DEVELOPING A MINE EROSION AND SEDIMENTATION CONTROL PLAN GUIDANCE DOCUMENT FOR EXPLORATION, CONSTRUCTION, OPERATION AND CLOSURE

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ABSTRACT

Erosion control during the mining cycle can be more effectively planned using Erosion and Sedimentation Control Plans (ESCPs). Ministry of Environment, Ministry of Forests, Lands and Natural Resources Operations and Ministry of Energy and Mines are developing an ESCP Guidance (ESCPG) document to clarify how the Environmental Management Act (EMA) pertains to the management of sediment. The benefits of having an ESCPG is expected to result in: (a) plans will be more standardized; (b) more clarity and efficiency for those generating ESCPs; (c) assisting regulators tasked with reviewing/approving ESCPs; (d) providing guidance for EMA mine effluent permitting; (e) establishing an expectation for including ESCPs in the BC Environmental Assessment (EA) phase and the mine economic assessment; (f) applying and optimizing ESCPs above the "watersheds" of sediment ponds; (g) utilizing the ESCPG document for "exploration"/"advanced exploration" sites as defined under EMA; (h) lowering the risk of adversely impacting water quality downstream of mining activities; and (i) providing a methodology for determining the need for sedimentation pond(s) during the construction and production phases. ESCPs will proactively create increased administrative efficiency in the EA and sub-EA reviews, EMA mine effluent permitting, and other governmental processes, and add support to the BC government "One Project, One Process" approach.

KEY WORDS: planning, assessment, sediment, discharge, fine particles, RUSLE method

INTRODUCTION

This paper is a joint government effort to develop a guidance document for developing erosion and sediment control plans which are vital to minimizing soil loss, both across the landscape and into watercourses. The Ministries of Environment (MOE), Forests Lands and Natural Resource Operations (FLNRO), and Energy and Mines (MEM) are developing the guidance document.

Soil is a valuable and non-renewable resource. When erosion results in significant "sediment yield" (i.e., sediment discharging into a watercourse) the inorganic portion becomes a lost resource, triggering additional adverse consequences, both on land and particularly in watercourses. Mining activities present a risk during exploration, construction, operation and post mining phases by generating a total suspended

solids concentration (TSS) in runoff (effluent) entering receiving waters at soil erosion rates significantly above “natural” erosion rates (Goldman et al., 1986).

It is recognised that sediment is essential to stream structural integrity and stream health; but when received in concentration and/or duration beyond natural regimes, it becomes a pollutant (Nordin, et al, 2009). The Ministry of Environment’s Environmental Protection Division (EPD) administers the *Environmental Management Act* (EMA) by setting criteria to define when “sediment yield” becomes a “pollutant”. EPD applies BC ambient water quality guidelines (refer to reference cited) and authorizes the concentration of sediment in effluents from mining activity based on (a) 50 mg/L TSS (coal mines) and (b) 30 mg/L TSS (metal mines); while (a) is based on Best Achievable Technology, (b) is required under federal legislation.

A sediment discharge from mining site runoff and mining-related activities requires a site specific authorization (permit/approval) which sets effluent discharge limits and specifies the Best Achievable Technology that must be applied. The need to manage sediment discharges from mine sites and to enhance consistency and transparency relative to ESCPs supports the development of an ESCPG document.

GUIDANCE DOCUMENT AND SITE SPECIFIC PLANS

The ESCPG document is intended to assist the erosion control professional when writing an ESCP by describing “what to” include in the plan, rather than a “how to” for erosion control. The ESCPG document will support a consistent approach across the province by enhancing environmental protection relative to minimizing soil loss and contribute to maintaining the applicable receiving water guidelines for total suspended solids concentration (TSS mg/L) and turbidity (as NTU). There are many “guidance documents” related to erosion control (e.g. Reclamation and Environmental Protection Handbook for Sand, Gravel and Quarry Operations in BC; EPA, 1976). The ESCPG will require mining companies to provide a site specific ESCP. Mine effluent permits may require the permittee to provide MOE with an acceptable ESCP based on the requirements in the ESCPG. If an ESCP becomes a condition in an effluent permit, the ESCP becomes a legal requirement that must be complied with. The mine effluent permits may also specify the manner in which the ESCP is adapted to reflect the erosion prevention needs at a particular mine site.

