Guidelines for the Assessment of Alternatives for Mine Waste Disposal

Disclaimer

For all purposes of interpreting and applying the law, users should consult:

- the Acts as passed by Parliament, which are published in the "Assented to" Acts service, Part III of the Canada Gazette and the annual Statutes of Canada, and
- the regulations, as registered by the Clerk of the Privy Council and published in Part II of the Canada Gazette.

The above-mentioned publications are available in most public libraries. Official versions of the Statutes and regulations can also be found at the Department of Justice website at http://laws.justice.gc.ca/en/index.html. The law as stated in the above-mentioned publications will prevail should any inconsistencies be found in these guidelines.

These guidelines are subject to amendments from time to time. Each version is dated, therefore users should ensure that they are always consulting the most recent version of these guidelines. Users can contact Environment Canada for this information.

Table of Contents

List of Tables

List of Figures

List of Annexes

1 Guidance for Proponents on the Federal Process for Designating Metal Mine Tailings Impoundment Areas

1.1 Context

It is expected that natural water bodies frequented by fish shall be avoided to the extent practicable for the long-term disposal of mine waste; and that mine waste shall be managed to ensure the long-term protection of Canada's terrestrial and aquatic environment.

Using a natural water body frequented by fish for mine waste disposal requires an amendment to the *Metal Mining Effluent Regulations* (MMER), which is a federal legislative action. The MMER, enacted in 2002, were developed under subsections 34(2), 36(5) and 38(9) of the *Fisheries Act* to regulate the deposit of mine effluent, waste rock, tailings, low-grade ore and overburden into natural waters frequented by fish. These regulations, administered by Environment Canada, apply to both new and existing metal mines. They are available at http://laws-lois.justice.gc.ca/PDF/Regulation/S/SOR-2002-222.pdf. Schedule 2 of the MMER lists water bodies designated as tailings impoundment areas (TIAs). A water body is added to that Schedule through a regulatory amendment.

1.2 Purpose

These guidelines describe the process that must be undertaken when a proponent is considering using a natural water body frequented by fish as a TIA such that a regulatory amendment to the MMER would be required. In the context of these guidelines, the term TIA refers to a natural water body frequented by fish into which deleterious substances (such as tailings, waste rock, low-grade ore, overburden, and any effluent that contains any concentration of the deleterious substances specified in the MMER, and of any pH) are disposed.

Waste rock, low-grade ore, and overburden

Metal mine waste rock, low-grade ore and overburden may be deleterious, in which case disposing them in a water body would require that the water body first be listed on Schedule 2 of the MMER as a TIA.

If the proponent can demonstrate that they are *not* deleterious, then no Schedule 2 listing would be required.

For more information on deleterious substances please see Annex 1.

These guidelines pertain to metal mines where a TIA has been proposed in a natural water body frequented by fish. However, the requirements for the conduct of alternatives assessments that are presented in Part 2 provide useful guidance for the assessment of all mine waste disposal areas including those developed on land. The overall objective of the alternatives assessment process is to minimize the environmental footprint of the disposal area.

1.3 Environmental Assessment

A project which includes a proposal to use a natural, fish-frequented water body for the disposal of mine waste triggers a requirement for a federal environmental assessment (EA) under the *Canadian Environmental Assessment Act* (CEAA), where applicable. Proposals may also be subject to additional provincial and land claim based EA obligations such as those outlined under the Inuvialuit Final Agreement for the Inuvialuit Settlement Region of the Northwest Territories.

For projects in the Yukon (http://www.yesab.ca/act_regulations/), Nunavut (http://env.gov.nu.ca/programareas/environmentprotection/legislation) and the MacKenzie Valley portion of the Northwest Territories (http://www.gov.nt.ca/agendas/land/index. html) where CEAA does not apply, EA requirements are met through other federal and territorial regimes.

Proposals may also be subject to provincial EA obligations.

An Environment Canada policy, which was developed in conjunction with the repeal of the *Alice Arm Tailings Deposit Regulations* when the MMER were registered in 2002, recommends against unconfined tailings disposal in the sea.

1.3.1 Overview

A mining project that includes a proposal to use a natural water body frequented by fish as a TIA must undergo an EA and the project proponent must also:

- prepare an assessment of alternatives for mine waste disposal for consideration (see Part 2 of these Guidelines);
- prepare a fish habitat compensation plan for consideration as part of the EA; and
- participate in public and aboriginal consultations on the EA, including on possible amendments to the MMER.[1]

[1] If the proposed use of a natural water body as a TIA would impact navigable water, then an Order in Council approval is also required under the *Navigable Waters Protection Act*. In such cases, Transport Canada is involved in the EA, and would be involved in the regulatory process for the proposed TIA, in the event that the regulatory process is undertaken.

Details of the EA process vary depending on the legislation or land claim under which the EA is conducted and the type of EA conducted. The project proponent needs to verify which EA regime applies (e.g., screening, comprehensive study or review panel for EAs conducted under the CEAA). The Canadian Environmental Assessment Agency has resources to help guide proponents through the federal EA process under the CEAA; they are available at http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=F1F30EEF-1.

In preparing the documentation for the EA, the proponent should take into consideration the requirements of the *Cabinet Directive on Regulatory Management* (CDRM), which are available at http://www.tbs-sct.gc.ca/ri-qr/directive/directive00-eng.asp. While the CDRM does not apply to proponents directly, it is a requirement of the regulatory process and it is strongly recommended that the proponent help lay the necessary groundwork to carry out a cost-benefit analysis in respect of the CDRM. More specifically, the necessary regulatory action should be demonstrated to maximize net benefits for society through an assessment of impacts as well as the distributional implications.

The proponent should also take into consideration the recommendations in Environment Canada's *Environmental Code of Practice for Metal Mines* during the EA (available at http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=CBE3CD59-1). The Code supports the MMER, but also covers a broad spectrum of environmental aspects that extend well beyond it.

1.3.2 Assessment of alternatives

A project proponent seeking to use a natural water body as a TIA must conduct an assessment of alternatives for mine waste disposal. It is strongly recommended that this assessment be undertaken during the EA to streamline the overall regulatory review process and minimize the time required to proceed with the MMER amendment process. Generally speaking, at least one of these alternatives should not impact a natural water body that is frequented by fish. It is important to note that a decision by the proponent to conduct the alternatives assessment after the EA has been completed could more than double the target timeline that has been established for the processing of Schedule 2 amendments.

This alternatives assessment must objectively and rigorously assess all feasible options for mine waste disposal. The project proponent must demonstrate through the EA and this assessment that the proposed use of the water body as a TIA is the most appropriate option for mine waste disposal from environmental, technical and socio-economic perspectives. It should also be demonstrated that the option offers the greatest overall benefit to current and future generations of Canadians, as per the CDRM. Part 2 describes the requirements of an assessment of alternatives.

1.3.3 Fish habitat compensation plan

Section 27.1 of the MMER requires the project proponent to develop and implement a fish habitat compensation plan to offset the loss of fish habitat that would occur as a result of the proposed addition of a water body to Schedule 2. The proposed plan must be submitted during the EA for consideration as part of the EA. The plan must describe, among other things:

1. fish habitat that would be lost as a result of the proposed TIA;
2. compensation measures that would be implemented, if approval is given to use the water body as a TIA, to offset the loss of fish habitat that would result;
3. plans to monitor the implementation of the compensation plan; and
4. a breakdown of estimated costs for implementation and monitoring of the plan.

A *Practioner's Guide to Habitat Compensation* is available at: http://www.dfo-mpo.gc.ca/habitat/role/141/1415/14155/compensation/index-eng.asp.

If the Governor in Council approves the regulation adding the water body as a TIA in Schedule 2, then, as per Section 27.1 of the MMER, the proponent must submit to DFO an irrevocable letter of credit to cover the plan's implementation costs.

The proponent must also develop and implement a fish habitat compensation plan under subsection 35(2) of the *Fisheries Act* to offset the harmful alteration, disruption or destruction of fish habitat as a result of the works needed for constructing the TIA. See Annex 2 for an explanation as to why two fish habitat compensation plans are needed.

1.3.4 Consultations

During the EA, Environment Canada and DFO consult local and national stakeholders and representatives of Aboriginal peoples to ensure that all interested parties have access to information about the project and have the opportunity to provide input and comments. The project proponent participates in the consultations to directly communicate the results of their alternatives assessment and its conclusions to all engaged parties.

Consultations on the proposed MMER amendment are conducted in accordance with the Treasury Board *Guidelines for Effective Regulatory Consultations*, available at: www.tbs-sct.gc.ca/ri-qr/documents/gl-ld/erc-cer/erc-certb-eng.asp.

DFO leads any additional Aboriginal consultations to ensure that all obligations that may exist in relation to rights protected by section 35 of the *Constitution Act, 1982* have been satisfied. Guidance on these consultations, which may be informed in part by the consultations undertaken pursuant to the alternatives assessment, is available at http://www.mpmo-bggp.gc.ca/desc/aboriginal-autochtones-eng.php.

