to indirectly measure the organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers), making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution. Older references may express the units as parts per million (ppm); chemical consumption of oxygen, i.e. the index of contamination; its value (usually stated in mg/l) states how large a part of the contamination has an organic origin; water from households has an average value of 600 - 800 mg/l, treated water has less than 100 mg/l.

Turbidity: Turbidity is a measure of the relative clarity of a liquid. Natural water, especially the running river, is often turbid. Factors that increase water turbidity are soil erosion, increased nutrients from algae flowering, wastewater, and bottom-eating predators, which are caused by excessive movement of bottom sediments. Excessive turbidity of water reduces the ability of sunlight to penetrate the water surface, resulting in lower photosynthesis and a decrease in the amount of oxygen produced by aquatic plants.

The redox potential (REDOX): is important in determining the type and transition conditions of chemical elements in water, and Eh is directly related to pH. A positive redox potential indicates the ability to accept electrons (i.e., it is an oxidizing agent, oxidant) and a negative redox potential indicates the ability to donate electrons under those conditions (i.e., it is a reducing agent, reductant). Because free electrons do not accumulate in water, the oxidation of one substance follows the release of another. Therefore, the valence of the reactant's changes during oxidation and reduction. Oxidation-reduction reactions play an important role in explaining the processes taking place in natural reservoirs. The state of natural water depends on the nature of the oxidation-reduction process, its kinetic properties, and the value of the redox potential that occurs in each system at equilibrium.

Cyanide: Cyanide is a toxic chemical compound which is used in the recovery of gold in many facilities that process gold ore and some cyanide is discarded in tailings. It is also used in small amounts in some flotation separation circuits and cyanide compounds may also occur in wastewater.

Ammonia: Ammonia may be present in wastewater from mining operations as a result of the use of ammonium nitrate and fuel oil (ANFO) as a blasting agent.

Thiosalts: Sulphur oxide compounds, including thiosulphate and polythionates, formed when partial oxidation occurs during the milling, grinding and floatation of some sulphide ores under alkaline conditions. Thiosalts can oxidize in water to form sulphuric acid.

Base metals: Base metals such as copper, lead, zinc, and arsenic, which are the target of mining operations, or are closely associated geologically with targeted base metals, can be present at elevated levels in wastewater and can be considered as contaminants if released to receiving waters

ANNEX II. MONITORING DATASHEETS

Table 6. Field datasheet

Site Code:_______________________ GPS: ______________________________________

Elev._____________________ Location: ____

____

Investigators:______________________ Form Completed By:__________________________

Date:_________________ Time Started: _____________ Time Completed ________________

Current Weather (X):

Heavy Rain______Steady Rain ________ Intermittent Showers________% Cloud Cover_____

Sunny_____ Other__________________

Weather Past 24 Hours (X)

Heavy Rain_____ Steady Rain_____ Intermittent Showers_____% Cloud Cover_____ Sunny_____

Other___________________

Habitat Type (X)

River_____Stream_____Spring_____Wetland_____Lake_____ Well _____ Borehole_____

Mining Facility Name ______________________Other______________________

Land-use Type in watershed (%)

% Grazing______ % Town_______ % Ger_______% Mining ______% Natural________ % Other___________

Note our relative position, upstream and downstream, collection localities and North, South, East and West

Description of Photos Taken:	**Coordinates**	**Direction**
(extra info in additional notes)		

Water Samples Collected: ___Yes ___ No ___

1)		
2)		
3)		

Onsite measurements

Parameter	**Measurement**	**Parameter**	**Measurement**	**Parameter**	**Measurement**
Air Temp.		DO ppm		Hardness	
Water Temp.		Turbidity		TDS	
Conductivity		Nitrite		pH	
Water level, m		Water meter reading m^3		Water balance =Input-Output	

Notes:

Table 7. Float method flow estimation worksheet

Location:		Date: Time:	
GPS:		Staff:	
Length of float section:			
Width of Stream:			
Depth Point	Depth Measurement (cm)	Float #	Float Time
1		1	
2		2	
3		3	
4		4	
5		5	
Average Depth		Average Time	
Width X Depth X (Length of Float Section/Average Time) X 0.85 = Discharge m^3/sec			
X X (/) X 0.85 = m^3/sec			

Table 8. Watermeter reading worksheet

No	Date and time	Name and type of the water source	Location	Facility name	Water level, m	Water reading, m^3	Water balance =Input-Output
1							
2							
3							
4							
5							
6							
7							
	Total amount	-	-	-			

Table 9. Custody chain for surface and groundwater sample

ДЭЭЖ БҮРТГЭХ МАЯГТ БОЛОН ХИЙЛГЭХ ШИНЖИЛГЭЭ/CHAIN OF CUSTODY and ANALYSIS REQUEST

Харилцах хаяг /All corresponence addressed to:

Үр дүнг явуулах хаяг /Final data emailed to:

Хүлээн авсан /Received

Лабораторийн нэхэмжлэхийн № /LAB. QUOTE:

Баримт бичгийн № /DOC No

Лаб баталгаа/Lab to confirm — урьдчилсан дүн өгөх хугацаа/preliminary date by / / ; эцсийн дүн өгөх хугацаа/and final report date by / /

CLIENT/ Захиалагчийн нэр:

Төслийн нэр/ PROJECT NAME:

COLLECTOR'S NAME/Дээж авсан хүний нэр:

Ажлын /TASK #:

Лав нэр/LAB.