REGULATORY REQUIREMENTS UNDER THE ENVIRONMENTAL MANAGEMENT ACT

Mining, and mining-related activities, have the potential to generate significant sediment release, which generally places the consequences of the activity within the *Environmental Management Act* definition of (actual and/or potential) “pollution”, and therefore necessitates the need for a *permit* or *approval* (short term “permit”). The ESCPG and EMA permitting (related to sediment release) are pertinent to the following distinct mine development phases:

(a) **“exploration**” phase (some activities have the potential to generate significant sediment mobilization);
(b) **“advanced exploration”** phase;

(c) Environmental Assessment phase (ESCPs generated at the EA review stage, create support for subsequent EMA permit development);
(d) EMA initial permitting phase (**construction phase**);
(e) **mine operational** EMA permitting phase; and
(f) any phase of mining, and mining-related activities that could result in significant sediment release, resulting in pollution.

For (a), the intent is to require the mining company to make the proactive decision on how to reduce the risk of "pollution" by having an ESCP based on the judgement of the exploration company; or alternatively, MEM may elect to have a requirement in the Notice of Work permit for an ESCP. For (b), which would necessitate an EMA authorization, the ESCPG would emphasize the need for an ESCP to be included in the permit/approval. The dual intent of (d) and (e) is to include an ESCP in an EMA mine effluent permit. For administrative efficiency, (d) and (e) related to the construction/operational phases is not intended to suggest one permit for construction, one permit for mine operation; the one permit for the construction/operational phase is the suggested permitting process.

Mining in the Province of BC is regulated by the MEM and the MOE. Under the *Mines Act* and *Health and Safety Regulation Code for Mines*, MEM is responsible for approving mineral exploration, mine construction and operation, and reclamation. MOE's Environmental Protection Division (EPD) through its legislation, *Environmental Management Act* (EMA), the Waste Discharge Regulation (WDR), and various other statutes (e.g. Placer Mining Waste Control Regulation, Hazardous Waste Regulation, and Municipal Wastewater Regulation) is responsible for regulating/authorizing the quantity and quality of any discharge to the environment from activities relating to mining/exploration of:

- metals (e.g. gold, copper etc.);
- non-metals (fertilizers);
- coal;
- gemstones;
- industrial mineral ores (diamonds); and
- beneficiating mineral ores (including custom milling).

An authorization from MOE is *not* required for activities associated with the mining/exploration of:

- aggregate (i.e., gravel, sand, crushed rock) and
- dimensional stone (i.e., quarries).

Despite the lack of a requirement for MOE authorization for aggregate and dimensional stone mining, a general prohibition from introducing waste into the environment in such an amount or quantity as to cause pollution is applicable (to all mining-related activity). Detailed guidance relative to MEM exploration requirements is found in the MEM document: "Handbook for Mineral and Coal exploration in British Columbia".

PROPOSED CONTENT OF THE ESCPG

An ESCP should be developed in the context of the broader planning framework of erosion and sediment control and sediment pond design at a mine site for the various stages of mining activity. Preferably this planning is initiated prior to, or when the environmental impact assessment report preparation is undertaken. The costs of erosion and sediment control and sediment pond design and operation, and the importance of demonstrating robust environmental protection for a proposed mining project, are significant enough to warrant inclusion in the *preliminary economic assessment* phase (for example) to allow the management plans to be created and entered into the environmental assessment documents.

As a mine progresses through the various development phases, the ESCP will need to be updated accordingly. The following is a suggested Table of Contents for an ESCP guidance document:

Table of Contents

1. **Description of the Project**
    a. Project History
    b. Site Mapping
        i. Watercourses
        ii. Erosion and sediment control structure locations
        iii. Camp location
        iv. Drill pad location
        v. Mine or future mine site location
        vi. Monitoring locations
    c. Surface Preparation Activities
    d. Existing Site Conditions
    e. Proposed Mine Site
        i. Meteorological conditions (rainfall intensity and frequency)
        ii. Trails
        iii. Erosion and sediment control works
        iv. Description of contingency materials
    f. Updated Plan to reflect current mine status
2. **Risk Assessment (Soil Loss Estimation)**
    a. Conduct a soil loss estimation for the mine area using Revised Universal Soil Loss Equation (RUSLE) or acceptable alternative methodology
    b. Collect representative soil samples upstream of the pond watershed
    c. Collect representative samples of soils that will potentially be eroded
    d. Perform particle size analyses down to 2 microns on soil samples
    e. Analyze relevant data and perform a risk assessment
3. **BMPs [Erosion – Sediment Control Specialist will provide this]**
    a. Road Construction
    b. Site Runoff
    c. Spring Break Up
    d. Severe Weather Shutdown
4. **Environmental Monitoring and Reporting**
    a. Sampling,

i. Incorporated into the mines Operational Plan
ii. Runoff and receiving water sampling (follow BC Field Sampling Manual)
iii. Visual Sampling as per FREP Water Quality Effectiveness Evaluation Field Tables
iv. Turbidity measurements of runoff at key locations to "test" effectiveness of BMPs and the need to install additional BMPs when turbidity levels that are becoming elevated.

