# Implementation of Field Methods Outlined in the Environment Canada Metal Mining EEM Guidance Document at Four Mine Sites in Northern Ontario - Challenges and Recommendations

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## INTRODUCTION

Field Methods prescribed in the Metal Mining Environmental Effects Monitoring (MMEEM) Guidance Document issued by Environment Canada were implemented at four metal mining sites in the Sudbury basin in the Fall of 2002. The studies were conducted during the months of October, November and December 2002. Field methods for the sampling of benthic invertebrates, fish, sediments and water outlined in the Environment Canada document “Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring” June 2002 were followed in the development and implementation of the study design for each site. Several challenges became apparent when implementing these methods in the field and in situ modifications to the study designs became necessary.

Mining activity is bound by the location of the ore bodies that are being developed. Thus the flexibility of locating a production facility close to large bodies of water with excess assimilative capacities (as is the case with other resource based industries i.e. pulp and paper) does not usually exist with metal mining.

Applying the MMEEM guidelines to metal mining sites created several challenges for field crews. Typically, metal mines in Ontario discharge into small, low flow receiver streams and are often at the headwaters of larger watersheds. This was the condition encountered at three of the four sites where the studies were conducted. Consequently, sampling protocols for benthos and fish needed to be modified to accommodate these circumstances.

The author notes that site specificity will ultimately drive the design of EEM studies at metal mining sites. Accordingly, the flexibility to customize the study design to suit the physical characteristics of the receiver is essential in obtaining meaningful and representative data.

## STUDY DESIGN PHASE

Typically, an MMEEM study begins as a desktop exercise with the formulation of a study design which will meet the requirements of the program, or in other words, to answer the hypothesis “ is the mine effluent having an effect on the receiving environment”. The study team then begins the task of designing a study which will measure several environmental variables within the study area; namely, water, sediment, fish and benthos.

Problems encountered during this phase of the study relate to interpretation of some of the definitions in the MMEEM Guideline Document and the regulation. For instance, the definition of a mining effluent is extremely broad in these documents and can include any or all of the following; tailings impoundment effluent, mine water, mill process water, smelter effluent, treatment pond or treatment facility effluent, seepage and surface drainage from the site. The problem lies with the latter two definitions since typically they are non-point sources, which are extremely difficult to quantify and determine the area in which they are entering or affecting a surface receiver. To date, ASI Group’s approach has been to concentrate on point source only when formulating study designs for a mine site.

Another area where potential problems could arise during the study design phase is in the selection of an appropriate reference area. As noted in the introduction, mine sites are typically located in remote areas and usually at the origin of watersheds. This means that some sites may not have upstream reference areas or, have upstream reference areas that are dissimilar in physical characteristics to downstream exposure sites. While it is always best to utilize a reference area on the same receiver stream as the mine, in many cases alternate watersheds may have to be utilized. In almost all cases, this is never known until the fieldwork begins unless extensive reconnaissance by trained staff is completed prior to the study design phase. Choosing a reference area by only using a topographic map is not recommended. Determination of an appropriate reference area is an extremely important step since all downstream data collected will be compared to this benchmark and will determine if an "effect" is measured or not. The author also notes that from experience, in almost every case a good representative reference area can be located if enough investigative time is taken in the field during the site reconnaissance stage.

A secondary consideration when designing MMEEM studies is timing. There is little or no harmonization of the MMEEM requirement with existing provincial regulations (MISA or Ministry of the Environment Certificate of Approval's). Therefore, in an effort to minimize costs, the timing of these studies can sometime be chosen to coincide with provincial regulations requiring similar receiving water based studies. If this can be done, the MMEEM studies almost always satisfy any provincial C of A or MISA requirement.

## SITE CHARACTERIZATION

Prior to obtaining any samples in the field, each station is carefully characterized. This information is important when comparing data sets between stations. This is a crucial step and time must be taken to document all of the physical characteristics of each site in a comprehensive manner. Information collected during this stage includes:

- Global Position Coordinates (GPS)
- Bottom substrate
- Shoreline and aquatic vegetation
- Flow and velocity
- Surrounding topography
- Water clarity
- Hydrology characteristics
- Anthropogenic influences

## WATER QUALITY MONITORING

Potential problems that may be encountered when undertaking the water quality assessment phase of EEM include the following:

**Seasonal changes to receiving environments** – Presently, only one set of water samples is required from each of the sampling areas in the receiver during an EEM study. The conditions in these small receivers can change drastically from season to season with respect to flow, depth, velocity, suspended solids, pH, and conductivity and dissolved oxygen. Depending on the timing of the sample, worst case or best case receiving water quality may be captured. Sampling during seasonal variations (four times per year) would provide a better indication of how the water quality in the receiver is being affected by the mine effluent over a longer period and under varying flow regimes.

**Measurement of total or dissolved metals-** presently only total metals analysis is required, however, some parameters (i.e., aluminum) should also be measured in dissolved form (i.e. field filtered) so that comparisons to other criteria (PWQO) can be made.

**Laboratory Detection Limits** – Before submitting samples for analysis, ensure that the lab being using is accredited by the proper regulatory bodies and that they are able to measure at or below criteria (CCME or PWQO)

**Sample replication (QA/QC)** - At least 10% of samples should be split to determine lab precision. Travel blanks and spiked blanks should also be used as a QA/QC practice.

Beaver activity is another factor to consider since beaver dams can drastically alter the flow patterns and characteristics of a receiver stream from year to year. A proper site reconnaissance is strongly recommended prior to establishing sampling stations.