ХИЙГДЭХ ШИНЖИЛГЭЭ/ANALYSES REQUIRED

Дээжний үр дүнг авах хугацаа/ REPORT TURNAROUND TIME: Хэвийн /Normal | 48 цаг/48 Hour | 24 цаг/24 Hour | *

№	Дээжний дугаар/SAMPLE ID	Дээж авсан өдөр/ Sampling date	Савны тоо/No OF BOTTLES	LAB #	Дээжний төрөл/MATRIX: Гүний ус /Ground water	Дээжний төрөл/MATRIX: Савласан ус/Bottled water	Дээжний төрөл/MATRIX: Хэрэглэсэн ус/Processed water	Дээжний төрөл/MATRIX: Цэвэршүүлсэн ус/Treated water	Хадгалалт/PRESERVATION: Хүчиллэгжүүлсэн/acidified	Хадгалалт/PRESERVATION: Байхгүй/none	1 pH	2 ЦДЧ/ЕС s/cm	3 Өнгө/Color	4 Амт/Taste	5 Үнэр /Odour	6 Булингар /Turbidity	7 Нийт ууссан хатуу нэгдэл /TDS g/L	8 Умбуур /Suspended Solids mg/L	9 HCO3 mg/L	10 CO3	11 Хатуулаг/Hardness meq/l	12 Calcium, Ca mg/L	13 Магни /Magnesium, Mg mg/l	14 Кали /Potassium, K mg/L	15 Натри/ Na mg/L	16 Фтор /Fluoride, F mg/L	17 Сульфат/Sulphate, SO4 mg/L	18 Хлор /Chloride, Cl mg/L	19 Нитрит /Nitrite as N	20 Аммони/Ammonia, NH3-N mg/L	21 Нитрат /Nitrate as N	22 Фосфат /Phosphate PO_4^{3-} mg/l	23 23 Хүнд металлууд/23 trace metals	24 Мөнгөн ус/Hg	25 БХХ5 /BOD5	26 ХХХ /COD	27	ТЭМДЭГЛЭГЭЭ/REMARKS
1																																						
2																																						
3																																						
4																																						
5																																						
6																																						

Хүлээлгэн өгсөн/Relinquished by:	Огноо/ Date:	Хүлээн авсан/Received by:	Огноо /Date:
Хүлээлгэн өгсөн/Relinquished by:		Хүлээн авсан/Received by:	

Хөргөгчийн байдал/Condition of cooler:

Битүүмжилсэн/Sealed: Тийм/Yes Үгүй / No

Температур/Temperature: Орчны/Ambient Хүйтэн/ Chilled

(Аль тохирохыг нь дугуйлна уу /Please circle as appropriate)

Table 10. Bacteriological sampling custody chain

Document number/: ___________________ Organization name/:___________________

Laboratory address/:___________________ Client/: ___________________

Sampling locations/:___________________ Sampling date/:__Year/Month/Day____

Sampling start time/:___________________ Sampling finish time/: ___________________

SAMPLE ID AND NAME/		SAMPLING Date/	SAMPLING TIME/	No. of CONTAINERS/
1	Raw water	Year/Month/Day	00:00	
2	Tap water			
3				
4				
5				
6				
7				
8				

Analysis required/:___________MNS 900-2018___Drinking water_________________

Sampling analysis within/: a) 24hour b) 72hour c) normal

Sample preservation/:____________ICE BOX___________________________________

Relinquished date and time/:___________ Report turnaround date and time/: ________

Collectors name and signature ___________

Table 11. Wastewater sampling custody chain

Document number/: ________________ Organization name/:________________
Laboratory address/:________________ Client/: __________________
Sampling locations/:__________________ Sampling date/:__Year/Month/Day____
Sampling start time/:__________________ Sampling finish time/: __________________

SAMPLE ID AND NAME/	SAMPLING TIME	No OF CONTAINERS/
1) WWTP inlet	Year/Month/Day: time	**300 ml**
2) After sand filter	Year/Month/Day: time	**300 ml**
3)	Year/Month/Day: time	**300 ml**
4) outlet	Year/Month/Day: time	**300 ml**

Analysis required/: MNS 4943:2015__Wastewater treatment plant effectiveness chemical and wastewater analyses

