SITE C CLEAN ENERGY PROJECT

ACID ROCK DRAINAGE AND METAL LEACHATE MANAGEMENT PLAN

Prepared by

Klohn Crippen Berger Ltd. and SNC-Lavalin Inc.

For

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1. Objective

The objective of this Acid Rock Drainage and Metal Leachate Management Plan (ARD and ML Management Plan) is to describe measures to mitigate potential adverse effects on the receiving environment resulting from known or potential sources of acid rock drainage (ARD) or metal leaching (ML) material. This ARD and ML Management Plan describes the measures that would be adopted to effectively dispose of materials that would be excavated, exposed or disturbed during the construction of the Project at the various project component activity sites defined in Volume 1 Section 4.3 Project Description.

2. Background

The ARD and ML Management Plan includes risk-based planning and design approaches to quantify the long-term impacts of mitigation option(s) and select the most appropriate mitigation option(s). Mitigation measures include testing and analysis of materials that will define handling and storing plans to reduce discharges and minimize long-term monitoring and maintenance.

Acid rock drainage and metal leaching occur when sulphide minerals react with oxygen, ferric iron and water to produce sulphuric acid. Sulphuric acid could then leach metals thereby further increasing the acidity (H^+) and producing sulphates (SO_4^2), and metals (denoted as Fe^{3+} in the following equation). The chemical equations include:

1. $FeS_2 + 7/2\ O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^2 + 2H^+$
2. $FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^2 + 16H^+$
3. $Fe_2^+ + 1/4O_2 + H^+ \rightarrow Fe^{3+} + 1/2H_2O$

Acid rock drainage can be neutralized with the addition or presence of carbonate minerals (such as calcite) or aluminosilicate minerals.

The primary approach to prevent and mitigate ARD and ML is to minimize the supply of the primary reactants for sulphide oxidation and/or maximize the availability of acid neutralizing minerals. Examples of these approaches include one or a combination of the following:

- Minimize oxygen
- Minimize water and moisture
- Minimize, remove or isolate sulphide minerals
- Control pore water solution pH
- Maximize acid neutralizing minerals and pore water alkalinity
- Control bacteria and biogeochemical processes

The main objectives of the ARD and ML Management Plan are to:

- Identify the procedures for managing and storing excavated materials during the construction and operation of the Project
- Recommend and implement a monitoring program to assess the performance of material management and storage strategies
- Take corrective action as required

The Geochemistry subsection of Volume 2 Section 11.2 Geology, Terrain and Soils, describes the current geochemical characterization program. It states that although the characterization program is currently at an advanced stage, it will continue to be developed and therefore this ARD and ML Management Plan will be revised in parallel, as knowledge of the geochemistry of the materials is refined. This Plan is based on geochemistry data and characterizations up to the end of 2012 (KCB & SLI 2013) and the construction and excavation schedule described in the Volume 1 Section 4.3 Project Description.

The current geochemical characterization program includes material from the Site C dam site, the Highway 29 realignment segments, Hudson's Hope shoreline protection, as well as West Pine and Portage Mountain quarries.

3. Regulations and Guidelines

3.1 Statutory Requirements

The legislation that contains provisions relevant to prevention and management of acid rock drainage and metal leachate include the federal *Fisheries Act*, and the provincial *Environmental Management Act* and the *Fish Protection Act*. If the drainage of metal leaching material has the potential to affect surface water or groundwater, then the *Water Act* and *Groundwater Protection Act* would also apply.

3.2 BC Hydro Policies

The applicable corporate policy is the Environmental Responsibility Policy (BC Hydro 2010).

3.3 Voluntary Commitments

The ARD and ML Management Plan is consistent with relevant management practice guidelines, which includes:

- Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, Ministry of Energy and Mines and Ministry of Environment, Lands and Parks, July 1998
- Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, Ministry of Energy and Mines, August 1998
- DRAFT Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, Ministry of Employment and Investment, April 1997
- List of Potential Information Requirements in Metal Leaching/Acid Rock Drainage Assessment and Mitigation, Mine Environment Neutral Drainage Report 5.10E, January 2005
- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND Report 1.20.1, December 2009
- The Global Acid Rock Drainage Guide, http://www.gardguide.com/index.php/Main_Page, International Network for Acid Prevention INAP, 2012
- British Columbia Ministry of Environment Approved and Working Water Quality Guidelines

4. Mitigation and Environmental Protection Measures

This ARD and ML Management Plan is based on Project planning and geochemical characterization at the time of preparation of the Environmental Impact Statement and could change as a result of procurement and contractor preferences as well as project planning and advancements in the geochemical characterization of the materials. The geochemical characterization of construction materials will be completed prior to use and therefore, this ARD and ML Management Plan would be updated to include all construction materials based on the results.