1.3.5 EA decision

The application for a TIA following the EA decision can only proceed to the regulatory stage if the decision taken pursuant to the environmental assessment is that the project can be carried out, in whole or in part, past the EA stage. If the government decision is that the project should not proceed, no further action is taken with respect to the possible MMER amendment.

1.4 Regulatory Process

The decision to add a water body to Schedule 2 of the MMER is made by Treasury Board. Key elements needed for the regulatory process (assessment of alternatives, fish habitat compensation plan) take place during the EA phase, described above. The next steps in the regulatory process are:

1. Environment Canada prepares the regulatory amendment package to move forward with the TIA listing on Schedule 2 of the MMER. The package includes the text of the proposed regulatory amendment, which provides the name and geographical description of the water body being proposed as a TIA. The package also includes a Regulatory Impact Analysis Statement (RIAS) which is a key document in justifying the proposed Schedule 2 amendment. It includes, among other things:

- a description of the project;
- the rationale for the proposed amendment;
- a summary of the proposed fish habitat compensation plan;
- a description of the options that are considered during the alternatives assessment evaluation;
- a summary of the consultations; and
- a cost-benefit analysis of the proposed amendment, which assesses potential impacts from a broad societal perspective (e.g., environment, businesses, consumers, and other sectors of society). A key element of the cost benefit analysis is the development of a baseline and regulatory scenario. Cost information related to the alternatives assessment as well as costs related to the fish habitat compensation plan are included in this analysis. For more information, see Annex 3 and also the Treasury Board of Canada Secretariat *Guide to the Regulatory Process* at http://www.tbs-sct.gc.ca/ri-qr/processguideprocessus-eng.asp.

2. If approved by the Ministers of Environment and Fisheries and Oceans, the regulatory amendment package is sent to the Treasury Board for consideration.

3. If approved by the Treasury Board, the proposed amendment is published in Part I of the *Canada Gazette* for a 30-day public comment period.

4. 30-day public comment period.

5. Review of comments received.
6. Environment Canada prepares the final regulatory package, with the final RIAS incorporating responses to the comments received.
7. Submission of the final regulatory package to the Ministers of Environment and Fisheries and Oceans for approval to submit the regulatory amendment to the Treasury Board.
8. If approved by the Treasury Board, the regulatory amendment becomes law and is registered.
9. The regulatory amendment and the RIAS are published in Part II of the *Canada Gazette*, approximately two weeks after being registered.

These steps conform to the requirements of the CDRM.

Annex 4 provides a flow chart of the key steps in the EA and regulatory processes.

1.4.1 Timing

The regulatory amendment process typically takes 8-12 months after the end of the EA. However, if additional information is required (e.g., data gaps, missing cost information about the TIA or fish habitat compensation plan, etc) or if there is litigation, the process could be longer.

For major resource projects, target timelines for the EA and regulatory processes are publicly tracked and monitored by the Major Projects Management Office (http://www.mpmo-bggp.gc.ca/index-eng.php).

1.4.2 Other Fisheries Act authorizations

Where subsection 35(2) *Fisheries Act* authorizations (regarding the harmful alteration, disruption or destruction of fish habitat) associated with the construction of the TIA is granted, this occurs *after* the Schedule 2 amendments are completed, typically no later than three weeks following listing.

However, subsection 35(2) authorizations that are *not* related to the construction of the TIAs could be issued prior to the Governor in Council decision on the Schedule 2 amendment.

1.5 Getting started

Proponents of metal mines south of 60° are encouraged to contact the Major Projects Management Office (www.mpmo-bggp.gc.ca/index-eng.php) and, for mines north of 60°, the Northern Projects Management Office (www.north.gc.ca/pr/emp-eng.asp). The offices provide overarching project coordination, management, project tracking and guidance to proponents.

2 Requirements of Alternatives Assessment

The MMER stipulates that for mine waste to be deposited in a natural, fish-bearing water body, the water body must be listed in Schedule 2 of the Regulations, designating it as a tailings impoundment area (TIA). In the context of these guidelines, a TIA is a natural water body frequented by fish into which tailings, waste rock, low-grade ore, overburden and any effluent that contains any concentration of the deleterious substances specified in the MMER, and of any pH, are disposed.

The alternatives assessment should objectively and rigorously consider all available options for mine waste disposal. It should assess all aspects of each mine waste disposal alternative throughout the project life cycle (i.e., from construction through operation, closure and ultimately long-term monitoring and maintenance). The alternatives assessment should also include all aspects of the project, direct or indirect, that may contribute to the predicted impacts associated with the each potential alternative. These may include the design of the mine and ore processing system to the extent that they would impact mine waste production, storage options, water management and water treatment. The assessment will consider the predicted quality and quantity of effluent that would be discharged from each alternative assessed, taking into account the effluent quality limits set in the MMER, and the predicted impacts (inclusive of mitigation measures) associated with the proposed TIA, if any, on surface and groundwater water quality and flow.

The assessment should address environmental, technical and socio-economic aspects of all of the elements as described above for each alternative throughout the project life cycle. A comprehensive economic assessment of the alternatives is also required and should consider the full costs of each alternative throughout the project life cycle. This economic assessment should also consider all costs associated with any compensation agreements that are to be developed, including the habitat compensation plan associated with using the water body as a TIA.

2.1 Alternatives Assessment Process

Selecting the most suitable mine waste disposal alternative from an environmental, technical and socio-economic perspective, and obtaining input and striving to achieve consensus on the decision from a broad stakeholder group is a complex undertaking. From a purely technical perspective, the breadth of concerns and issues involve individuals from many disciplines within engineering, economics, and natural and social sciences. On the other hand, this complicated scientific language needs to be openly communicated such that the broader stakeholder group can meaningfully participate in the decision making process, or, at least when objectively looking in from the outside have confidence that the decision process is unbiased and representative.

This in itself introduces another level of complexity, in that decisions require judgement and cannot solely be based on technical merit. Two types of judgement are inherent in these decisions: technical judgements regarding the likely consequences inherent in the decision, and value judgements regarding the importance or seriousness of those consequences.

To overcome these challenges tools have been developed to facilitate the decision making process and to make them as transparent and reproducible as practicable. The underlying principal is that a successful decision making tool will allow technical specialists to communicate essential technical considerations while allowing stakeholders to establish value judgements for the decision.

The collective term for these decision making tools are multiple criteria decision analysis (MCDA). MCDA approaches can be classified in different ways, but one of the primary classifications distinguishes between multi-objective decision making (MODM) and multi-attribute decision making (MADM). The primary distinction between these methods is the number of alternatives under evaluation. MADM is designed for selecting discrete alternatives such as mine waste disposal alternatives, while MODM methods are designed for multi-objective planning problems when a theoretically infinite number of interdependent alternatives are defined.

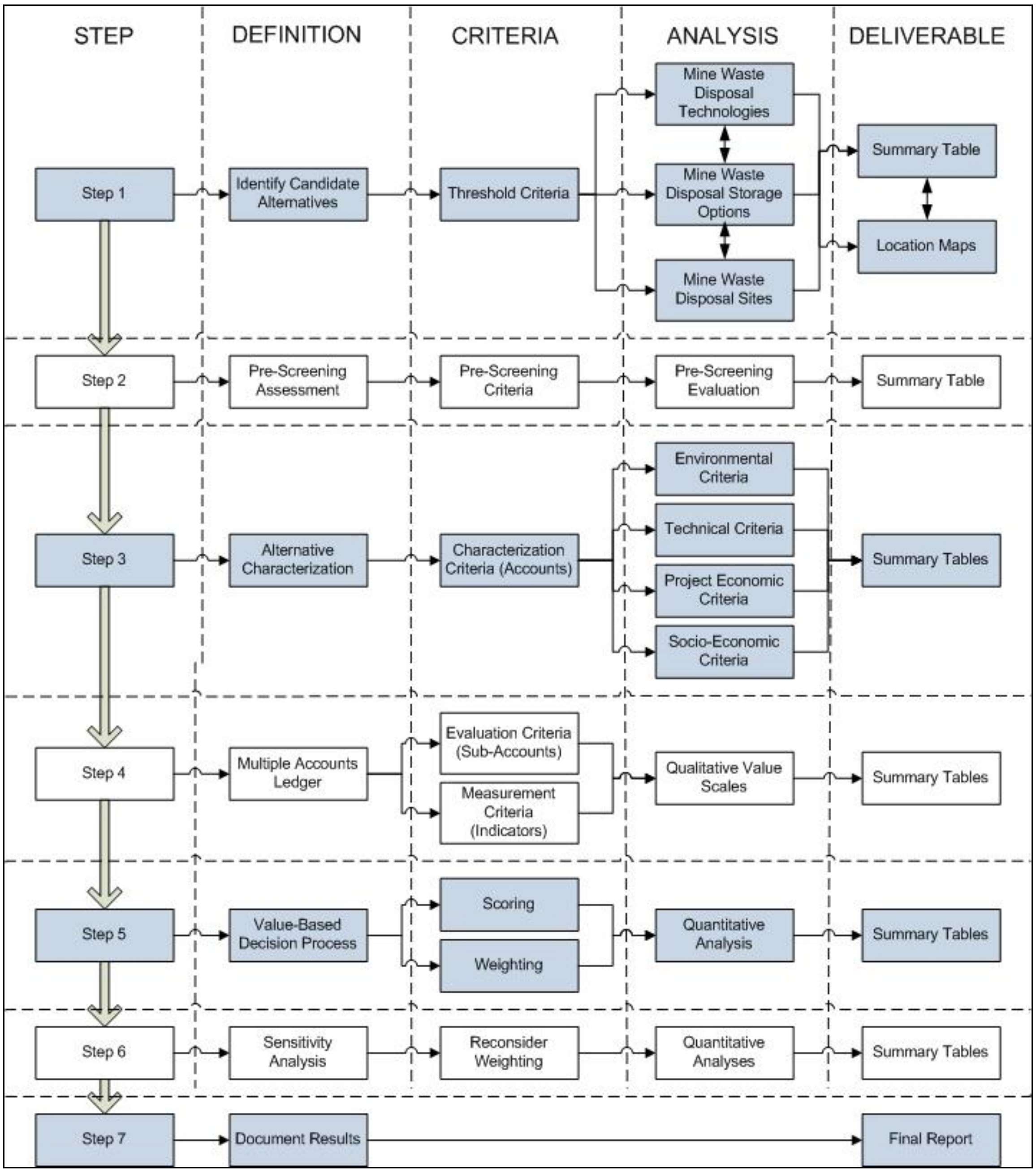
Different categories of MCDA methods are found, but the most relevant in the context of assessment of alternatives for mine waste disposal are value measurement models. In these models numerical scores are constructed to represent the degree to which one decision option may be preferred over another. MCDA is a valuable tool to aid decision making, which is a process which seeks to integrate objective measurement with value judgement and make explicit and manage subjectivity which is inherent in all decision making.