Sampling analysis within/: a) 24hour b) 72hour c) normal

Sample preservation/: ____________ ICE BOX_________________________________

Relinquished date and time/:_________ Report turnaround date and time/:________

Collectors name and signature/: _________________________________

Table 12. Physical Habitat Assessment field sheet of rocky bottom rivers [5]

(Note: Complete a separate assessment for each of your river sites)

Date____		**Habitat Assessment Rocky Bottom Rivers**	**Site #□**
Parameters 1 through 5: ASSESS WITHIN SAMPLING SITE.			
1. Substrate Habitat Types for BMI's and Fish		**4. Velocity/Depth Types**	
a. Check ALL substrate/cover types that are present and stable		a. Check ALL Velocity/depth types that are present	
□ threes that have fallen into river		□ show& deep	
□ submerged logs		□ show& shallow	
□ undercut banks		□ fast & deep	
□ cobble or large rocks		□ fast & shallow	
□ other stable substrate materials		(show is <0.3 meters/second; deep is> 0.5 meters/second)	
b. Check ONE category:	Points	b. Check ONE category:	Points
□ > 70% has mix of stable habitat types	8	□ all velocity/depth types present	8
□ 40 to 70% has mix of stable habitat types	6	□ 3 velocity/depth types present	6
□ 20 to 40% has mix of stable habitat types	4	□ 2 velocity/depth types present	4
□ <20% stable habitat; substrate unstable or absent	2	□ 1 velocity/depth types present	2
Score for Substrate Habitat Types:		Score for Velocity Depth Types:	
2. Embeddedness		**5. Frequency of Riffles**	
Check ONE category:	Points	Check ONE category:	Points
□ 0 to 25% embedded; rocks easy to move	8	□ occurrence of riffles very frequent	4
□ 25 to 50% embedded; rocks more difficult to move	6	□ occurrence of riffles common	3
□ 50 to 75% embedded; rocks are mostly buried	4	□ occasional riffles	2
□ 75 to 100% embedded; rocks cannot be moved	2	□ generally all flat water or shallow riffles	1
Score for Embeddedness:		Score for Frequency of Riffles:	
3.Sediment Deposition		**Subtotal Page 1**	
Check ONE category:	Points		
□<5% of riverbed effected by deposition	8		
□ 5 to 30% of riverbed effected by new deposition	6		
□ 30 to 50% of riverbed effected by new deposition	4		
□ >50% of riverbed changing frequently	2		
Score for Sediment Deposition		Add scores for #1+ #2 + #3 + #4 + #5=	

Parameters 6 through 10: ASSESS BEYOND SAMPLING SITE

6. Channel Flow Status		**7. Channel alteration**	
Check ONE category:	Points	Check ONE category:	Points
□ water reaches from bank to bank; minimal substrate exposed.	8	□ alteration minimal; river with natural pattern	4
□ water fills > 75% of channel;< 25% of substrate exposed.	6	□ some alteration present; usually near bridges	3
□ water fills 25 to 75% of channel; <0.5 meter deep.	4	□ alteration extensive; 40 to 80% of area disrupted	2
□ very little water in channel; mostly presents in standing pools	2	□ riverbanks artificially lined; >80% disrupted	1
Score for Channel Flow Status:		Score for Channel Alteration:	
8. Bank Stability- Score each bank, looking upstream			
LEFT Bank-Check ONE category:	Points	RIGHT Bank-Check ONE category:	Points
□ stable;<5% eroded or collapsed	4	□ stable;<5% eroded or collapsed	4
□ moderately stable; 5 to 30% eroded or collapsed	3	□ moderately stable; 5 to 30% eroded or collapsed	3
□ somewhat unstable; 30 to 60% eroded or collapsed	2	□ somewhat unstable; 30 to 60% eroded or collapsed	2
□ unstable; 60 to 100% eroded or collapsed	1	□ unstable; 60 to 100% eroded or collapsed	1
Score for Bank Stability- LEFT Bank:		Score for Bank Stability- RIGHT Bank:	
9. Riverbank Vegetation- Score each bank, looking upstream			
LEFT Bank-Check ONE category:	Points	RIGHT Bank-Check ONE category:	Points
□ >90% covered by natural vegetation	4	□ >90% covered by natural vegetation	4
□ 70 to 90% covered by natural vegetation	3	□ 70 to 90% covered by natural vegetation	3
□ 50 to 70% covered by natural vegetation	2	□ 50 to 70% covered by natural vegetation	2
□ <50% covered by natural vegetation	1	□ <50% covered by natural vegetation	1
Score for Riverbank Vegetation- LEFT Bank:		Score for Bank Stability- RIGHT Bank:	
10. Riparian Vegetation - Score each bank, looking upstream			
LEFT Bank-Check ONE category:	Points	RIGHT Bank-Check ONE category:	Points
□ width > 18 meters; no human impact	4	□ width > 18 meters; no human impact	4
□ width 12 to 18 meters; minimal human impact	3	□ width 12 to 18 meters; minimal human impact	3
□ width 6 to 12 meters; much human impact	2	□ width 6 to 12 meters; much human impact	2
□ width <6 meters; little or no riparian vegetation	1	□ width <6 meters; little or no riparian vegetation	1
Score for Riparian Vegetation - LEFT Bank:		Score for Riparian Vegetation - RIGHT Bank:	
TOTAL SCORE			
Subtotal Page 1 (#1+ #2 + #3 + #4 + #5): + Subtotal Page 2 (#6 + #7 + #8 + #9 + #10):___=			
Good Habitat: Score of 60 to 80- Fair Habitat: Score of 40 to 59- Poor Habitat: Score of 0 to 39			