To ensure this ARD and ML Management Plan remains current, it would be updated at a minimum of once per year or as required based on Project advancements.

The current plan is described below.

4.1 Proposed Mitigation

Based on the current geochemical characterization and Project construction plans, the ARD and ML Management Plan at respective sites described below are recommended to mitigate the potential generation of ARD and ML.

4.1.1 Dam Site

Volume 1 Section 4.3 Project Description describes how the construction of the dam, generating station and spillways would produce unsuitable construction material as a result of excavating overburden and bedrock material. This material would be contained within the relocated spoil excavated material (RSEM) areas at the dam site as shown in Figures 4.37, 4.38 and 4.39 in Volume 1 Section 4.3 Project Description. Table 4.16 Volume 1 Section 4.3 Project Description summarizes the sources of the excavated materials, disposal area and approximate embankment volumes.

Geochemistry results and characterization up to the end of 2012 (KCB & SLI 2013) reported:

- Bedrock Unit 12 as potentially acid generating
- Bedrock Unit 11 as potentially acid generating to uncertain
- Bedrock Unit 10 as potentially acid generating to not potentially acid generating
- Bedrock Units 9, 8, 7, 4, 2 and 1 as generating or potentially acid generating with a lag time of 1 year and a duration of up to 5 years

- Bedrock Units 6 and 5 as generating or potentially acid generating with a lag time between 7 and 8 years after exposure and a duration of up to 16 and 23 years for Units 5 and 6, respectively
- Bedrock Unit 3 as generating or potentially acid generating with a lag time of 1 year and a duration of up to 12 years
- Overburden as not acid generating nor potentially acid generating

Based on the preliminary geochemical characterization of the dam site materials, the main ARD and ML mitigation strategies for the design of the RSEM areas are to:

- Prevent or minimize water contact, by limiting the infiltration of surface run-off, precipitation, snow melt or groundwater into the material
- Prevent or minimize air (oxygen) ingress into the material
- Incorporate acid neutralizing minerals, where practical

Although the overburden is not acid generating or potentially generating acid, elevated selenium in the leachate was present in the majority of the unconsolidated overburden units. No specific material management units are defined at this time, and all units require that selenium leaching as well as other readily soluble trace elements be prevented or mitigated by applying the mitigation strategies for the RSEM areas as listed above.

4.1.1.1 North Bank RSEM Area L3 Management Measures

Overburden from the north bank excavations would be relocated to RSEM Area L3. RSEM Area L3 is located in a gulley on the north bank. Prior to placing any excavated overburden material an underdrainage system would be installed to carry surface water through the area. When compacted the glaciolacustrine silts and clays overburden materials have a very low permeability; therefore the material overlying the underdrainage system would be compacted to provide an impervious barrier to minimize infiltration into the underdrainage system. In addition, material in contact with the ground surface would be compacted to minimize seepage into the ground.

The following measures would be taken to control runoff during filling:

- Compacting the downstream face after each lift of fill with a sheep foot or similar roller to give a compacted indented face
- Topsoiling and seeding the downstream face each spring at the start of the growing season

- Installing gravel-lined or half round pipe drains along the contacts between the compacted fill and the natural ground
- Sloping the top surface of the fill to the upstream so that surface runoff will be conveyed to the drains along the contacts and not down the downstream face
- Installing appropriate erosion and sediment control structures

The final surface would be compacted to minimize infiltration and drainage control would be incorporated to prevent erosion by carrying surface runoff to the bed of the gulley. The final surface would be topsoiled and seeded.

4.1.1.2 North Bank RSEM Area L5 Management Measures

Overburden and bedrock from the north bank excavations would be relocated to RSEM Area L5, located on the north bank of the river upstream of the dam. A gravel retention berm would be constructed around the area. An impervious layer would line the inside face and ground surface within the retention berm to minimize infiltration into the ground and seepage into the river.

The following measures would be taken to control seepage and runoff during filling:

- The gravel containment berm would be raised so that it would always be above the fill placement level enabling any runoff to be contained and if required, treated. Contractor preferences would determine how the water is treated.
- All rock placed in this area would be encapsulated with compacted glaciolacustrine material to isolate it from water and oxygen.

Following construction, an impervious capping layer would be overlaid on the relocated materials. This lining and capping would minimize infiltration of air and water to mitigate the potential of ARD and ML. Containment and treatment of runoff from this area would continue until reservoir filling. Area L5 would be permanently submerged which would prevent any further oxidation and resultant ARD or ML.