Within the general theory of MCDA there is a multitude of specific tools, each tailored for specific applications. Multiple Accounts Analysis (MAA) is one of the tools which have been successfully used to conduct assessments of alternatives for mine waste disposal and other mining related decision processes. A notable example of the use of MAA in this context is that which was conducted as an element of the environmental assessment of the Meadowbank gold mine in Nunavut. The text of this document can be viewed at ftp://ftp.nirb.ca/02-REVIEWS/COMPLETED%20REVIEWS/03MN107-MEADOWBANK%20GOLD%20MINE/02-REVIEW/08-FINAL_EIS/174._051108-CRL-FEIS-MB-ITAE/SUPPORTING_DOCS/004project%20alternative/.

MAA consists of the development of a multiple accounts ledger, which is an explicit list of accounts (and sub-accounts) of the impacts from various alternatives and for each account indicator, which gives a clear understandable measurable description of those impacts. This is followed by a value-based decision process whereby indicator values are scored and weighted in a systematic transparent manner such that the value basis for the effects impacting them is readily apparent.

MAA is only part of a larger alternatives assessment process. This process, as it applies to proposed TIAs in the context of these guidelines, is illustrated graphically in Figure 1. Each of the seven steps of the process is described in greater detail in subsequent chapters of these guidelines. It should be noted that the MAA as presented in this guideline is slightly modified from the original method first described by Robertson and Shaw (1998, 1999). This modified approach makes the process more transparent and eliminates multiple levels of bias and subjectivity.

Figure 1: Flow diagram of the process of assessing alternatives for mine waste disposal



2.2 Step 1: Identify Candidate Alternatives

The first step in the alternatives assessment process entails developing a list of all possible (i.e., reasonable, conceivable and realistic) candidate mine waste disposal alternatives for the site. This should include different mine waste disposal technologies, different disposal storage options, and different disposal locations. At this time it is imperative that no a priori judgements be made about any of the alternatives.

It may be appropriate to establish a basic set of threshold criteria to establish the regional boundaries for selecting candidate alternatives. These threshold criteria should be as broad as possible and must be fully described and rationalized to ensure transparency. There is no master list of threshold criteria, but typical examples include:

- *Exclusion based on distance*: There is sufficient precedent to suggest that at some point the distance between the mill/mine complex and the TIA becomes too great to ensure a positive economic outcome to the project. For any given project this distance may be set.
- *Exclusion based on presence of protected areas*: There may be protected areas (e.g., nature reserves or sacred land) within the regional boundaries considered for candidate mine waste disposal alternatives. If it is known that a TIA in these areas would under no circumstances be allowed, these areas can justifiably be excluded from evaluation.
- *Exclusion based on legal boundaries*: Areas may be justifiably excluded from evaluation if legal boundaries would preclude mine waste disposal. These may include country borders or cadastral/land use/lease boundaries.
- *Exclusion based on corporate policy*: A project proponent may have specific corporate sustainability policies which would eliminate a candidate alternative from consideration. These may include a policy statement limiting consideration of alternatives that would require relocation of local inhabitants.

Mine waste deposition technologies and storage options should not be separately evaluated from deposition sites as the impacts linked to an individual site could vary substantially based on the deposition technology or storage option selected. Therefore, if a candidate site justifiably lends itself to more than one mine waste deposition method; these should be considered as candidate alternatives in their own right.

Due to the volume of waste rock associated with most mines, is not uncommon to have a number of different waste rock piles associated with any given project. This is typically not the case for tailings management facilities (TMFs). It is a generally understood fact that for any given project a single consolidated TMF is usually preferred over a series of smaller TMFs. However, there are justifiable reasons why multiple TMFs may be considered for a project, such as:

- *Separation of the tailings stream*: In some cases separation of the float tailings (which typically represents the largest fraction of the tailings volume) from the leach residue tailings would result in the larger volume of float tailings being geochemically benign, which greatly reduces any potential impacts. This may justify more than one TMF for a site.
- *Using tailings as mine backfill*: Mine backfill is often required as part of the mine plan. It may be advantageous to consider tailings as a backfill material to achieve two goals. Firstly, it may offer a logical rationale to separate the leach and float tailings, and secondly, by reducing the volume of tailings that needs to go to the TMF, the potential impacts are reduced.

Should more than one TIA facility be considered for a project, the alternatives assessment process described in these guidelines applies equally to each disposal alternative under consideration.

It is recognized that the level of detail available about mine waste disposal alternatives during this stage of the process is highly conceptual. However, each candidate alternative should at least in principle be sufficiently thought through to allow an understanding of the concept. This is best done by developing a summary table which lists each alternative with a concise qualitative statement as to how the alternative would apply through each of the pertinent phases of the project (i.e., the project life cycle). Table 1 provides an example of the level of information that should be targeted during this step. The objective at this step in the process is to demonstrate to an external reviewer that all reasonable mine waste disposal alternatives have been brought forward.

Table 1: Example of the Step 1 summary table to identify candidate TMF alternatives

Project Phase	Alternative A	Alternative B	Alternative C
Construction approach	Construction of two large dams to impound Lake ABC, and an engineered diversion of stream DEF	Construction of a small dam to impound the stream XYZ valley	Construction of a ring dike on a land saddle at the catchment divide
Operational approach	Subaqueous deposition with discharge of effluent via treatment plant	Sub aerial deposition of thickened tailings with discharge of effluent via treatment plant	Sub aerial deposition of un-thickened slurry tailings with discharge of effluent via treatment plant
Closure approach	Draining of water cover and placing a dry cover	Buttressing of dam and placement of dry cover	Buttressing of ring dike and placement of dry cover

The deliverable after completing this step of the alternatives assessment process would be a summary table of candidate alternatives complemented by maps or figures showing the locations of each of the alternatives. Furthermore, any threshold criteria must be properly documented, such that an external reviewer would consider the criteria reasonable.

It should be noted that tailings separation goes against what is currently done at uranium mines where all tailings are placed in one single engineered pit. This is due to the fact that a review of historical practices for uranium mines indicated that tailings separation has caused more long term problems than benefits. Thus, the Canadian Nuclear Safety Commission expects that mine workings be used to the maximum extent possible for tailings disposal.

2.3 Step 2: Pre-Screening Assessment

Generally, it is not too difficult to develop a substantial list of alternatives during Step 1 of the process. However, this list of alternatives should be screened during Step 2 to allow the decision process to be carried out on an appropriate and manageable set of sufficiently detailed alternatives. It is important to note that the objective of this step is not to “make less work” for the proponent, but rather to “optimize the decision making process” by not evaluating alternatives that have obvious deficiencies.

The process of screening, called the pre-screening assessment in these guidelines, entails excluding those alternatives that are “non-compliant” in that they do not meet certain unique minimum specifications which have been developed for the project. This process is often referred to as a “fatal-flaw analysis” in the context of mine waste disposal alternatives assessments. A fatal flaw is defined as any site characteristic that is so unfavourable or severe that, if taken singly, it would eliminate that site as a candidate mine waste disposal alternative. In simple terms, these would be considered the “show-stoppers”.