Table 13. Physical habitat assessment field sheet for muddy bottom rivers [5]

(Note: Complete a separate assessment for each of your river sites)

Date____	**Habitat Assessment Muddy Bottom Rivers**		**Site #□**
Parameters 1 through 5: ASSESS WITHIN SAMPLING SITE.			
1. Substrate Habitat Types for BMI's and Fish		**4. Pool Types**	
a. Check ALL habitat types that are present and stable		a. Check ALL pool types that are present	
□ threes that have fallen into river		□ large & shallow	
□ submerged logs		□ large & deep	
□ undercut banks		□ small & shallow	
□ other stable substrate materials		□ small & deep	
b. Check ONE category:	Points	(shallow is <0.5 meter)	
□ > 50% of site has mix of stable habitat types	8	b. Check ONE category:	Points
□ 30 to 50% of site has mix of stable habitat types	6	□ Even mix of all 4 types	8
□ < 30% of site has mix of stable habitat types	4	□ Most pools large & deep; very few shallow pools	6
□ Very little stable habitat for BMI's and fish	2	□ shallow pools much more common than deep pools	4
		□ Most pools small & shallow, or pools absent	2
Score for Substrate Habitat Types:		Score for PoolTypes:	
2. Pool Substrate Types		**5. Channel Flow Status**	
Check ONE category:	Points	Check ONE category:	Points
□ Mix of substrate types, mostly gravel and firm sand	8	□ water reaches from bank to bank; minimal substrate exposed.	8
□ Mix of soft sand, mud, or clay	6	□ water fills > 75% of channel;< 25% of substrate exposed.	6
□ All mud, or all clay, or all sand	4	□ water fills 25 to 75% of channel; riffle substrates mostly exposed	2
□ Hard-packed clay or bedrock	2	□ very little water in channel; mostly presents as standing pools	1
Score for Pool Substrate Types:		Score for Channel Flow Status:	
3. Sediment Deposition		**Subtotal Page 1**	
Check ONE category:	Points		
□<5% of riverbed effected by deposition	8		
□ 5 to 30% of riverbed affected by new deposition	6		
□ 30 to 50% of riverbed affected by new deposition	4		
□ >50% of riverbed affected by deposition	2		
Score for Sediment Deposition		Add scores for #1+ #2 + #3 + #4 + #5=	

Parameters 6 through 10: ASSESS BEYOND SAMPLING SITE

6. Channel Alteration		**7. Frequency Bends**	
Check ONE category:	Points	Check ONE category:	Points
□ Alteration minimal; river with natural pattern	4	□ Bends increase river length 3 to 4 times if straightened	4
□ Some alteration present; usually near bridges	3	□ Bends increase river length 2 to 3 times if straightened	3
□ Alteration extensive; 40 to 80% of area disrupted	2	□ Bends increase river length 1 to 2 times if straightened	2
□ Riverbanks artificially lined; >80% disrupted	1	□ River is straight for a long distance	1
Score for Channel Alteration:		Score for Bends:	
8. Bank Stability- Score each bank			
LEFT Bank-Check ONE category:	Points	RIGHT Bank-Check ONE category:	Points
□ Stable;<5% eroded or collapsed	4	□ Stable;< 5% eroded or collapsed	4
□ Moderately stable; 5 to 30% eroded or collapsed	3	□ Moderately stable; 5 to 30% eroded or collapsed	3
□ Somewhat unstable; 30 to 60% eroded or collapsed	2	□ Somewhat unstable; 30 to 60% eroded or collapsed	2
□ Unstable; 60 to 100% eroded or collapsed	1	□ Unstable; 60 to 100% eroded or collapsed	1
Score for Bank Stability- LEFT Bank:		Score for Bank Stability- RIGHT Bank:	
9. Riverbank Vegetation- Score each bank			
LEFT Bank-Check ONE category:	Points	RIGHT Bank-Check ONE category:	Points
□ > 90% covered by natural vegetation	4	□ > 90% covered by natural vegetation	4
□ 70 to 90% covered by natural vegetation	3	□ 70 to 90% covered by natural vegetation	3
□ 50 to 70% covered by natural vegetation	2	□ 50 to 70% covered by natural vegetation	2
□ < 50% covered by natural vegetation	1	□ < 50% covered by natural vegetation	1
Score for Riverbank Vegetation- LEFT Bank:		Score for Riverbank Vegetation - RIGHT Bank:	
10. Riparian Vegetation - Score each bank			
LEFT Bank-Check ONE category:	Points	RIGHT Bank-Check ONE category:	Points
□ width > 18 meters; no human impact	4	□ width > 18 meters; no human impact	4
□ width 12 to 18 meters; minimal human impact	3	□ width 12 to 18 meters; minimal human impact	3
□ width 6 to 12 meters; much human impact	2	□ width 6 to 12 meters; much human impact	2
□ width < 6 meters; little or no riparian vegetation	1	□ width < 6 meters; little or no riparian vegetation	1
Score for Riparian Vegetation - LEFT Bank		Score for Riparian Vegetation - RIGHT Bank	
TOTAL SCORE			
Subtotal Page 1 (#1+ #2 + #3 + #4 + #5):___+ Subtotal Page 2 (#6 + #7 + #8 + #9 + #10):___=			
Good Habitat: Score of 60 to 80 - Fair Habitat: Score of 40 to 59- Poor Habitat: Score of 0 to 39			