b. Reporting.
    i. Annual Report
        1. Sampling results
        2. Quantity and quality of the discharge
        3. Maintenance performance
        4. Inspection results
    ii. Unauthorized discharges (spill or emergency)

5. Maintenance

a. Inspection
b. Repair/Restore Function of Erosion and Sediment Control Systems

EROSION CONTROL STRATEGY AND THE USE OF SEDIMENTATION PONDS

Full scale sediment ponds, including associated design and location of these ponds are needed for all mine sites. Erosion control plans typically do not link conventional erosion control methodology and sediment ponds. The major watershed characteristics common to the ESCP and the sediment pond design affecting soil erosion are: climatology, geology, soils, vegetation, topography and hydrology. There are four main sources of sediment associated with surface mining: (1) haul and access roads, (2) areas of active mining, (3) areas being cleared for mining activities, and (4) areas in the process of reclamation. The scientific rationale for the need to install sediment ponds at a mine site is informed by the results of performing the following tests and RUSLE calculations (for example, as described in EPA, Hardrock Mining, 2003, Terrence et al., 1998, EPA, 1976 Volumes 1 & 2 and Rescan 2007):

(a) perform particle size distributions of representative soils that will be eroded;
(b) perform settling tests to predict settleability of the runoff soils into the sediment pond; and
(c) perform settling tests using settling aids as indicated by the results of (a) and (b).

While these tests are traditionally considered to be related *only* to the design of sediment ponds, the soil particle size data and settling tests provide a valuable tool to the design of ESCPs. The ESCPG encourages the application of RUSLE (or equivalent) methodology to assess the sedimentation from proposed mining projects, and to include this assessment in documents supporting the EA and sub-EA processes, to accelerate subsequent waste permitting associated with erosion and sediment control.

The development of a site water management plan strives to divert un-impacted water around, or through, the mine site and into the watercourses. The ESCP strives to minimize erosion and control sediment as near to the source as feasible. The ESCP is essential for preliminary mine development activities and construction of the water management system. Construction planning should emphasize the goal of

building sediment ponds as soon as feasible to capture surface runoff from disturbed areas. The construction planning process may be influenced by RUSLE calculations and the testing as outlined in (a) and (b) above.

It is recommended that a risk analysis cannot be effectively conducted without determining the particle size analyses of the soils to be disturbed. It is also recommended that a RUSLE approach be applied to quantify the magnitude of the soil loss based on the type of surface disturbance, areas of surface disturbed, and soil type, in addition to the many other variables identified in the RUSLE methodology. In addition, the settling testing of soils that will enter the sediment ponds will also assist in defining the challenge associated with the "sedimentation control" strategies of the ESCP. Soil samples from a mine site should include the collection of dedicated samples for particle size analyses and settling tests. These tests are recommended prior to submitting the Environmental Assessment application. The results of (a), (b) and (c) outlined above are necessary to provide a complete proposal as to how sediment will be controlled (Clark, 2010 Flocculants). Soil samples from the depth of soil that will be exposed at various phases of the site disturbance are considered appropriate.

The most important factor, which may cause excessive sediment discharges to receiving waters, is the presence of un-settleable fine particles in the soils ("fines") being excavated, or otherwise disturbed. Whether such soils become problematic in runoff, will be dependent on the effectiveness of the erosion control, rainfall intensity and duration, and other factors captured in RUSLE calculation. Preventing mobilization of soil particles becomes more difficult for soils with an elevated minus 2 and minus 10 micron particle size fraction. For example, if the runoff contains 1000 mg/L TSS and the soil eroded contains 10% minus 2 micron, these particles are unlikely to settle with 24 hours settling time (due to the universal phenomenon of Brownian motion). The "sedimentation control" part of the ESCP will need to use some form of "filtration" mechanism or directing runoff into a vegetated area, through a "sand filter", a commercial filter sock, or equivalent. Filter socks may require careful addition of a (low toxicity) flocculant to prevent the fabric from sealing. Alternatively, the ESCP should recommend the use of a sediment pond to provide treatment and produce acceptable discharge quality for the local receiving environment.