There is not a “master list” that qualifies as pre-screening criteria. These criteria need to be uniquely developed for each project, and a thorough qualification and justification of the rationale must be provided. The selection of pre-screening criteria and its rationale needs to be carefully considered since the objective at this time is to provide a transparent process for potentially eliminating the majority of alternatives from detailed analysis and assessment. Therefore, it should be clear to external reviewers that the pre-screening criteria, when evaluated singly, are sufficiently important to eliminate an alternative from further consideration. The level of detail required to support that conclusion has to be evaluated on a case-by-case basis, and it may have to be extensive to be sufficiently supportive.

Pre-screening criteria should be formulated such that there is a simple “YES” or “NO” response to whether the alternative complies with the set criteria. Most importantly, it must be clear to the external reviewer that there would be no reasonable mitigation strategy that would convert a “YES” into a “NO”.

Examples of pre-screening criteria and the possible associated rationale are presented below. It is important to note that these criteria are provided as examples and should not be considered as practices that would be acceptable in all circumstances. It is incumbent on the proponent to consider and examine criteria according to these guidelines in order to determine which would provide the best practicable manner to manage mine waste and provide for acceptable protection of the environment.

- *Would the TIA preclude future exploration or mining of a potential resource?* A TIA located over an area where there are proven indicators of mineralization, or a reasonable indication of possible mineralization based on regional trends, may be one possible reason to exclude it from further consideration. Under this scenario, it may not be reasonable to expect the proponent to conduct a lengthy exploration program to prove out whether an economically viable resource does exist in the area.
- *Is any part of the mine waste disposal system unproven technology?* If a specific disposal method relies on technology that has not been demonstrated to be effective in the context of the site under consideration, then it could justifiably be argued that the alternative should be excluded from further consideration. It would not be reasonable to expect the proponent to conduct lengthy fundamental or applied research to prove whether the technology may be successful.
- *Will the TMF capacity be too small to store the proposed upper limit of tailings?* Unless there is good rationale to have more than one TMF for any given project site (e.g., due to separation of tailings streams), it can justifiably be argued that if a site does not have sufficient capacity using reasonable technically viable containment strategies then it can be excluded from consideration.

– *Will the TIA result in negative life of project economics?* It is justifiable to exclude TIAs from further consideration if they would result in negative life of project total (overall) economics. When using project economics as pre-screening criteria, the proponent needs to be careful to not evaluate the mine waste disposal economics in isolation of the total project economics. It is conceivable that a more expensive mine waste disposal alternative could result in improved project economics.

Furthermore, it must be recognized that specific legal requirements may preclude the possibility of pursuing some potential alternatives. For example, the requirements of the *Species at Risk Act* could preclude the development of a TIA if the TIA was to be located in an area that would impact the habitat of specific endangered species.

Results of the pre-screening assessment are best presented in the form of a summary table that lists each alternative against the pre-screening criteria (and associated rationale) set for the project. Table 2 provides an example of what this summary table would look like. This table, complete with all applicable supporting information, will be the deliverable for this step.

Table 2: Example of the pre-screening criteria summary table

Pre-Screening Criteria	Rationale	Alternative A	Alternative B	Alternative C
Would the TIA sterilize a potential resource?	A TIA located over an area where there are proven indicators of mineralization, or a reasonable indication of possible mineralization based on regional trends may be excluded from further consideration.	NO	YES	NO
Is any part of the mine waste disposal system unproven technology?	If a specific deposition method relies on unproven technology at the project site, then it could justifiably be argued that the alternative should be excluded from further consideration.	YES	NO	NO
Should alternative be excluded from further assessment?		YES	YES	NO

2.4 Step 3: Alternative Characterization

At this stage in the alternatives assessment process, there should be a reduced number of alternatives remaining. However, there will have to have been sufficient justifiable pre-screening undertaken to ensure that any of the remaining alternatives could prove to be the preferred alternative. There is no “ideal number” of alternatives that should be carried through at this stage, but a general rule-of-thumb is that there would be at least three or more alternatives remaining and determined to be worthy of detailed assessment. At least one of these alternatives should not impact a natural water body that is frequented by fish, unless it can be demonstrated that this possibility does not reasonably exist based on site-specific circumstances.

These remaining alternatives need to be thoroughly characterized, and this serves two purposes:

- Firstly, complete characterization of each alternative ensures that every aspect and nuance of the alternative is properly considered, and;
- Secondly, the provision of a thorough characterization in a clear and concise format that directly compares alternatives, ensuring complete transparency of the alternatives assessment process.

Site specific *characterization criteria* should be developed for each project. To facilitate smooth transition towards the next more rigorous steps of the evaluation process these criteria should be categorized into four broad categories, or "accounts" in the context of these guidelines, that consider the entire project life cycle. This means that both short and long term environmental, technical and socio-economic aspects associated with construction through operation, mine closure and ultimately post-closure maintenance and monitoring need to be considered. The "accounts" can be summarized as follows:

- *Environmental characterization*: This account focuses on characterizing the local and regional environment surrounding the proposed TIA. These include elements such as climate, geology, hydrology, hydrogeology, water quality and potential impacts on aquatic, terrestrial and bird life.
- *Technical characterization*: This focuses on characterization of the engineered elements of each alternative such as storage capacity, dam size and volume, diversion channel size and capacity, dumping techniques, haul distances, sedimentation and pollution control dam requirements, tailings discharge methods, pipeline grades and routes, closure design, discharge and/or water treatment infrastructure and supporting infrastructure such as access roads.
- *Project economic characterization*: The focus of this account is to characterize life of project economics. All aspects of the mine waste management plan need to be considered including investigation, design, construction (inclusive of borrow development and royalties where applicable), operation, closure, post closure care and maintenance, water management, associated infrastructure (including transport and deposition systems), compensation payments and land use or lease fees.
- *Socio-economic characterization*: This account focuses on how a proposed TIA may influence local and regional land users. Elements that are considered here include characterization and valuation of land use, cultural significance, presence of archaeological sites and employment and/or training opportunities.

It is essential that the characterization remain factual, or where statements of judgement, risk or uncertainty are made, that they be explicitly defined and qualified. As previously stated, it should be clear to any external reviewer what the basis is for the characterization criteria stipulated for any alternative. In most cases there needs to be supporting information for these criteria in the form of technical reports completed by appropriately qualified specialists. In populating the characterization criteria, care must be taken to not make a priori judgement about any criteria or alternative. It is also important to note that characterization of the alternatives in this step does not entail evaluating impacts. Impact evaluation is left to Step 4 of the assessment process when a thorough characterization of each alternative is readily available. The level of detail at which a project is characterized and subsequently documented should be evaluated based on project specific needs.

Selecting and documenting characterization criteria should be done by a multidisciplinary team with representatives from all four accounts. In some cases multiple representatives may be required from a single account, for example a person familiar with the aquatic habitat in an area may not be familiar with the bird or terrestrial life. There is no prescribed way as to how these teams should be solicited to set and populate the characterization criteria for a project. However, clearly documenting the process that was followed throughout this step can greatly help to instill confidence of the external reviewer that all alternatives have been thoroughly characterized.

Every project is unique, and as a result it is not appropriate to provide a standardized list of characterization criteria against which to document alternatives. The lists provided in Tables 3 through 6 offer a reasonable sampling of characterization criteria that are likely to be required for the majority of projects. Naturally, the selection of criteria would also depend to some extent on the type of mine waste under consideration, i.e., a TMF or waste rock pile.

When deciding upon characterization criteria, it may be useful to pose the following question: "*What would be reasonable questions that a stakeholder, regulator or technical reviewer may ask about any of the proposed mine waste disposal alternatives?*" By anticipating the response to this question, a reasonable basis for setting characterization criteria can be established. During this step of populating the characterization criteria table, it is conceivable that elements are "double-counted", i.e., the footprint size of the TIA may be listed under technical characterization criteria, with the goal of differentiating physical size, and again as an environmental characterization criteria, but with the goal of demonstrating loss of habitat. This apparent double-counting is not relevant at this time, as Step 4 is designed to address this issue. Notwithstanding, it does help the external reviewer if the logic behind the inclusion of all characterization criteria is immediately apparent though extensive documentation.