ANNEX III. WATER QUALITY STANDARDS

Annex 3.1 MNS 0900:2018 environment. Health protection. Safety. Drinking water. Hygienically requirements, assessment of the quality and safety

Table 14. Tangible indicator of drinking water

No	Indicator name	Unit	Permissible maximum value
1	Taste	Point	2.0
2	Smell	Point	2.0
3	Color	Degree	20.0
4	Cloudiness	mg/L	1.5

Table 15. Natural indicators of chemical content of drinking water

No	Indicator name	Unit	Permissible maximum value
1	Molybdenum (Mo)	mg/L	0.07
2	Barium (Ba)	mg/L	0.7
3	Boron (B)	mg/L	0.5
4	Copper (Cu)	mg/L	1.0
5	Calcium ion (Ca^{2+})	mg/L	100.0
6	Magnesium ion (Mg^{2+})	mg/L	30.0
7	Manganese (Mn)	mg/L	0.1
8	Sodium (Na)	mg/L	200.0
9	Phosphate ion (PO_4^{2-})	mg/L	3.5
10	Fluorine (F)	mg/L	0.7-1.5
11	pH		6.5-8.5
12	Selenium (Se)	mg/L	0.01
13	Strontium (Sr)	mg/L	2.0
14	Sulfate ion (SO_4^{2-})	mg/L	500.0
15	Hardness	mmol/L	7.0
16	Chloride ion (Cl^-)	mg/L	350.0
17	Arsenic (As)	mg/L	0.01
18	Hydrogen sulfide (H_2S)	mg/L	0.1
19	Chromium (Cr)	mg/L	0.05
20	Dry residue	mg/L	1000.0
21	Uranium (U)	mg/L	0.015

Table 16. Chemical indicators of household and industrial contamination in drinking water

No	Indicator name	Unit	Permissible maximum value
	Inorganic substances		
1	Beryllium	mg/L	0.0002
2	Cadmium	mg/L	0.003
3	Mercury	mg/L	0.0005
4	Cyanide	mg/L	0.01
	Organic substances		
5	Benzene	mg/L	0.01
6	Xylene	mg/L	0.5
7	3-Nitril-acetic acid	mg/L	0.2
8	Dichloromethane	mg/L	0.02
9	Dichloro-ethane	mg/L	0.03
10	Trichloro-ethane	mg/L	0.07
11	Tetrachloride-ethane	mg/L	0.04
12	Phenol and its compounds	mg/L	0.002
13	Stearin	mg/L	0.02
14	Toluene	mg/L	0.7
15	Ethylbenzene	mg/L	0.3

Table 17. Chemical indicators of agricultural contamination in drinking water

No	Indicator name	Unit	Permissible maximum value
1	Ammonium ion (NH_4^+)	mg/L	1.5
2	Nitrate ion (NO_3^-)	mg/L	50.0
3	Nitrite ion (NO_2^-)	mg/L	1.0
4	Phosphate ion (PO_4^{3-})	mg/L	3.5
Pesticides			
5	Anthracite	mg/L	0.002
6	Carbopyran	mg/L	0.007
7	Lindane	mg/L	0.002
8	Molinate	mg/L	0.006
9	Endrin	mg/L	0.00006

Table 18. Chemical indicators of contamination producible during the quality improvement of drinking water