Soil loss may be approximately quantified using the RUSLE method. The United States Department of Agriculture has developed viable methods over the past half a century, and Terrence, et al., 1998 has adapted the methodology for mined lands. Quantification of soil loss is needed to determine when erosion control alone is insufficient, thus necessitating the installation of sediment pond(s) to adequately protect receiving waters. Useful references on the application of RUSLE at mine sites are found in Terrence et al 1998, U.S. Department of the Interior 1982 and Rescan 2007. Figure 1 is a suggested process diagram for determining whether sediment ponds are required:

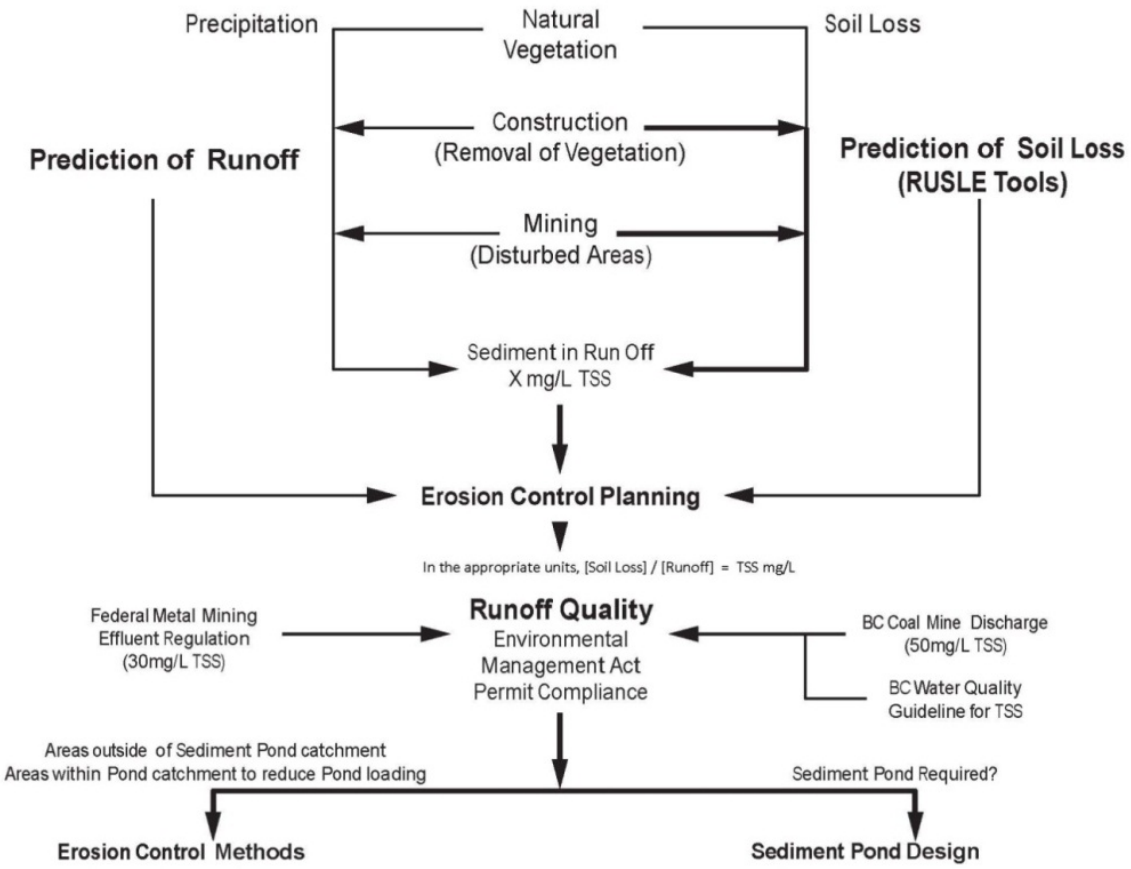

Figure 1 – Erosion and Sedimentation Control Plan Process Diagram

It should be emphasized that a sediment pond is viewed as standard, minimum treatment works required at a mine site. Any departure from this minimum expectation requires justification at the environmental assessment stage using a sound scientific rationale based on the foregoing suggested testing procedures (Clark, 2010, Sediment Ponds).