Table 3: Sampling of environmental characterization criteria

Geochemical characterization of wastes (e.g., acid rock drainage and/or metal leaching, weatherability)
Geochemical characterization of all construction materials and associated excavation waste (i.e., unsuitable soils stripped from foundations, quarries, or other borrow sources)
Geographical boundaries (e.g., country/provincial/territorial/municipal boundaries, land claim/land use/cadastral/other re-defined boundaries)
Topography (e.g., relief, complexity of topography)
Geotechnical and seismic conditions (e.g., geological setting, depth of overburden and/or permafrost, fault/fracture zones)
Hydrology (e.g., surface water features, size of streams/rivers/lakes/wetlands, catchment boundaries, flood lines)
Hydrogeology (e.g., depth to groundwater, perched water tables, presence of springs/artesian wells)
Climate (e.g., prevalent wind strength and direction, snow drifting, precipitation and/or temperature inversions)
Climate change projections (e.g., predicted changes in precipitation patterns and extreme precipitation events, warming impacts in permafrost areas)
Atmospheric issues (e.g., particulates, heavy metals)
Overall affected land footprint size of impoundment (including secondary/polishing ponds), related infrastructure (e.g., dams, saddle dykes), and access road
Water quality (e.g., surface water, groundwater, impacted waters)
Water quantity and storage issues
Special features (e.g., seismicity, avalanches, permafrost, radioactivity)
Vegetation (e.g., types, rarity/uniqueness, coverage)
Aquatic life and habitat (e.g., species variation/uniqueness, habitat suitability)
Terrestrial life and habitat (e.g., species variation/uniqueness, habitat suitability)
Bird life and habitat (e.g., species variation/uniqueness, habitat suitability)

Table 4: Sampling of technical characterization criteria

Physical characterization of wastes (e.g., grain size distribution, settlement rate, consolidation parameters)
TIA design (e.g., overall affected land footprint size of impoundment (including secondary/polishing ponds), related infrastructure (e.g., dams, saddle dykes), access and haul roads)
Containment structure design (e.g., size, hydraulic capacity, artificial materials, substrate, possible use of impermeable or geo-textile liner for impoundment)
Diversion structure designs (e.g., size, hydraulic capacity, construction materials, substrate)
Supporting infrastructure design (e.g., type, size, construction materials, substrate)
Borrow source and quarry design (e.g., size, volumes extracted, development methods, water management, rehabilitation)
Tailings delivery and deposition system design (e.g., type, capacity, location, containment)
Water management system design (e.g., water balance, discharge strategy, water treatment strategy, recycle strategy)
Closure design (e.g., approach, construction materials)
Flexibility (e.g., ability to handle upset conditions (chemical/volumetric/physical), expansion capacity, variable discharge strategies)
Precedent (e.g., new technologies, case studies – should include thickened, paste or dry stacking alternatives)
Design and construction of impermeable covers over wastes
Technical risks and benefits (e.g., variable foundation conditions, water balance)
Constructability (e.g., seasonality, access)

Table 5: Sampling of project economic characterization criteria

Capital cost (e.g., investigations, design, borrow development, construction, supervision, commissioning)
Operational cost (e.g., sustaining capital such as dam raises, deposition, monitoring, maintenance, water treatment)
Closure cost (e.g., bonding, investigations, design, borrow development, construction, supervision, commissioning)
Post-closure cost (e.g., monitoring, maintenance, inspections, water treatment)
Fish habitat compensation (e.g., bonding, construction, monitoring)
Land use cost (e.g., land use fees, lease rates, royalties on borrow materials)
Economic risks and benefits (e.g., permitting timelines, construction seasonality, design certainty, post-closure timeline)

Table 6: Sampling of socio-economic characterization criteria

Archaeology (e.g., location, size, type, importance, risk of unidentified sites such as burial sites)
Community/Aboriginal land/mineral use rights (e.g., formal/informal agreements, grandfathered agreements)
Maintenance of traditional lifestyle (e.g., loss of hunting, fishing or natural food harvesting, loss of access)
Ecological/cultural values (e.g., value of land, value of water, value of aquatic, bird or terrestrial species, value of lifestyle)
Perception (e.g., apparent acceptance or distrust, nature of communication)
Previous and existing land use (e.g., recreation/tourism, spiritual well being, mining, industry, hunting, fishing)
Aesthetics (e.g., line of sight, landform engineering, re-vegetation)
Employment (e.g., short and long-term opportunities, “boom-and-bust” cycles)
Capacity building (e.g., training opportunities, contracting opportunities, community infrastructure)
Economic benefits (e.g., partnerships, royalties, lease payments, compensation and benefit agreements)
Community safety (e.g., construction methods, operational management of TIA, closure state of TIA)
Overall perceived socio-economic consequences, benefits and relative preferences

The deliverable for this step should ideally be a series of summary tables that list the selected characterization criteria for each account for each of the alternatives under consideration. The table should include a concise summary of the rationale behind each criterion. This format allows an external reviewer to easily compare the factual characteristics across alternatives. Table 7 provides an example of what this summary table may look like.

Table 7: Example of the characterization criteria summary table

Account: Technical Characterization

Characterization Criteria	Rationale	Alternative A	Alternative B	Alternative C
Dam size	Larger dams are more complex, pose greater risk, require more construction materials, require a larger footprint	One dam, 300 m long, 20 m total height, final dam footprint of 2 ha	Two dams; first is 150 m long, 30 m high with a footprint of 1 ha; second is 200 m long, 15 m high with a footprint of 2 ha	Two dams; first is 400 m long, 30 m high with a footprint of 3 ha; second is 50 m long, 20 m high with a footprint of 0.5 ha
Dam foundation conditions	Dams constructed on poor foundation conditions are more complex, pose greater seepage and stability risk	Shallow (3 m thick) glacio-fluvial soil overlying competent intact bedrock	Shallow (0.5 m thick) organic layer overlying 5-8 m thick bouldery till, overlying fractured bedrock	Shallow (3 m thick) glacio-fluvial soil overlying competent intact bedrock
Supporting infrastructure	More supporting infrastructure results in greater demand on construction material, occupy larger footprint	5 km access road, and 4 km service road for discharge spigots	3 km access road and 8 km ring road to service discharge spigots	10 km access road and 7 km service road for discharge spigots

2.5 Step 4: Multiple Accounts Ledger

Up to this point in the process, the emphasis has been on identifying and characterizing alternatives. In order to evaluate alternatives using the MAA decision making tool, it is necessary to develop a *multiple accounts ledger*. This ledger seeks to identify those elements that differentiate alternatives, and provides the basis for scoring and weighting as described in Step 5, which is necessary to complete the evaluation. The multiple accounts ledger consists of the following two elements:

- Sub-accounts, known as evaluation criteria, and;
- Indicators, known as measurement criteria.

Complete definitions and procedures for developing sub-accounts and indicators are described in the following sections.

2.5.1 Sub-Accounts

Sub-accounts (evaluation criteria) are developed using the characterization criteria selected during Step 3. The fundamental difference between these sets of criteria is that characterization criteria are factual and have been developed with no a priori judgements being made regarding any of the alternatives being considered, while evaluation criteria consider only the material impact (i.e., benefit or loss) associated with any of the alternatives being evaluated.

The choice of sub-accounts must be carefully considered so that only those sub-accounts that truly differentiate mine waste disposal alternatives are presented for evaluation. To facilitate this, sub-accounts should comply with the following guidelines:

– *Impact driven*: The evaluation criteria must, as far as practicable, be linked to an impact as opposed to merely being a factual element. For example, the size of an impacted lake in itself is not a relevant sub-account, but if the size of the lake is linked to its value or potential habitat loss, then the sub-account is appropriate.

– *Differentiating*: The sub-account must define an aspect which distinctly differentiates one alternative from another, and that difference is expected to have a material effect on the final selection of an alternative. For example, land ownership may be an important evaluation criterion, if different alternatives fall on ground with different ownership. Conversely, if all the mine waste disposal alternatives under consideration were on land belonging to a single owner, then there really is no need to consider this sub-account in the analysis.

– *Value relevance*: A sub-account must be relevant in the context of the alternatives being evaluated. For example, the size of dams in itself is not a relevant sub-account unless it is linked to a relevant context such as increased long-term risk of failure or increased maintenance and inspection requirements.

– *Understandability*: Sub-accounts must be unambiguously defined, such that two external reviewers cannot interpret the outcome differently. For example, distance between the TIA and the mill complex may be a sub-account with the understanding that greater distances pose greater technical and environmental risk. However, someone may assume that because there is a significant dust hazard associated with a proposed alternative, a greater distance could be advantageous due to reduced worker health and safety risks.

– *Non-redundancy*: There should not be more than one sub-account that measures the same evaluation criteria. If individual sub-accounts measure similar criteria, consideration should be given to combining those criteria.

– *Judgemental independence*: Sub-accounts should be judgementally independent, which means that preferences with respect to a single criteria, or trade-offs between criteria, cannot depend on the value of another. For example, assume “traditional land use” is one sub-account and another is “landowner perception”. It may be concluded that for one alternative “hunting” will be impacted which would result in a negative impact on "traditional land use". However, if "landowner perception" is influenced by a decrease in hunting then judgemental independence does not exist.

As with all the other criteria mentioned throughout this alternatives assessment process, there is no "master list" of evaluation criteria applicable to all projects and there is no ideal number of evaluation criteria. These should be defined on a project specific basis by a multi-disciplinary team with input from stakeholders. This helps instill confidence in the process in the eyes of an external reviewer, and ensures transparency which is an integral part of the success of the alternatives evaluation process.

