

**National Exams May 2016****09-MMP-A6, Mining and the Environment*****3 hours duration*****NOTES:**

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a Open book exam.  
Any non-communicating calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.  
The first five questions as they appear in the answer book will be marked.
4. Each question is of equal value (20 marks).
5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

**Question 1: Prediction of Acid Generating and Neutralizing Potential**

A study for a planned open pit mine assessed the acid generating potential of the mine's waste rock. The presence of limited sulphide mineralization was known and there were several natural sulphidic outcrops in the region of the planned mine.

The study predicted that waste rock would be net neutral from the perspective of acid generation due to:

- a visual assessment concluding the rock contained little or no sulphide minerals;
- a visual assessment that the sulphide minerals on exposed surfaces did not appear to have reacted; and,
- a belief that the sub-alpine climate was not conducive to weathering.

The mine was brought into production and subsequently experienced significant unanticipated acid generation from waste rock, including the discovery of acidic drainage from naturally occurring outcrops.

5 marks A. Provide a brief critique of the method (in general) employed to assess the acid generating potential of the waste rock. This critique should take approximately 5 sentences.

15 marks B. Describe the steps that should be taken to assess the acid generating or neutralizing potential of a rock mass:  
i) during the exploration and pre-production phases of a mine; and,  
ii) during the production phase of a mine.

The description should take approximately 15-20 sentences and highlight both sampling procedures and the most commonly used static and kinetic testing methods for assessing the acid generating or neutralizing potential of rock.

**Question 2: Effluent Regulations (Metal Mines)**

The Metal Mining Effluent Regulations (MMER) govern the discharge of effluent from all metal mines in Canada.

- 6 marks
- A. Under the MMER what three conditions must be met for a metal mine to discharge effluent to the environment without a transitional authorization. The three conditions may be presented in point form.
- 14 marks
- B. Describe the process to obtain approval to deposit tailings to a naturally occurring body of water that is frequented by fish. The discussion should take 10-15 sentences and reference the specific requirements of the MMER, the Fisheries Act, and the Canadian Environmental Assessment Act. Indicate the role of First Nations, non-governmental organizations, and other interested stakeholders in the process.

**Question 3: Closure Planning and Reclamation**

- 5 marks
- A. Waste dumps are often capped with impervious clay or rock when acid drainage and leachate formation are a concern. The impervious cap increases the potential for erosion due to the high volumes of surface water runoff created. List three methods of controlling water-based erosion when impervious caps are used on waste dumps. Point form is acceptable.
- 15 marks
- B. Mine closure planning is required to obtain and maintain a mining license in all jurisdictions in Canada. Identify what engineering investigations need to be considered in a closure plan for an underground mine in order to deal with hazards associated with the mine complex (mine entry points, mine working areas, mine gas, groundwater, etc.).

A table format may be used for this question.

**Question 4: Tailings Impoundment Construction**

15 marks A. There are three common methods of raised embankment design and construction: downstream; upstream; and, centerline. Populate the following table and provide a cross-sectional sketch of each method showing embankment construction progression, beach location, pond location, and any other relevant features. (An additional copy of the table is included at the end of the exam).

	Upstream	Centerline	Downstream
Embankment fill/construction material requirements			
Mill tailings requirements			
Suitability for water storage			
Seismic resistance			
Rising rate restrictions			
Methods for phreatic surface control			
Relative cost			
Sketch			

5 marks B. On the following cross-sectional sketch identify:

- the expected beach above water and beach below water slopes; and,
- the expected distribution of coarse and fine materials within the tailings beach and decant pond as a result of hydraulic separation (i.e. indicate horizontal variability of material grain size).

NOTE: The section is representative only, and is not to scale. An additional larger copy of the diagram is included at the end of the exam.



**Question 5: Effluent, Dust, and Gaseous Emissions**

A. What are the primary environmental and human health concerns associated with the following four substances:

12 marks

- Arsenic
- Polycyclic aromatic hydrocarbons (PAHs)
- Molybdenum
- Silica

Discussion should take four to six sentences for each substance and include typical air or waterborne transmission mechanisms, human health effects and/or environmental impacts, and identification of the deposit types typically associated with the substances.

B. Discuss two methods of dust control used for waste dumps or tailings impoundments. For each method discuss the benefits as well as any drawbacks. Four to six sentences should be sufficient for each method.

8 marks

**Question 6: Monitoring and Management of Tailings Impoundments**

A. Tailings dam failures can have catastrophic results on the environment, communities, social perceptions of mining, and corporate finances.

10 marks

Describe FOUR of the following failure modes. Include a description of typical causes and the physical failure process for each.

Three to five sentences should be sufficient for each mode. The use of diagrams is encouraged in describing the physical failure process.

Select FOUR of:

- Erosion
- Foundation Failure
- Liquefaction
- Overtopping
- Piping
- Rotational Sliding

10 marks B. Performance monitoring and maintenance activities are critical to ensure safe impoundment performance. Discuss the role of EACH of the following in a tailings dam management program including the equipment or methods involved in each activity and how the data are analyzed and used.

Discussion should take four to six sentences for each monitoring activity/method.

- Visual observation
- Piezometers
- Slope displacement via survey monuments or inclinometers

Question 4A

	Upstream	Centerline	Downstream
Embankment fill/construction material requirements			
Mill tailings requirements			
Suitability for water storage			
Seismic resistance			
Rising rate restrictions			
Methods for phreatic surface control			
Relative cost			
Sketch (Please use your exam booklet if more space is required)			

Question 4B