No	Indicator name	Unit	Permissible maximum value
Disinfection Substances			
1	Residual free chlorine	mg/L	0.3
2	Residual ozone	mg/L	0.1-0.3
3	Silver (Ag)	mg/L	0.1
4	Iodine (I)	mg/L	1.0
5	Chloramines	mg/L	0.1
Substance generated after disinfection			
6	Bromine ion (Br^-)	mg/L	0.01
7	Bromoform	mg/L	0.1
8	Bromo-dichloro-methane	mg/L	0.06
9	Dibromo-nitrile-acetate	mg/L	0.07
10	Dibromo-chloro-methane	mg/L	0.1
11	Chlorate ion (ClO_3^-)	mg/L	0.7
12	Trichloro-amine	mg/L	0.1
13	Dichloro-nitril-acetate	mg/L	0.02
14	Chloroform	mg/L	0.2
15	Monochloro-acetic acid	mg/L	0.02
16	Dichloro-acetic acid	mg/L	0.05
17	Trichloro-acetic acid	mg/L	0.2
Washing substances			
18	Polyacrylamide	mg/L	2.0
19	Epichlorohydrin	mg/L	0.0004
Substance generated by water distribution piping materials			
20	Vinyl chloride	mg/L	0.0003
21	Nickel	mg/L	0.02
22	Lead (Pb)	mg/L	0.01
23	Aluminum	mg/L	0.5
24	Antimony (Sb)	mg/L	0.02
25	Iron	mg/L	0.3
26	Zinc (Zn)	mg/L	5.0

Table 19. Safety indicators of microbiology of drinking water

No	Water source	Indicator	Permissible value
1	Centralized water supply	- Total amount of bacteria in 1ml water - Amount of E. coli in 100ml water - Amount of intestinal group pathogenic bacteria in 100 ml water	20 0 0
2	Non-centralized water supply	- Total amount of bacteria in 1ml water - amount of E. coli in 100ml water - Amount of intestinal group pathogenic bacteria in 100 ml water - To determine anaerobic thiooxidans and count colon. - protozoa and parasites	20 0 0 0 0
3	The other permitted water source (mine and tubular well, river, wells along the lake and pond shore, springs)	- Total amount of bacteria in 1ml water - amount of E.coli in 100ml water - Amount of intestinal group pathogenic bacteria in 100 ml water - To determine anaerobic thiooxidans and count colon. - protozoa and parasites	100 1 0 0 0

Table 20. The number of sampling for drinking water monitoring analysis per month

Service population number	The number of samples per month
up to 5000	2
5001-10000	5
10001-20000	10
20001-30000	40
30001-50000	80
50001-100000	160
above 100001	200

Table 21. Frequency and number of safety examination of microbiology

Service population	Inspection frequency	
	Source disinfected	Source not disinfected
up to 5000 5000-20000 20000-50000 and above	once per month once per 14 days once per week	once per week once per every 2 days once per day

Table 22. Drinking water quality, safety indicator, inspection, and frequency of assessment

No	Water type to be used as source	Sampling point	First year		Thereafter	
			Inspection frequency	Indicator	Inspection frequency	Indicator
1	Underground water 1. Centralized water supply 2. non-centralized water supply	Water source	Quarterly Quarterly PS: twice a year in center of soum	By all valid, standardized indicators for the examination method	Once a year Once a year	By the indicator defined by authorized organization
2	Surface water 1. centralized water supply 2. non-centralized water supply	Water source	Twice a month Once per month PS: Quarterly in center of soum	By all valid, standardized indicators for the examination method	Twice a month Quarterly PS: once a year in center of soum	By the indicator defined by authorized organization

Annex 3.2 MNS 6561: 2015 environment. Water quality. Effluent water for sewerage network. General requirements.

Table 23. MNS6561:2015

№	Name of the parameter	Unit	Permitted level
1	Water temperature	^0C	+30
2	pH	-	6-9
3	Suspended solids	mg/l	400
4	BOD	mgO/l	400
5	COD	mgO/l	800
6	Ammonia	mg/l	15
7	Total Nitrogen	mgN/l	30
8	Chloride	mg/l	1000
9	Sulfate	mg/l	700
10	Sulfide as H_2S, HS^-, S^{2-}	mg/l	5
11	Copper (Cu)	mg/l	1
12	Cadmium (Cd)	mg/l	0.05
13	Cobalt (Co)	mg/l	0.1
14	Mercury (Hg)	mg/l	0.005
15	Nickel (Ni)	mg/l	0.5
16	Selenium (Se)	mg/l	0.1
17	Total iron (Fe^{2+3})	mg/l	3
18	Lead (Pb)	mg/l	0.2
19	Aluminum (Al)	mg/l	0.5
20	Total Chromium (Cr)	mg/l	1
21	Chromium ($Cr^{6+)}$	mg/l	0.01
22	Arsenic (As)	mg/l	0.1
23	Zinc (Zn)	mg/l	5
24	Total cyanide (CN)	mg/l	0.1
25	Total phosphorous	mgP/l	5
26	Phenol (C_6H_5OH)	mg/l	0.5
27	All detergent	mg/l	10
28	Fat	mg/l	25
29	Mineral oil	mg/l	5
30	Total chlorocarbons	mg/l	0.3

Annex 3.3 MNS 4943: 2015 environment. Water quality. Effluent water for general requirements.