The deliverable at this stage in the process will be a summary table which lists the sub-accounts complete with the rationale behind each. Appropriate supporting documentation will likely have to be clearly referenced. Table 8 provides an example of what this summary table may consist of.

Table 8: Example of the sub-account (evaluation criteria) summary table for a TMF

Account	Sub-account	Rationale
Environmental	Distance from mill site	A longer distance implies that the risk of an accidental spill of tailings along the pipeline is greater. Greater distance further implies more linear infrastructure which negatively affects Caribou migration.
	Value of aquatic life affected	A lake with larger species diversity has been deemed to carry greater value from a traditional use perspective.
	Post-closure land use	Alternatives that would most closely return land use to pre-mining conditions would be more palatable to the landowner.
Technical	Containment structure design	Larger or more complex containment structures are generally less desirable due to uncertainty associated with long term integrity particularly if the area is seismically active.
	Water management system	Long term water treatment is not desirable due to long term risks associated with treatment sludge handling and storage.
	Complete system flexibility	Waste characteristics are expected to change over the life of the project, affecting physical stability and water management strategies. Alternatives that are least susceptible to risks associated with these changes are preferred.
Project economics	Capital cost	Greater pre-production expenditure affects early cash flow and the ability to generate capital to execute the project.
	Operational (and sustaining capital) cost	The project has a short lifespan and therefore benefits of delaying sustaining capital are not easily realized. Higher operational costs are less desirable as the ore grade reduces rapidly over the life of the mine.
	Closure and post closure cost	Due to the short life of mine, capital intensive closure costs directly affect the internal rate of return.
Socio-economic	Archaeology	The prevalence of archaeological sites in the region implies complete avoidance will be impossible. Sites which would minimize the impact would be more amenable.
	Society and Culture	A regulatory proposal may have impacts or implications on people’s way of life, culture, community and well being. Special consideration should be given to vulnerable social and economic groups such as Aboriginal peoples.
	Traditional land use value	It would be less desirable to impact areas which have direct use values (e.g., agriculture, recreation, tourism and functional ecosystem benefits) as well as passive values such as the existence value of the natural habitat and ecosystem.
	Perception	Tailings, irrespective of their geochemical composition, are generally perceived to be highly toxic by the local communities. Therefore, TMFs where animals and/or birds could have direct contact with tailings are less desirable.

2.5.2 Indicators

To allow qualitative or quantitative measurement of the impact (i.e., benefit or loss) associated with each alternative for any given sub-account, the sub-account needs to be measurable. Sub-accounts by nature are often not directly measurable, and need to be sufficiently decomposed to allow measurability. This decomposition takes the form of sub-sub-accounts, which in the language of MAA are called *indicators*, or measurement criteria.

The concept of indicators is best described by examples:

- *Example 1*: The sub-account “traditional land use” may have a list of indicators including “effects on hunting”, “effects on fishing” and “effects on harvesting berries”.
- *Example 2*: The sub-account “water quality” may have a list of indicators including “pH”, “conductivity”, “TDS”, etc.

These indicators may be different for the different life-cycle stages of the project (i.e., construction, operation and closure) and, where appropriate, may be divided into separate time periods.

When selecting indicators thought should be given to the parameter that will be used to define measurability. This measurability is required in order to continue to Step 5, which is the value-based decision process. Assigning measurability is relatively simple for sub-accounts that readily lend themselves to parametric terms such as “water quality” or “capital costs”. The challenge comes when measurability needs to be assigned to sub-accounts that do not readily lend themselves to parametric terms such as “traditional land use” which must be supplemented by indicators such as “effects on hunting”.

This problem can be overcome by constructing qualitative value scales. Common examples of such qualitative value scales are the Apgar score used to quickly and summarily assess the health of newborn children immediately after birth (Apgar, 1953), and the Beaufort scale used by mariners to measure the strength of wind (Huler, 2004). For illustration, the Beaufort scale has been reproduced in Table 9. The Beaufort scale was developed because mariners could not actually measure the strength of wind, and they needed to communicate their sailing conditions in a fashion that could readily be understood by all. By taking factual information about how the sea state changes as the wind strength changes, a qualitative value scale was developed, and to this day it remains valid and is used in weather forecasts. Similar qualitative value scales can be developed for indicators where precise measurability is not immediately apparent.

Table 9: Beaufort scale (example of a qualitative value scale)

Force	Wind Speed (kts)	Descriptor	Sea Condition
0	0-1	Calm	Sea like a mirror
1	1-3	Light air	Ripples with the appearance of scales are formed, but without foam crests.
2	4-6	Light Breeze	Small wavelets, still short, but more pronounced. Crests have a glassy appearance and do not break.
3	7-10	Gentle Breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.
4	11-16	Moderate Breeze	Small waves, becoming larger; fairly frequent white horses.
5	17-21	Fresh Breeze	Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray.
6	22-27	Strong Breeze	Large waves begin to form; the white foam crests are more extensive everywhere. Probably some spray.
7	28-33	Near Gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
8	34-40	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift. The foam is blown in well-marked streaks along the direction of the wind.
9	41-47	Severe Gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.
10	48-55	Storm	Very high waves with long over-hanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On the whole the surface of the sea takes on a white appearance. The 'tumbling' of the sea becomes heavy and shock-like. Visibility affected.
11	56-63	Violent Storm	Exceptionally high waves (small and medium-size ships might be for a time lost to view behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility affected.
12	64-71	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected

In order to develop a qualitative value scale it is necessary to define at least two points on the scale (usually the end points). The points on the scale are defined descriptively and draw on multiple concepts in the definition of the indicator. The number of points on the scale will be determined by the indicator definition, and in the context of MAA for mine waste disposal alternatives, a good rule of thumb would be to target a six-point scale. This provides for sufficient capacity to differentiate, without being overly onerous, and also by providing an even number scale, the tendency to select the “middle-of-the road” value is eliminated. Qualitative value scales should be developed to have the following characteristics:

- *Operational*: The decision maker should be able to rate alternatives that were not specifically used to define the scale, i.e., should another TIA be added for evaluation at a later time, the scale developed previously should still be relevant.
- *Reliable*: Different external reviewers should be able to rate an alternative according to the value scale and assign the same score.
- *Value relevant*: The value scale must be directly relevant to the indicator being scored.
- *Justifiable*: Any external reviewer should reach the conclusion that the value scale is reasonable and representative.

The deliverable for this part of the process will be the expansion of the sub-accounts summary table to include indicators. As previously stated, this collective information is also known as the multiple accounts ledger, and Table 10 provides an example of what this may look like. Within Table 10, the indicator “fishing impact” and “ARD potential” are examples where indicator parameters are based on a qualitative value scale. This qualitative value scale must be documented, and Table 11 provides an example of what this may look like.

Table 10: Example of the completed multiple accounts ledger

Account	Sub-account	Indicator	Indicator Parameter	Unit	Indicator Quantity
Environmen-tal	Effect on traditional land use during construction	Hunting impact	Time	Yr	2 years
		Fishing impact	Value	#	3
		Berry harvesting impact	Area	ha	400 ha
	Mine waste geochemistry	ARD potential	Value	#	2
		Metal leaching potential	Value	#	6
Technical	Containment design	Dam height	Height	m	25 m
		Foundation conditions	Value	#	4
	Diversion design	Channel length	Length	km	3.8 km
		Catchment size	Area	ha	134 ha
Project economics	Life of mine cost	Capital cost	Cost	$	10 million
		Operational cost	Cost	$	2 million/yr
		Closure cost	Cost	$	3 million
	Economic risk	Capital	Value	#	2
		Operational	Value	#	3
		Closure	Value	#	5
Socio-economic	Landowner perception	Land owner perception	Value	#	4
	Archaeological sites	Presence of immovable sites	Quantity	#	2
		Presence of mitagable sites	Quantity	#	33

Table 11: Example of qualitative value scale for the indicator "fishing impact" listed in Table 10

Score	Descriptor
6 (Best)	No impact
5	Short term temporary loss of fishing. During construction fishing in the area will be prohibited for health and safety reasons
4	Loss of fishing for foraging species for at least 10 years
3	Loss of fishing for foraging species and 1 large bodies specie for at least 10 years
2	Loss of fishing for foraging species and 2 large bodies species for at least 10 years
1 (Worst)	Complete and permanent loss of all fishing for the life of the project and into perpetuity

2.6 Step 5: Value-Based Decision Process

At the conclusion of Step 4, the *multiple accounts evaluation* is complete and the *value-based decision process* begins. This process entails taking the list of accounts, sub-accounts and indicators and assessing the combined impacts for each of the alternatives under review. This entails scoring and weighting of all indicators, sub-accounts and accounts and quantitatively determining merit ratings for each alternative. These three processes are described in the following sections.

2.6.1 Scoring

Traditionally, MAA scoring is done through a process of ranking and scaling. This process is not inherently transparent, and for this reason these guidelines present a modification to the process that improves transparency.