ESCPG AND MINE ROADS

Roads at some mine sites may present a particular challenge if their drainage cannot be directed into a sedimentation pond. Roads built on steep slopes and adjacent to a watercourse or the road upslope/downslope areas may be potentially unstable masses and significant generators of sediment. If these features are present at a mine site, this situation warrants particular attention in the ESCP (FLNRO Forest Road Engineering Guidebook, 2002.). The following should be explored when assessing the potential generation and contribution of sediment from roads:

- assess the road surface and sub-surface conditions relative to the suitability of material placed on the road to resist erosion (this may require looking at the mineralogical make-up of the material used to surface the road and the particle size distribution);
- assess the geotechnical aspects upslope/downslope of the road to determine potential for mass movement of soils (into the adjacent watercourse);
- based on the risk of potential failure of the upslope/downslope soil masses, particular attention may be needed in the design of road ditching, or more intensive biotechnical stabilization of upslope/downslope of the road at critical locations; and
- the material placed on/under the road surface should be of known mineralogical/weathering characteristics which will not be susceptible to breakdown into to fine particles, both from heavy traffic loads and weathering breakdown.

DISCUSSION

Development of an ESCPG document outlining what to include in an ESCP will provide clarity to the erosion control specialist writing the plans. For the regulators reviewing ESCPs, a guidance document will be a useful aid for assessing the completeness of the ESCPs. For mining companies, the guidance document will allow more certainty on regulatory expectations and erosion control costs. Standardizing ESCP content streamlines EMA effluent permitting erosion control requirements, which is expected to lead to enhanced consistency in mine effluent permitting. An ESCP guidance document is not in any way intended to replace the erosion control specialists' key role in the preparation of ESCPs; the intention is to:

a) outline the minimum expectation for the Table of Contents,
b) provide guidance to mining companies relative to the importance and timing of providing an ESCP, and
c) identify site supervision requirements of ESCP implementation, reporting, maintenance, keeping the ESCP current, and erosion-control-specific monitoring requirements.

The ESCPG document is intended to clarify the MOE requirement for all mining activity which could potentially generate soil loss, to develop an erosion control plan, designed by an erosion control specialist, or equivalent qualified professional. The ESCP will ensure a consistent approach to environmental protection relative to minimizing soil loss and contribute to maintaining the applicable receiving water guidelines for total suspended solids concentration and turbidity. While there are many "guidance documents" related to erosion and sediment control, the proposed Ministry of Environment Erosion and Sedimentation Control Plan guidance document will describe what should be included in a site specific ESCP. Mine effluent permits may include a clause requiring the permittee to provide MOE with an acceptable ESCP based on the requirements in the ESCPG. This will ensure a mining company has a plan in place to reduce the risk of releasing unacceptable levels of sediment into a watercourse.

It is envisioned that the ESCP will be updated as the mining operation develops. Additional benefits derived from an ESCPG document are enhanced sediment control and environmental protection together with the following potential advantages:

(a) the ESCPG document will be available online, thereby providing easy access for all users;

(b) the online document will provide current information requirements, and reduce confusion regarding what are the current plan requirements;
(c) standardize requirements for the content of an ESCP relative to EMA mine permitting;
(d) provide transparency and improved efficiency for those generating ESCPs;
(e) provide a standardized framework for regulators who are tasked with reviewing/ approving ESCPs;
(f) the document will provide a defined tool for developing EMA mine effluent permits regarding erosion control clauses;
(g) the ESCPG document will provide a framework for including ESCPs in the BC Environmental Assessment project application; and
(h) The online ESCPG can be updated as required and the modified versions will then be readily available.

The use of ESCP guideline is intended to achieve the following desirable outcomes:

(a) encourages proposed mining projects to include ESCPs into the early phase mine economic assessment;
(b) emphasizes the efficacy of applying and optimizing ESCPs above the "watersheds" of sediment ponds;
(c) provides erosion control guidance for application to all phases of mine development;
(d) identifies the requirements which need to be applied on a site specific basis, and solidified in the form of an erosion and sedimentation control plan; and
(e) requires the mining company's erosion control specialists to perform site supervision with follow-up reporting, on-going maintenance inspection and reporting to EPD.

CONCLUSIONS

An ESCP guidance document will require mining companies to provide plans that:

- provide enhanced environmental protection;
- reduce the risk of an accidental release of sediment into a watercourse;
- require ongoing reporting to EPD of the erosion control specialist's inspections of BMPs, recommended maintenance requirements, and implementation of the recommended modifications;
- provide frequent site inspections of the adequacy of the erosion control works and BMPs;
- provide increased certainty of what the provincial government requires from mine proponents relative to reducing soil loss from a mine site;
- provide a one-process approach; and
- create increased efficiency during the EA/sub-EA review processes and EMA permitting.

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