4.1.1.3 North Bank RSEM Area L6 Management Measures

Overburden and rock from the north bank excavations, particularly the excavations for the diversion tunnels, would be relocated to RSEM Area L6, which is located on the north bank of the river, downstream of the dam. RSEM Area L6 would be constructed and filled as described for RSEM Area L5 except that:

- After compacting the glaciolacustrine capping layer a gravel layer would be added to provide a working surface as this area would be used for temporary construction facilities
- The riprap would be placed on a thick bed of acid neutralizing materials with a high fines content (e.g., crushed limestone), to provide buffering for any acidic drainage through the sides of the area in the long term
- The area would not be inundated and at the end of construction it would be graded and vegetated

4.1.1.4 South Bank RSEM Areas R5a, R5b and R6 Management Measures

Overburden and rock from the south bank excavations would be relocated to RSEM Areas R5a and R5b, which are located on the south bank of the river upstream of the dam. These areas would be constructed and filled as described for RSEM Area L5 except that:

- The lining and capping would be constructed from compacted shale, glaciolacustrine material or colluvium as there may not be sufficient excavated glaciolacustrine material excavated on the south bank to cap and line the areas. Alternatively a geomembrane may be used.

In addition to RSEM Areas R5a and R5b, overburden from the south bank excavations could also be relocated to Area R6, which is located downstream of the dam. This area would be constructed and filled as described for Area L3 since it would not contain any rock and it would be located downstream of the dam. The area would not be inundated at the end of the construction; therefore it would be graded and vegetated.

4.2 Construction Monitoring of Dam Site RSEM

4.2.1 Highway 29 Realignment Segments

The unconsolidated overburden samples collected from the Lynx Creek and Farrell Creek Highway 29 realignment areas indicate the material is not potentially acid generating (KCB & SLI 2013).

Testing is on-going to determine if the material is potentially metal leaching. If the material is determined to be metal leaching, the ARD and ML Management Plan would be revised to include feasible mitigation strategies for these materials.

4.2.2 Hudson's Hope Shoreline Protection

Overburden samples collected from the Hudson's Hope shoreline protection area were classified as not potentially acid generating (KCB & SLI 2013). Testing is on-going to determine if the material is potentially metal leaching. If the material is determined to be metal leaching, the ARD and ML Management Plan would be revised to include feasible mitigation strategies for these materials.

Results of the bedrock analyses reported some of the samples to be potentially acid generating. Testing is on-going to determine if a management plan is required for the bedrock material, this Plan will be revised to include this refinement. The current design of the shoreline protection does not include excavating or disturbing this rock.

4.2.3 West Pine Quarry

The rock from West Pine Quarry was classified as not potentially acid generating and the metal leaching potential is low, with the exception of elevated selenium (KCB & SLI 2013). A more detailed assessment to determine the mobility of selenium is on-going. This ARD and ML Management Plan will be revised to include selenium leaching mitigation if required.

5. Training and Human Resource Planning

A standard operating procedure and supporting manual would be prepared and provided to guide the personnel assigned to the geochemical characterization monitoring described below.

The personnel conducting the characterization program would be trained and managed by a professional geologist or engineer experienced in ARD and ML prediction.

6. Monitoring and Reporting

Throughout the construction phase of the Project, an on-site geochemical characterization program would be implemented to improve the understanding of the spatial variability of the geochemical properties of the materials and make adjustments to the ARD and ML Management Plan as necessary.

This characterization program would include either visual assessment techniques, field measurement techniques or both, as well as a laboratory quality assurance and quality control program.

In addition to the visual and field measurements, as determined by the professional geologist or engineer, groundwater and surface water would be monitored during construction.

At the dam site, construction monitoring would include:

- A series of shallow seepage monitoring wells installed down gradient of the RSEM Areas to monitor potential seepage migration and changes to groundwater quality during construction. The locations and depths of these monitoring wells would be planned in consultation with hydrogeologists familiar with the dam site hydrogeology.
- Contact runoff of surface water from the RSEM Areas to check whether the water quality is acceptable for release into the Peace River.

In the event the water quality does not meet the statutory requirements, the water would be treated prior to disposal.

The frequency of monitoring and the field parameters to be measured and analytes to be analyzed would be developed by the professional geologist or engineer in consultation with aquatic scientists and fisheries biologists.

7. Conclusion

This ARD and ML Management Plan is based on Project planning and geochemical characterization at the time of preparation of the Environmental Impact Statement and could change as a result of procurement and contractor preferences as well as project planning and geochemical characterization advancements.

This ARD and ML Management Plan will be refined with additional information on the geochemical testing listed in this report as well as other identified construction sources for which testing is underway.

8. References

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