Scoring is done by developing qualitative value scales for every indicator, including those which appear to be readily measurable. An example of such a qualitative value scale is presented in Table 12. The process of how these are developed has been described in Step 4. By following this procedure, it is abundantly obvious to the external reviewer why a particular indicator score has been assigned to an alternative, and since the qualitative value scale has been developed collaboratively, with input from stakeholders, there is built in confidence that the scoring is appropriate.

Table 12: Example of qualitative value scale for an indicator which at first glance would appear to be measurable, such as "capital cost"

Score	Descriptor
6 (Best)	Less than $10M
5	Between $10 and $20M
4	Between $20 and $30M
3	Between $30 and $40M
2	Between $40 and $50M
1 (Worst)	Greater than $50M

2.6.2 Weighting

At this time the analyst, with input from stakeholders, needs to have the ability to introduce their value bias between individual indicators. This is done by applying a weighting factor to each indicator. Weighting factors allow the analyst to assign relative importance of one indicator as compared to another, and this weighting factor is most likely to reflect the analyst's bias or value basis. Essentially what this means is that an indicator with a weighting factor of 2 is twice as important as an indicator with a weighting factor of 1.

It is important to bracket the weighting factor, and in the context of these guidelines, it is recommended that the weighting factors range from 1 through 6. This means that any one indicator can be considered to be up to 6 times more significant than another. If the multiple accounts evaluation has been rigorously carried out, then this range of weighting factors should be sufficient to satisfy an external reviewer. Further consideration of weighting factors can be conducted during the sensitivity analysis (Step 6).

Weighting factors should be constant for any given indicator, sub-account or account across all alternatives. This is best illustrated through the quantitative analysis procedure.

Considering the inherent subjectivity of weighting, there is a natural tendency to want to standardize or prescribe weighting factors. This would result in a fixed value bias, which reflects the value bias of the imposing guidelines with no consideration of site specific conditions, rather than allowing the analyst with input from stakeholders, to set value bias relevant to their project. Notwithstanding this, within the framework of these guidelines, it is proposed that the Base Case of the alternatives assessment use the following weightings for accounts (refer to Table 15 of the quantitative analysis section):

- Environment – 6
- Technical – 3
- Project Economics – 1.5
- Socio-Economic – 3

The analyst is still encouraged to assign other weightings to accounts and demonstrate their effect on the assessment outcome, as described in Step 6.

Recognizing that for an external reviewer it may not be immediately apparent how the chosen weighting factors effects the outcome of the alternatives assessment, it is recommended that in all cases the analyst produce a sensitivity analysis run (see Step 6) where all weighting factors are assigned equal value (i.e., a weighting of 1).

2.6.3 Quantitative Analysis

The quantitative analysis is relatively simple, and given the potentially large amount of accounts, sub-accounts, and indicators this analysis is well suited to using a spreadsheet type approach. For each indicator, the **indicator value (S)** of each alternative is listed in one column. The **weighting factor (W)** is listed in another column and the combined **indicator merit score (S x W)** is calculated as the product of these values. An example of this analysis is presented in Table 13.

Indicator merit scores can be directly compared across alternatives, and likewise **sub-account merit scores (Σ{S x W})** can be directly compared across alternatives. However, to allow comparison of these values against values for other sub-accounts, the scores must be normalized to the same six-point scale used to score each indicator value. This is achieved by dividing the sub-account merit score by the **sum of the weightings (ΣW)** to yield a **sub-account merit rating (R_s = (Σ{SxW}/ ΣW)**. This will again be a value between 1 and 6. This normalization is necessary to balance out different numbers of indicators and sub-accounts for each account. Without this normalization, the number of indicators associated with each sub-account, and the number of sub-accounts associated with each account, would have to be identical, otherwise the analysis will be skewed by accounts with more sub-accounts or indicators.

Table 13: Example of the quantitative analysis for indicators

Account: Socio-Economic					
Sub-Account: Effect on traditional land use during construction					
Indicator	**Indicator Weight (W)**	**Alternative A**		**Alternative B**	
		Indicator Value (S)	**Indicator Merit Score (S x W)**	**Indicator Value (S)**	**Indicator Merit Score (S x W)**
Hunting impact	2	6	12	1	2
Fishing impact	5	3	15	4	20
Berry harvesting impact	1	5	5	2	2
Sub-account merit score (Σ{S x W})			32		24
Subaccount merit rating (R_s = Σ{SxW}/ ΣW)			4		3

The same procedure of weighting and normalization is followed to determine **account merit scores (Σ{R_sxW})**, and **account merit ratings (R_a = Σ(R_sxW)/ ΣW)**. This is illustrated in Table 14. This process is repeated one final time, and an **alternative merit score (Σ{R_axW})**, and an **alternative merit rating (A = Σ(R_axW)/ ΣW)**, is determined for each of the alternatives, as illustrated in Table 15.

Table 14: Example of the quantitative analysis for sub-accounts

Account: Socio-Economic					
Sub-Account	**Indicator Weight (W)**	**Alternative A**		**Alternative B**	
		Sub-account Merit Rating (R_s)	**Sub-Account Merit Score (R_s x W)**	**Sub-account Merit Rating (R_s)**	**Sub-Account Merit Score (R_s x W)**
Effect on traditional land use during construction	6	4	24	3	18
Archaeology	1	6	6	6	6
Aesthetics	3	5	15	3	9
Account merit score ($\Sigma\{R_s$ x W$\}$)			45		33
Account merit rating ($R_a = \Sigma\{R_s xW\}/ \Sigma W$)			4.5		3.3

Table 15: Example of the quantitative analysis for accounts

Account	**Indicator Weight (W)**	**Alternative A**		**Alternative B**	
		Account Merit Rating (R_a)	**Account Merit score (R_a x W)**	**Account Merit Rating (R_a)**	**Account Merit score (R_a x W)**
Socio-economic	6	4.5	27.0	3.3	19.8
Technical	4	5.1	20.4	4.5	18.0
Project economics	3	3.4	10.2	5.6	16.8
Environment	5	4.4	22.0	3.8	19.0
Alternative merit score ($\Sigma\{R_a$ x W$\}$)			79.6		73.6
Alternative merit rating ($A = \Sigma\{R_a xW\}/ \Sigma W$)			4.4		4.1

At this time it is possible to compare alternative merit ratings for all mine waste disposal alternatives evaluated and the preferred option will be the one which has the highest merit rating.

The deliverable at this point in the process will be summary tables much like the examples presented in this section. It is, however, very important that justification is provided for all the weightings used along every step of the process. An external reviewer should be able to review the weightings, and conclude that they are reasonable, even though he may not agree with them.

2.7 Step 6: Sensitivity Analysis

The alternatives assessment and subsequent value based decision making process described in these guidelines is specifically tailored to be transparent, and to the extent practicable eliminate bias and subjectivity. However, the reality is that any decision making process is subject to bias and subjectivity, and the goal is to manage that bias and subjectivity to the point where an external reviewer would agree that the decision is justifiable and reasonable, irrespective of their own value system.

MAA as described in these guidelines uses weighting factors to encourage stakeholders to scale the importance of indicators according to their own value system. If the assignment of weighting has been done collaboratively with the appropriate stakeholders, then it is probably reasonable to assume that those weightings suggest general consensus. However, it is to be expected that some indicators would expose diametrically opposing value systems, and as a result general agreement on individual weightings may not be reached. At this point, the entire decision making process can come apart, as considerable effort may be exerted on discussing one or more problem indicators, whereas, potentially, irrespective on what value is adopted, those problem indicators may not be the ultimate deciding indicators.

The way to test the sensitivity of the value based decision making process is to assign different weightings to those indicators, sub-accounts and accounts according to a range of value systems representative of the perceived disparity.

The level and type of sensitivity analysis that should be carried out is not set, and should not be prescriptive. It is entirely project specific and to a large extent will be based on feedback received from stakeholders throughout the alternatives assessment process.

Table 16 presents an example of sensitivity analysis runs completed on the example dataset presented in Tables 13 through 15. The merit rating of each alternative is compared to the base case analysis to determine if the results of the sensitivity analysis are likely to lead to a different decision about which alternative may be the preferred option. In this example, all but the last case would have resulted in a different alternative having a higher merit rating.

It is conceivable that specific stakeholders may have completely biased opinions about how weightings should be evaluated, which may unfairly skew the assessment results. Sensitivity analysis is not intended to resolve this disparity. It does, however, provide a platform for presenting these opinions in a transparent manner where any stakeholder or external reviewer can make their own value judgements about all interpretations of the case.

