PREPARED FOR:
AGNICO-EAGLE MINES LIMITED
MEADOWBANK DIVISION

PREPARED BY:

ORIGINAL SIGNED AND SEALED BY

REV.	DATE	REASON FOR REVISION	BY	APP.
0	01/AUG/08	ISSUED FOR CONSTRUCTION	BW	TLE
D	20/MAY/08	ISSUED FOR TENDER	BW	TLE
C	04/APR/08	ISSUED FOR TENDER		
B	31/MAR/08	ISSUED FOR TENDER		

TABLE OF CONTENTS

LIST OF TABLES

S1 ADMINISTRATION

S1.1 Scope

This section of the specifications provides general administrative requirements for the East Dike at the Meadowbank Gold Project site in Nunavut Territory of Canada.

S1.2 General

The gold ore deposits at the Meadowbank Gold Project site are situated adjacent to and beneath Second Portage Lake, Third Portage Lake, and Vault Lake. Dewatering dikes are required to isolate open pit mining activities from the lakes. The current specifications are for the East Dike, which, with the West Channel Dike, is designed to allow dewatering of the northwest arm of Second Portage Lake.

S1.2.1 General Site Conditions

The current understanding of subsurface conditions is based on a limited number of boreholes and on interpretation of geophysical data. The presentation of subsurface conditions in the design report and Drawings are therefore subject to a large degree of interpretation. The Contractor is to make his own interpretation of geologic conditions.

S1.2.2 Definitions

The definitions used in the specifications for the East Dike construction are given in Table 1.

TABLE 1: Definitions

Accuracy	Degree of approximation of a measurement to the true value of the quantity measured.
Approval	A written engineering or geotechnical opinion concerning the Work.
Bentonite-Water Slurry	A stable colloidal suspension of powdered bentonite in water. The terms "slurry" and "bentonite-water slurry" are used interchangeably in the East Dike specifications.
Coarse Filter	Material produced from crushing of IV Rockfill and meeting the design specifications.
Construction Manager (CM)	Person employed by the Owner in order to oversee the project works and the Owner's interests. The primary point of contact for the Engineer and Contractor.
Core Backfill	Crushed granular material to support slurry trench construction, and meeting the design specifications.
Field Laboratory	The area and facilities provided for QA and QC testing.
Grouting Specialist	Person employed by the Engineer to provide technical direction for grouting works. Specialist in drilling and grouting.
Health and Safety	A planned set of activities and approach to ensure the health and safety of all persons involved in or affected by construction activities.
Ice-Rich Soil	Frozen soils that contain more than 10 percent visible ice and/or have a moisture content greater than 30%. Normally ice lenses are present.
Ice-Poor Soil	Frozen soils that contain less than 10 percent visible ice and have a moisture content less than 30%. No visible ice lensing.
Meadowbank	The Meadowbank Gold Project site.
NPAG	Non-Potentially Acid Generating
Owner	Agnico Eagle Mines Limited, Meadowbank Division
PAG	Potentially Acid Generating
Quality Assurance (QA)	A planned system of inspection and testing that documents, to the satisfaction of the Owner, the Engineer, other stakeholders and regulators, that the Work complies with the drawings and specifications.
Quality Control (QC)	A planned system of inspection, testing and documentation carried out during construction to ensure that the Work is being completed in a manner that will comply with the drawings and specifications.
Reproducibility	Degree of approximation to the arithmetic average of each one of a series of similar measurements.
IV Rockfill	Intermediate volcanic mine aggregate material meeting the design specification.
IF Rockfill	Iron formation mine aggregate material meeting the design specification.