## SEDIMENT QUALITY MONITORING

The main focus of this part of the MMEEM survey is to determine if sediment, or more appropriately, substrate composition is a contributing factor to any "effects" measured in the benthic community.

The problems encountered stem from the fact that there is little differentiation given in the guidance document as to what is considered sediment and what is considered natural bottom substrate. Sediment and natural bottom substrate are distinctly different and should be treated as such in the study design.

"Sediment" samples are to be collected at all stations where benthic samples are collected at each reference and exposure area. In many cases, receivers being studied have very few depositional zones where samples can be obtained. In most cases encountered to date, scoured bottoms or natural geological substrates (sand, gravel, boulders or bedrock) are the norm.

If this is the case, then only particle size and TOC analysis is required on a composite of each replicate benthic sample. Chemical analysis should not be a requirement unless depositional zones are present in the reference or exposure areas. This is not clear enough in the guidance document and could lead to unnecessary analytical costs. The purpose of this investigation should be to determine if habitat differences are a contributing factor to measured differences in the benthic community. This information should be well documented during the site characterization stage through visual observations. Sediment quality should only be an issue if it is present in enough quantity to obtain adequate volumes for analysis in the reference and near-field exposure areas.

## BENTHIC INVERTEBRATE MONITORING

Benthic invertebrate monitoring involves the collection of quantitative replicate benthic samples from reference and exposure areas of a mine receiver. The comments and recommendations in this manuscript will focus primarily on the "Control/Impact" or "Gradient" study design of MMEEM studies since, under most conditions these design approaches will yield the most representative data and all of the studies conducted do date by ASI Group followed these study design methods. Alternative study design approaches will be addressed later in this document.

In the traditional Control/Impact study design, a series of replicate stations are located in a reference area upstream of the point source and in a near-field area downstream of the point source. A minimum of five replicate stations are located in the reference and near-field areas. The replicate stations are located at a pre-determined distance apart, usually depending on bank width and are located to ensure that all major substrates are sampled. Quantitative field sub-samples (three) are then collected at each replicate station using quantitative methods that suit the physical conditions of the receiver. Generally, these fall into dredge or scoop type samplers like Ponar or Eckmann dredges or air lift devices. All benthic samples are then stained using a dye and preserved for analysis.

Problems can arise here if improper sampling techniques and equipment are used in the collection of samples for benthic analysis. Sampling environments and substrate conditions can vary drastically between sampling sites. The author emphasizes the need for flexibility in choosing sampling techniques and equipment that are designed to work in the environment that is encountered.

There has been much recent discussion about introducing alternative methods to benthic surveys for MMEEM since, in some cases, mine sites are at the origin of sub-watersheds and may lack appropriate reference areas. While these alternative methods such as the Reference Condition Approach (RCA) and Mesocosms studies have some merit, they should only be used under a set of very specific and pre-determined circumstances and only after all other traditional study design approaches have been considered. From the author's experience, data that is collected from the actual receiver, whether upstream or a distance downstream of the point source always yields the best and most representative data. With an appropriate amount of time and effort during the desktop design of the study and during field reconnaissance for sample site selection, in most cases a good representative reference area can easily be located. In addition, the increase in sample stations, replication and area of bottom substrate sampled using the new MMEEM methods add to the robustness of the data generated. The problem with some of the alternative methods like RCA is that the data generated is qualitative in nature and does not take into account area of bottom substrate sampled. This could introduce significant biases into the data collected depending on who is conducting the sampling. This is avoided in traditional approaches since standardized methods and sampling gear are used, which generate highly reproducible results regardless of the operator.

## FISH MONITORING

The objective of fish monitoring for MMEEM studies is threefold;

- to determine if the mine is having an effect on the fish community;
- to determine if the mine is having an effect on the fish population; and,
- to determine if fish usability is being affected.

To accomplish this, a fish community assessment is undertaken in the receiver only if there is no recent historical data on fish community structure. The purpose of the community assessment is to establish the fish community structure in the reference and near-field areas and to aid in the selection of sentinel species to be utilized during the fish population and usability assessments in subsequent cycles of MMEEM.

From the author's experience, the difficulties with undertaking fish monitoring for MMEEM lie in the lack of an established quantifiable level of effort in the MMEEM Guidance Document that, when reached, would allow field personnel to terminate this portion of the monitoring and investigate alternative methods or modify the study design.

Under the current guidelines, if insufficient numbers or sizes of fish are captured there is no mechanism that allows managers to terminate the fieldwork and investigate alternatives. This happens quite often since mine water receivers are often small creeks and rivers that are, by nature, not extremely productive to begin with in terms of habitat for large recreational fish species or are staging areas for juvenile or forage fish species.

This leads to excessive amounts of field time using different methods of capturing fish which, if done over successive MMEEM cycles, could have a negative impact on the fish populations that the MMEEM initiative is designed to protect.

Recommendations for fish monitoring include using non-destructive techniques in all cases and limit the monitoring to the evaluation of the fish community structure only. Fish population and usability studies should only be undertaken if there is evidence that the population is being negatively affected by the mine site.

## SUMMARY COMMENTS

In general, after completing several MMEEM studies at different sites, the author notes that the greatest challenge is ensuring that the data collected is going to be meaningful, relatively easy to interpret, and free of any "false positive effects". The only way of achieving this is through proper site reconnaissance prior to the study design phase and choosing sampling techniques which provide the most representative sample, taking into consideration the physical attributes of each station.

It is also important to use trained field staff to undertake the fieldwork and to employ proper QA/QC techniques in the collection of all environmental samples.