Table 24. MNS4943:2015

№	Name of the parameter	Unit	Permitted level
1	Water temperature	^0C	20
2	pH	-	6-9
3	Smell/odor	taste	Odorless
4	Suspended Solids	mgO/l	30
5	Biological Oxygen Demand	mgO/l	20
6	Chemical Oxygen Demand	mgO/l	50
7	COD permanganate	mgO/l	20
8	Dissolved salts/mineralization	mg/l	1000
9	Total nitrogen	mgN/l	15
10	Total Phosphorous	mgP/l	1.5
11	Hydrogen sulfide (H_2S)	mg/l	0.5
12	FAC (Cl_2)	mg/l	1
13	Barium (Ba)	mg/l	1.5
14	Beryllium (Be)	mg/l	0.001
15	Boron (B)	mg/l	0.5
16	Vanadium (V)	mg/l	0.1
17	Copper (Cu)	mg/l	1
18	Cadmium (Cd)	mg/l	0.03
19	Cobalt (Co)	mg/l	0.02
20	Manganese (Mn)	mg/l	0.5
21	Molybdenum (Mo)	mg/l	0.5
22	Mercury (Hg)	mg/l	0.001
23	Nickel (Ni)	mg/l	0.2
24	Selenium (Se)	mg/l	0.02
25	Strontium (Sr)	mg/l	2
26	Total iron (Fe^{2+3})	mg/l	1
27	Uranium (U)	mg/l	0.05
28	Lead (Pb)	mg/l	0.1
29	Total chromium (Cr)	mg/l	0.3
30	Chromium (Cr^{6+})	mg/l	0.01
31	Aluminum (Al)	mg/l	0.5
32	Arsenic (As)	mg/l	0.01
33	Zinc (Zn)	mg/l	3
34	Tin (Sn)	mg/l	0.05
35	Total cyanide (CN)	mg/l	0.05
36	Free cyanide (HCN)	mg/l	0.005
37	Phenol (C_6H_5OH)	mg/l	0.05
38	Benz(a) pyrene ($C_{20}H_{12}$)	mg/l	0.005
39	Fat	mg/l	5
40	Mineral oil	mg/l	1
41	All detergents	mg/l	2.5
42	Trichlorethylene (C_2HCl_3)	mg/l	0.2
43	Tetrachlorethylene(C_2Cl^4)	mg/l	0.1
44	Pathogenic bacteria		Not be detected in 1 ml

Table 25. Maximum tolerable soil concentrations of various toxic chemicals based on human health protection.

Elements	Soil concentration (mg/kg)	Organic compounds	Soil concentration (mg/kg)
Sb	36	Aldrin*	0.48
As	8	Benzene	0.14
Ba***	302	Chlordane*	3
Be***	0.2	Chlorobenzene	211
B***	1.7	Chloroform	0.47
Cd	4	2,4-D	0.25
F	635	DDT	1.54
Pb	84	Dichlorobenzene	15
Hg**	7	Dioxins	0.00012
Mo***	0.6	Heptachlor*	0.18
Ni	107	Hexachlorobenzene*	1.4
Se	6	Lindane*	12
Ag	3	Methoxychlor	4.27
Ta***	0.3	PAHs (as benzo (a) pyrene	16
V***	47	PCBs	0.89
		Pentachlorophenol	14
		Phthalate	13733
		Pyrene	41
		Styrene	0.68
		2,4,5-T (herbicide)	3.82
		Tetrachloroethane	1.25
		Tetrachloroethylene	0.54
		Toluene	12
		Toxaphene*	0.0013
		Trichloroethane	0.68

*chemicals with prohibited to use and import in Mongolia
** chemicals with limited usage in Mongolia
***The computed numerical limits for these elements are within the ranges that are typical for soils.
Source: WHO guidance, 2006; Vol2 pp 72

Annex 3.4 Surface water classification norm

Table 26. Surface water classification norm [26]