UM+Q Rockfill	Ultramafic and quartzite mine aggregate material meeting the design specification.
Sensitivity	Minimum unit of pressure or deformation to be detected by a system of measurement.
Slurry Trench	A vertical-walled trench of specified width excavated by the Slurry Trench Method which is backfilled with materials meeting the design specification to form a cutoff wall of low permeability.
Slurry Trench Method/Technique	A method of excavating a narrow, vertical trench using a slurry mixture to support the trench walls and prevent movement of groundwater into or through the excavated trench.
Slurry Trench Specialist	A Subcontractor who has proven and successful experience in the Slurry Trench Method and is knowledgeable of: (1) the proper methods employed to mix slurry and backfill; (2) the use, testing and control of bentonite as a slurry; (3) construction equipment for slurry trench construction; (4) excavation and backfill operations for the Slurry Trench Method; and (5) testing for Slurry Trench QC.
Slurry Wall or Cutoff Wall	A Slurry Trench backfilled with specified materials to form a cutoff wall of low permeability. The terms “Slurry Wall” and “Cutoff Wall” are used interchangeably in these specifications.
Soil-Bentonite (SB) Backfill	A homogenous mixture of Till and/or processed aggregate, bentonite-water slurry and/or bentonite meeting the design specifications.
Till	Unfrozen soil consisting of sizes ranging from clay to boulders and meeting the design specification.
Tube-a-manchette	Sleeve-port grout pipes allowing for the precise location and injection of grout at a predetermined depth at locations spaced apart where there are "sleeve-ports" formed into the "tube-a-manchette" pipe for that purpose.
Work	All activities associated with the construction of the East Dike including instrumentation installation.
Work Completion Reports	Summary report prepared by the Contractor.
Work Plan	Proposed construction equipment, procedures, and schedules for all components of the Work.
Working Platform	The working platform is the surface of fill and/or excavated surface from which the Work is conducted, e.g. for Slurry Wall construction, for Grouting and for instrumentation installation.

S1.2.3 Standards and Regulations

Work shall conform to, but not be limited to the requirements of the latest editions of the following standards and regulations, listed in Table 2.

TABLE 2: Standards and Regulations

API Spec 13A	Specification for Drilling Fluid Materials
API RP 13B-1	Recommended Practice for Field Testing Water-Based Drilling Fluids
ASTM C136-06	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138-07	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C143-05	Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150-07	Standard Specification for Portland Cement
ASTM C185-02	Standard Test Method for Air Content of Hydraulic Cement Mortar
ASTM C191-07	Standard Test Methods for Time of Settling of Hydraulic Cement by Vicat Needle
ASTM C266-07	Standard Test Method for Time of Setting of Hydraulic-Cement Paste by Gillmore Needles
ASTM C305-06	Standard Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
ASTM C349-02	Standard Test Method for Compressive Strength of Hydraulic-Cement Mortars (Using Portions of Prisms Broken in Flexure)
ASTM C494-05A	Standard Specification for Chemical Admixtures for Concrete
ASTM C595-07	Standard Specification for Blended Hydraulic Cements
ASTM C596-07	Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement
ASTM C618-05	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C845-04	Standard Specification for Expansive Hydraulic Cement
ASTM C940-98a	Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C941-02	Standard Test Method for Water Retentivity of Grout Mixtures for Preplaced-Aggregate Concrete in the Laboratory

ASTM C942-99	Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C953-06	Standard Test Method for Time of Setting of Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C1017	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1602-06	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D422-63	Standard Test Method for Particle-Size Analysis of Soils
ASTM D1140-00	Standard Test Methods for Amount of Material in Soils Finer Than No. 200 (75 µm) Sieve
ASTM D1633	Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders.
ASTM D2113	Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
ASTM D2216	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2434-68	Standard Test Method for Permeability of Granular Soils (Constant Head)
ASTM D2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4318-05	Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D4380-84	Standard Test Method for Density of Bentonitic Slurries
ASTM D4381-06	Standard Test Method for Sand Content by Volume of Bentonitic Slurries
ASTM D5084	Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D5856-95	Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter
ASTM D6910-04	Standard Test Method for Marsh Funnel Viscosity of Clay Construction Slurries
CSA A3000-03	Cementitious Materials Compendium
Mine Health and Safety Act (Nunavut)	
Mine Health and Safety Regulations (Nunavut)	

ASTM: American Society for Testing and Materials
API: American Petroleum Institute

Each publication shall be the latest revision and addendum in effect at time of construction. Except as modified by the requirements specified herein or the details of the Drawings, work included in this Specification shall conform to the applicable provisions of these publications.

S1.2.4 Alternative Standards

If the Contractor offers materials which conform to a standard other than that specified then the standard offered shall be equal to or superior, when tested, to the specified standard and full details of the differences between the standard offered and the standard specified shall be given.

S1.3 Execution

The East Dike construction package includes work to be carried out by the Contractor(s) and work to be carried out by Owner's mine employees.