Table 16: Example of the results of a sensitivity analysis

Analysis ID	Scenario Description	Merit Rating	
		Alternative A	Alternative B
Base	Base case as per Tables 13, 14 and 15	4.4	4.1
#1	Change weighting of indicator "berry harvesting impact" in Table 13 from 1 to 5	4.5	4.0
#2	Change weighting of sub-account "Aesthetics" in Table 14 from 3 to 1	4.4	4.1
#3	Change weighting from account "Project economics" in Table 15 from 1.5 to 0	4.6	3.9
#4	Apply all the changes from cases #1, #2 and #3 simultaneously	4.6	3.8
#5	Change weighting of all indicators in Table 13 as follows; "hunting impact" from 2 to 0; "fishing impact" from 5 to 6; and "berry harvesting impact" from 1 to 0	4.3	4.2
#6	Change all weighting factors to 1 in Tables 13, 14 and 15	4.5	4.4

The deliverable for this step would be a well-documented summary of the sensitivity analysis that was carried out. This may be presented in summary tables similar to those presented in Step 5 and Table 16.

2.8 Step 7: Document Results

The final step in the alternatives assessment process entails thorough documentation of the results. This is best done through a comprehensive technical report, which systematically describes the outcome of each of the steps as recommended in these guidelines. The primary technical alternatives assessment report should be a concise summary of the findings of each step, using comparative summary tables and descriptive definitions which make the results immediately apparent to the external reviewer. Detailed supporting information related to elements such as cost estimate breakdowns, or geochemical assessment should be presented in appendices, or if stand-alone reports have been produced, these should be properly referenced and made available for review.

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Annex 1: Deleterious Substances

Section 34(1)(a) of the *Fisheries Act* states that a deleterious substance means:

"any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water."

To determine if a substance, such as waste rock, is deleterious, mining proponents are to use established reference and guidance methods. These methods include, but are not limited to:

- the *Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, 2009* (MEND Report 1.20.1)*;*
- the *Global Acid Rock Drainage (GARD) Guide*, available on the "Mine Environment Neutral Drainage" website at www.mend-nedem.org**;** and
- Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage (Price W.A., 1997), available from the BC Ministry of Employment & Investment, Energy and Minerals Division.

These reference documents identify key characteristics of the substance in question, which help Environment Canada determine whether or not the substance should be considered deleterious. These characteristics include the substance's potential for: generating acid; leaching metal; and releasing non-metals and compounds that are of concern, specifically for ammonia, cyanide, arsenic, selenium and total suspended solids in a mining context, and the likely concentration, chemical speciation, and relevant site-specific conditions which would inform the determination of whether the substance is deleterious.

The concentration of all other non-regulated materials (e.g., oil, grease and mill processing chemicals) must also be managed so that there are no deposits of deleterious substances into water frequented by fish.

For the purposes of illustration, the following list shows a range of deleterious substances that are managed through regulations under subsection 36(3) of the *Fisheries Act*.

• Arsenic • Copper • Cyanide • Lead • Nickel • Zinc • Total suspended solids • Radium 226 • Any acutely lethal effluent • Biochemical oxygen demanding matter • Total suspended matter or solids	• Oil and grease • Phenols • Sulfide • Ammonia nitrogen • Any substance capable of altering the pH of liquid effluent or once-through cooling water • Mercury • Un-ionized ammonia • Total residual chlorine • Fish toxicants

Source: Metal Mining Effluent Regulations, Pulp and Paper Effluent Regulations, Fish Toxicant Regulations, Petroleum Refinery Liquid Effluent Regulations, Potato Processing Plant Liquid Effluent Regulations, Chlor-alkali Mercury Liquid Effluent Regulations, and the proposed Wastewater System Effluent Regulations

Annex 2: Fish Habitat Compensation Plans under Section 27.1 of the MMER and Subsection 35(2) of the *Fisheries Act*

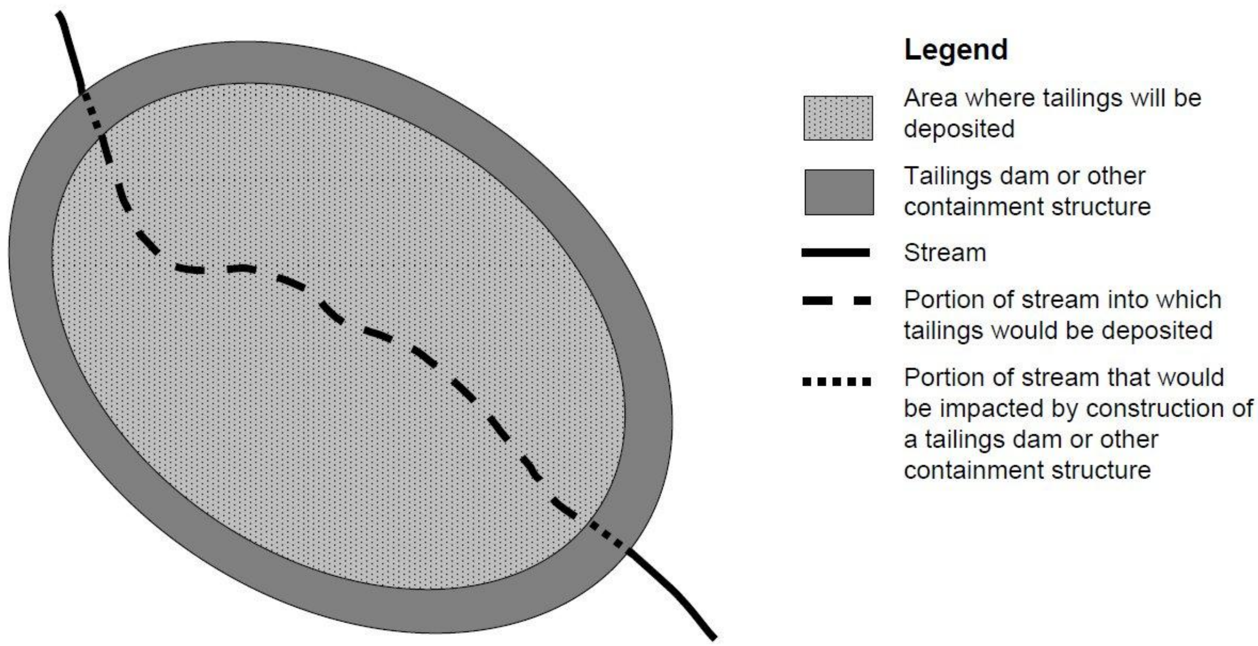
If a water body is added to Schedule 2 of the MMER the project proponent must develop and implement a fish habitat compensation plan in accordance with section 27.1 of the Regulations. In the majority of cases, a second fish habitat compensation plan is required under subsection 35(2) of the *Fisheries Act*. The key difference between these requirements is:

- Section 27.1 of the MMER requires fish habitat compensation to offset losses of fish habitat associated the deposit of a deleterious substance into the water body(ies) that are added to Schedule 2.
- Subsection 35(2) requires fish habitat compensation to compensate for the losses of fish habitat associated with the construction of the works themselves, such as a tailings dam.

Figure 2 illustrates the rationale for the need for the two separate fish habitat compensation plans in the case where a tailings impoundment area is established in an stream valley.

In this case, the losses of fish habitat in those portions of the stream into which mine waste would be deposited must be compensated under section 27.1. Losses of fish habitat in those portions of the stream that would be under the footprint of a tailings dam or other containment structure must be compensated under subsection 35(2).

Figure 2: **Fish habitat compensation requirements in typical TIA scenarios**



Annex 3: Regulatory Impact Analysis Statement

The Regulatory Impact Analysis Statement (RIAS) is a summary of the expected impact of a regulatory initiative that addresses each of the requirements of the federal government's regulatory policy as presented in the Cabinet Directive on Regulatory Management.[1] The use of regulatory impact analysis has long been recognized as an international best practice, and the RIAS has been used in Canada for over 20 years.

A properly prepared RIAS provides a cogent, non-technical synthesis of information that allows the various RIAS audiences to understand the issues being regulated. It allows audiences to understand the reason the issue is being regulated, the government's objectives, and the costs and benefits of the regulation. It also addresses who will be affected, who was consulted in developing the regulation, and how the government will evaluate and measure the performance of the regulation against its stated objectives. The RIAS is, in effect, a public accounting of the need for each regulation.[2]

The RIAS allows government decision-makers to do the following:

- synthesize information;
- improve their understanding of regulatory impacts; and
- better communicate the impacts of regulation to stakeholders

Outside the government, the RIAS gives the public and affected parties information that can be used to do the following:

- Evaluate proposed regulations;
- Better understand the regulation and obligations it imposes;
- Generate questions and comments about the regulation.

[1] In 2012, the CDRM (http://www.tbs-sct.gc.ca/ri-qr/directive/directive00-eng.asp) came into force, updating and replacing the *Cabinet Directive on Streamlining Regulation* (dated 2007) and the *Government of Canada Regulatory Policy* (dated 1999). The Directive applies to all stages of the regulatory life cycle (i.e., planning, development, implementation, evaluation, and review), including regulatory management.
[2] Privy Council Office (2001). *Guide to Making Federal Acts and Regulations*, 2nd edition. Page 181.

Annex 4: Steps in the EA and Regulatory Processes