No	Parameter	Unit	I. Very clean	II. Clean	III. Slightly polluted	IV. Polluted	V. Very Polluted
1	DO	m/g	9<	8	6	4	<4
2	DO saturation	%	<90	75	60	40	<40
3	BOD_{20}	mgO/l	<3	5	10	15	15<
4	COD		<10	15	25	50	70<
5	H_2S		ND		0.1	1	1<
6	REDOX		<3	5	10	20	30<
7	Total Hardness	meq/l	<10	15	20	30	40<
8	Ca^{2+}	mg/l	<45	90	150	200	300<
9	Mg^{2+}	mg/l	<15	30	50	100	200<
10	TDS	mg/l	<200	300	500	800	1200<
11	Chloride		<50	150	250	350	500<
12	Sulfate		<50	100	200	300	400<
13	Ammonia	mg/l	<0.02	0.05	0.1	0.3	0.5<
14	Nitrite	mg/l	<0.002	0.005	0.02	0.05	0.1<
15	Nitrate	mg/l	<1	3	5	10	20<
16	Organic N	mg/l	<0.3	0.5	1	2	2<
17	pH		6.5-8.5	6.5-8.5	6.0-8.5	6.0-9.0	5.5-9.5
18	Total Fe	mg/l	<0.3	0.5	1	1.5	1.5<
19	Mn^{2+}	mg/l	<0.05	0.1	0.3	0.8	1.5<
20	Phenol	mg/l	ND	0.001	0.002	0.005	0.01<
21	Phosphate	mg/l	<0.02	0.05	0.1	0.5	0.5<
22	Total P	mg/l	<0.025	0.1	1	2	2<
23	Color		colorless	colorless	slightly colored	colored	
24	Turbidity	scale	35<	30	25	20	<20
25	Suspended solids	mg/l	10<	20	50	100	100<
26	Coli titration		>10	1	0.1	0.01	<0.01
27	Pathogenic Bacteria		ND	ND	ND	ND	ND
28	Total number of Microbes		<5.105	106	3.106	5.106	5.106<
29	CN^-	mg/l	ND	ND	<0.01	0.05	0.1<
30	Hg^{2+}	mg/l			0.001	0.005	0.005<
31	As	mg/l		0.01	0.02	0.05	0.05<
32	F	mg/l	0.2	0.5	1	1.5	1.5<
33	B	mg/l	ND	ND	0.5	1	<1
34	Se^{2+}	mg/l	ND	0.01<	0.05	0.1	<0.1
35	Zn^{2+}	mg/l	<0.2	1	2	5	5<
36	V	mg/l	ND	ND	ND	<1	1<
37	Cu^{2+}	mg/l	<0.01	0.05	0.1	0.5	0.5<
38	Cd^{2+}	mg/l	ND	0.005	0.01	0.1	0.1<
39	Co^{2+}	mg/l	<0.01	0.02	0.05	0.1	1<
40	Mo^{2+}	mg/l	<0.001	0.1	0.5	1	1<
41	Ag^{+3}	mg/l	<0.001	0.01	0.02	0.05	0.05<
42	Ni^{2+}	mg/l	<0.01	0.05	0.1	0.2	0.2<
43	Pb^{2+}	mg/l	<0.01	0.05	0.1	0.2	0.2<
44	Cr^{3+}	mg/l	ND	0.2	0.1	0.5	0.5<
45	Cr^{6+}	mg/l	ND	0.01	0.05	0.1	0.1<
46	FAC	mg/l	0	0	0	0.5	0.1<

Annex 3.5 List of hazardous substances of water pollution

Annex to the Minister's Order No. A/543, 2019, MET

Table 27. List of hazardous chemicals of water pollution

№	Chemical substances Mongolian name	Latin name	Chemical formula
1	Биндэр	Beryllium	Be^{2+}
2	Кадьми	Cadmium	Cd^{2+}
3	Мөнгөн ус	Mercury	Hg^{2+}
4	Уран	Uranium	U
5	Хар тугалга	Lead	Pb^{2+}
6	Хром (VI)	Chromium (VI)	Cr^{6+}
7	Хүнцэл	Arsenic	$As^{+3,+5}$
8	Цианид	Cyanide	CN^{-}
9	Бензо(а)пирен болон бусад олон цагирагт үнэрт нүүрстөрөгчид	Benzo[a]pyrene, polycyclic aromatic hydrocarbons (PAH)	$C_{20}H_{12}$
10	Бензол	Benzene	C_6H_6
11	Диоксин/Фуран (PCDDs/PCDFs)	2,3,7,8 Tetrachlorodibenzo-*p*-dioxin (TCDD)/Tetrachlorodibenzofuran (TCDF)	$C_{12}H_4CI_4O_2$/ $C_{12}H_4CI_4O$
12	Полихлорт бифенилүүд	Polychlorinated Biphenyls (PCBs)	-
13	Трихлорметан (хлорформ)	Trichloromethane (Chloroform)	$CHCl_3$
14	Тетрахлорэтилен	Tetrachloroethylene (PERC)	C_2Cl_4
15	Трихлорэтилен	Trichloroethylene (TCE)	C_2HCl_3
16	Фосфорт органик пестицидүүд	Organophosphate pesticides	-
17	Фенол	Phenols	C_6H_5OH
18	Хлорт органик пестицидүүд	Organo-chloro pesticides	-

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