S1.4 Scope of Work

The East Dike construction drawings and these specifications describe the Scope of Work. The Scope of Work is listed in Table 3, estimated quantities are listed in Table 5 and a list of drawings is given in Table 6. A general description of the East Dike construction includes the following tasks:

TABLE 3: Scope of Work

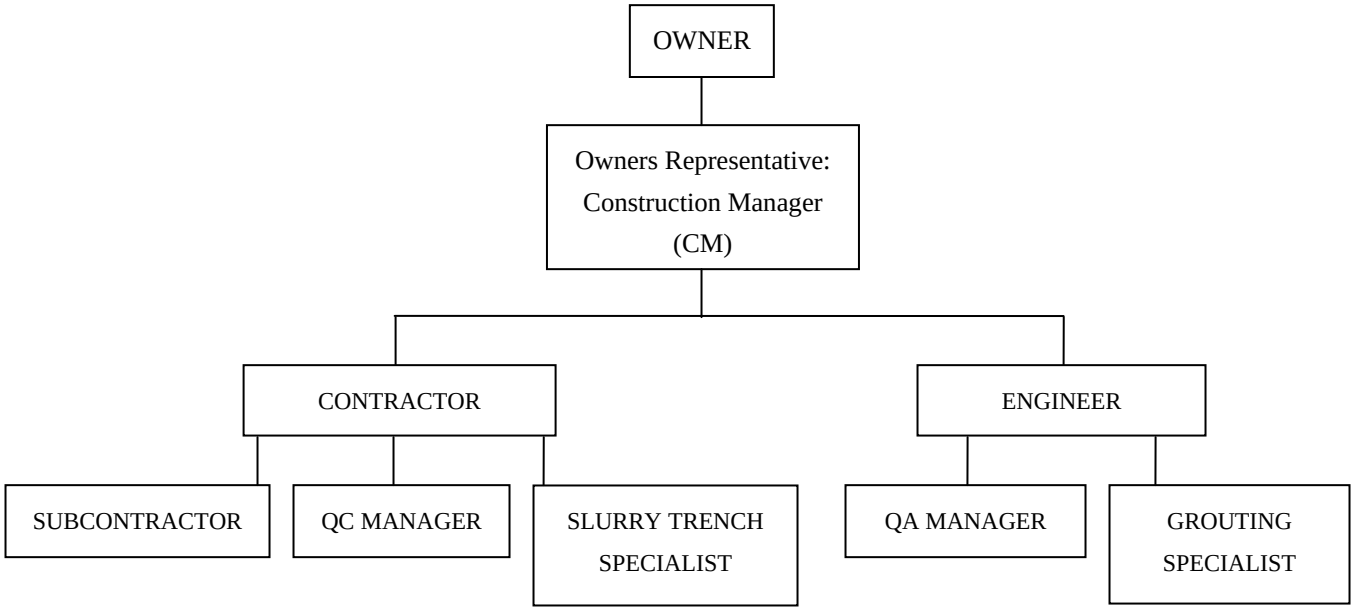
Construction item	Owner / Contractor Responsibility
Placement of turbidity barrier	Owner
Placement of rockfill embankment	Owner
Excavation of rockfill embankment and in-situ soil from lakebed to expose bedrock, including abutments	Contractor
Bedrock foundation preparation	Contractor
Placement of Coarse Filter on downstream face of excavation	Contractor
Placement of Core Backfill and Coarse Filter wings	Owner
Densification of the Core Backfill	Contractor
Geotechnical investigation of Core Backfill at the discretion of the Slurry Trench Specialist	Contractor
Construction of the Slurry Trench and Cutoff Wall	Contractor
Grouting of bedrock foundation and contact between Cutoff Wall and bedrock	Contractor
Installation of instrumentation within the dike and foundation	Contractor
Dewatering of the northwest area of Second Portage Lake enclosed by the East Dike and the West Channel Dike	Owner
Construction of drainage works in the dewatered area at the downstream toe	Owner
Installation of instrumentation at the downstream toe	Owner

The tasks are not listed in order. A construction sequence shall be developed by the Construction Manager (CM).

S1.5 Roles and Responsibilities

S1.5.1 General

Unless otherwise stipulated by project-specific addenda, the responsibility and authority of each party involved in the Work shall follow the lines set forth in the following Sections and the applicable regulations and/or permit conditions for the following management structure.



S1.5.2 Owner

The Owner is Agnico-Eagle Mines Limited (AEM), Meadowbank Division. All references to the Owner in this document shall implicitly include the Construction Manager (CM), who is the Owner's representative designated specifically for the project by the Owner. The Owner is responsible for:

- providing items as required in these specifications and all incidentals needed to bring the Work to final completion, not including those to be supplied by the Contractor;
- obtaining all relevant permits;
- preparing, implementing and maintaining the Global Construction Schedule, the Site Wide Environmental Management Plan and the Site Wide Health & Safety Plan;
- environmental management including prevention of pollution and other environmental problems related to the construction activities of the East Dike construction;
- health and safety at the work site;

- providing reasonable access to the general open areas surrounding the work site for the Contractor and Subcontractors;
- scheduling, coordination and direction of the Work;
- co-ordinating communication for the project;
- arranging the preconstruction and weekly progress meetings;
- holding problem resolution meetings for resolving Quality Control and Quality Assurance issues;
- preparing plans for corrective action for Work not in compliance with the specifications;
- survey to confirm quantities;
- pre-processing of construction materials, including Coarse Filter, Core Backfill and Till;
- supply of diesel, cement, rockfill materials, till, Coarse Filter, Core Backfill, and waste disposal areas;
- any blasting, including blast notification to the Contractor and Engineer or their representative;
- traffic control on dike crest and in abutment areas;
- grading the site to the proper elevation as set forth in the project design;
- preparation of an as-built report at the completion of the project; and
- inspection and maintenance of site, e.g. sumps, before any section of the site is handed to the Contractor for the commencement of works.

S1.5.3 Contractor

The Contractor is responsible for:

- Preparation of a Work Specific Health & Safety and Environmental Management Plans conforming to the Owner's plans, schedules, and other documents as required for submittal;
- Specific Work Plans;
- Daily Summary Report, including work completed and Quality Control testing results;
- construction of the Work in compliance with the drawings and specifications, including any work performed by Subcontractors;
- health and safety of employees under the Contractor's supervision at the worksite, and for health and safety of Subcontractors employed by the Contractor;
- blast notification to the Contractors employees and Subcontractors;
- site preparation;
- protection of materials before and after placement;
- survey and survey control;

- Quality Control;
- protection of the environment during construction; and
- inspection and maintenance of site, e.g. sumps, before any section of the site is handed to the Owner after the completion of works, or a Subcontractor before their work is due to commence.

S1.5.4 Subcontractors

The Contractor is responsible for completion of the Work undertaken by any Subcontractors they may employ. The work must be completed in accordance with the intent of the design, as described in the design report, Drawings, and Specifications.

S1.5.5 Engineer

The Engineer is Golder Associates Ltd. (Golder), the dike design Engineer Of Record. The Engineer is responsible for:

- the design including the engineering drawings and specifications;
- generation and approval of all design and/or specification modifications and clarifications which pertain to the design; and
- design modifications and clarifications that may occur prior to and/or during construction.

The Engineer is represented on site by the QA Manager.

The Grouting Specialist represents the Engineer and provides technical direction to the grouting contractor.

S1.5.6 Quality Assurance Manager

The Quality Assurance Manager (QA Manager) represents the Engineer on site and is responsible for:

- Blast notification to Engineering staff including the QA team;
- performing tasks outlined in QA and QC Requirements Section, including observing, testing, inspecting, documenting, monitoring and reporting the relevant project activities;

- implementation of changes in Quality Control and Quality Assurance aspects of the work including frequency of testing, monitoring, or additional testing to confirm conformance to the specifications;
- preparing QA Weekly Reports outlining the progress of the Work and the result of testing carried out during the week; and
- approving aspects of the Work as compliant with the drawings and specifications and the intent of the design.

The QA Manager has the authority to stop work that is not in compliance with the design but does not have the authority to change methodology or to make any decisions related to the cost without prior approval of the Construction Manager.

For construction of the East Dike, QA services are provided by Golder.

S1.5.7 Quality Control Manager

The Quality Control Manager (QC Manager) is responsible for checking the Work as construction proceeds with the purpose of aiding the Contractor to complete the Work in accordance to the specifications, drawings, and design report. The QC Manager is responsible for:

- performing tasks outlined in QA and QC Requirements Section, which includes observing testing, inspecting, documenting, monitoring and reporting the relevant project activities;
- directing QC work and QC personnel;
- implement changes in Quality Control aspects of the work including frequency of testing, monitoring, or additional testing to confirm conformance to the specifications; and
- preparation of Daily Summary Reports documenting the Work carried out each day, including QC testing results.

The Contractor is responsible for Quality Control of his own work.

For work completed by the Owner, QC services are provided by Golder.

S1.5.8 H&S Supervisors

The Owner will have a Heatlh and Safety (H&S) Supervisor who is responsible for site wide H&S.

The Contractor will have a H&S Supervisor who is responsible for the Health and Safety of the Contractor's staff and any Subcontractors.

The Engineer will have a H&S Supervisor who is responsible for Engineer's staff and representatives.

Each H&S Supervisor's primary responsibility will be H&S, with other duties allowed. Each Health and Safety Supervisor will be on site.

S1.6 Communications

The Construction Manager has the responsibility to organize communications through various meetings described in this Section. Other meetings may be called as required by the CM.

All official communications shall be in writing, in English, with records of communications kept by both the Owner and the Engineer.

Official communications between the Engineer and the Contractor will be through the CM.

S1.6.1 Pre-Construction Meeting

Prior to construction and the implementation of the QA and QC component for each element of the project, the CM, QA Manager and QC Managers shall meet to discuss aspects of the QA and QC Requirements Section that are to be implemented. Issues to be discussed at the meeting, when applicable, should include:

- Review of the Specifications and Drawings;
- Review of responsibilities of all parties as defined in the Specifications;
- Review procedures for deficiency resolution, documentation and reporting;
- Review of QA and QC procedures, including testing frequencies, testing methods and material acceptance/rejection criteria;
- Review of site conditions;
- Review of stockpile areas and areas to be used for temporary storage/stockpiling where applicable;
- Review of construction quantities;
- Review of the Global Construction Schedule and Specific Work Plans;
- Review of each task of the Work with respect to overall Construction Schedule;

- Review of Site Wide and Work Specific Health and Safety Plans, including procedures for blasting and related to haul truck and heavy equipment traffic;
- review of the Site Wide Environment Management Plan; and
- Conduct site walk-over to discuss proposed construction sequence, start-up and inspect borrow areas, where applicable.

S1.6.2 Daily Health and Safety Meeting

Daily Health and Safety Meetings will be held on site including a Site Wide Supervisors meeting and Work Area Specific Meetings. The CM will attend the Site Wide Supervisors meeting, and relay any relevant information to the Work Area Specific Meeting. The CM will be responsible for meeting minutes.

S1.6.3 Weekly Meeting

Weekly progress meetings will be held and chaired by the CM and shall be attended by the QA Manager and the Contractor, or their representatives, and by their Health and Safety Supervisors. H&S concerns will be reviewed.

The CM will be responsible for meeting minutes.

S1.6.4 Deficiency Resolution Meeting

A deficiency resolution meeting shall be held by the CM and the relevant construction work shall be suspended until a resolution is attained, if a construction problem or deficiency occurs. A deficiency resolution document shall be filled out by the party that identified the deficiency and shall be provided to the various other parties (CM, QA Manager and QC Managers) prior to the deficiency resolution meeting.

The purpose of this meeting shall be to identify, isolate and resolve the problem or deficiency to achieve compliance with the specifications and the intent of the design to the satisfaction of all parties to the extent possible. The deficiency resolution document will include method of resolution and will be signed by the CM and the QA Manager once the deficiency has been corrected.

The deficiency resolution meeting shall be attended by the CM, Contractor, QA Manager, and QC Managers or their representatives, either in person or by phone. If the circumstances require modification(s) to the design, then only the Engineer will make changes to the design.

The meeting will be documented by CM and the minutes of the meeting and deficiency resolution document shall be included in the QA Weekly report and distributed to all parties in attendance.

S1.7 Environmental issues

A site specific Environmental Management Plan (EMP) shall be prepared by the Owner prior to the start of construction. The Environmental Management plan shall be distributed to all parties, including the Contractor, Subcontractors, and to the QA and QC Managers prior to start of construction.

The Owner shall provide labour and equipment as required to contain and/or clean up any environmental spills.

The Owner shall incorporate environmental considerations while developing and implementing work procedures. The EMP may discuss, but is not limited to the following:

- Spill Management;
- Animal protection;
- Turbidity Monitoring Plan;
- Water Management; and
- Refuse Management.

An up-to-date EMP must be maintained to cover all work activities being conducted throughout the Work.

The Contractor will comply with the Owner's EMP and all standard procedures related to environmental issues.

Any spill or environmental concern shall be reported immediately to the CM.

S1.8 Health and Safety

The Owner is entirely responsible for the Health and Safety (H&S) at the site, including the All Weather Private Access Road to Baker Lake.

The Contractor is responsible for Health and Safety of the Contractor's employees and the Subcontractor's employees.

The Contractor and his Subcontractors shall incorporate H&S considerations while developing and implementing their own work procedures.

The Contractor shall also comply with relevant H&S regulations and AEM H&S protocols and procedures (March 2007 Safety Handbook).

The Contractor shall observe the regulations, procedures and restriction for the ingress to the construction area.

The Contractor shall prepare and submit to the CM for review and approval a Work Specific H&S plan that compiles with AEM regulations and in addition covers any additional health and safety requirements specifically related to the Contractor's work. The Work Specific H&S plan shall comply with the Mine Health and Safety Regulations in effect in Nunavut Territory. Following approval of the plan, the plan shall be implemented.

A draft copy of the Contractor's site specific Construction H&S plan shall be prepared and submitted to the CM for review a minimum of 1 month prior to mobilization to Meadowbank. The CM and AEM will review and provide comments on the draft H&S plan to the Contractor.

The Contractor must have an AEM approved H&S Plan covering all work activities being conducted.

Any accident, near accident or H&S concern shall be reported immediately to the CM.

S1.9 Cooperation

The Contractor and his Subcontractors shall cooperate with other parties to allow time and provide safe work conditions to carry out any site visit required to check environmental or health & safety concerns, perform control surveys and QA/QC operations. The Contractor and his Subcontractors shall provide labour and equipment as required to contain and/or clean up any environmental spills.

S1.10 Construction Facilities and Temporary Controls

Access to the site will be provided by the CM. The Contractor will not have sole access to the Work area and must be prepared to share and coordinate activities and access with others, through the CM. The Contractor shall coordinate with the CM the location of any staging areas, temporary facilities, haul roads or access roads.

S1.10.1 Power Supply

The Contractor shall provide any temporary power required for the Work in the form of a diesel powered generator. The Owner will supply diesel at no charge to the Contractor.

S1.10.2 Construction Water

Water for dust control, moisture conditioning material to be placed as fill, and for maintaining in-place fill soils shall be obtained by the Contractor. The Contractor must supply all the pumps and tanks necessary. Water will be available at a location defined by the CM.

S1.10.3 Dust Control

During performance of the Work defined by the Specifications or any related operations, the Contractor shall control dust emissions.

S1.10.4 Surface Water Control

The Contractor is responsible for controlling surface water and protecting Work from damage caused by this water.

S1.10.5 Work Area

The Contractor shall:

- Store and dispense fuel, lubricating oils, and chemicals in such a manner to prevent or contain spills and prevent materials from entering local streams, lakes or groundwater according to applicable regulatory requirements.

- Maintain copies of Material Safety Data Sheets (MSDS) on file at the site for all hazardous materials. Copies of MSDS will be provided to the CM as the CM is responsible for the delivery and storage of goods on site.

- Avoid damaging instrumentation or instrumentation cables, such piezometers, used at the site.

S1.10.6 Traffic Control

The Owner is responsible for traffic control at the site and at the construction site.

AEM Mine heavy equipment and haulage traffic has the right of way at all times with the exception of emergency vehicles.

The Owner shall provide a flag person or persons at intersections with limited visibility and heavy traffic.

S1.11 Mobilization and Demobilization

Mobilization comprises mobilizing to the mine all materials, supplies, equipment and tools required to carry out the Work. Demobilization includes transporting out of the mine all remaining materials, equipment, and tools, hauled on site to carry out the Work.

The Contractor is solely responsible for the planning and mobilization of materials in consultation with the Owner in accordance with the construction schedule. Subcontractors and their transportation equipment must comply with the same safety regulations as the Contractor.

It is required that all equipment that is to be used in the Work, pass a technical inspection to be conducted before being sent to site. This is to be completed by qualified Mine Operations' personnel employed by the Owner.

Upon completion of the Work, any temporary structure built during the Work and/or any temporary construction that may have been installed during the Work shall be removed.

All regulations regarding mobilization towards and within the mine shall be followed.

S1.12 Submittals

Table 4 summarizes the submittals required prior to construction, during construction and post construction. These documents are in addition to those presented by the Contractor to the Owner at the tender stage.

TABLE 4: Submittals

Item	Submitted to	Submitted from	Required
Global Construction Schedule	Engineer, QA Manager, Contractor, QC Managers, and Subcontractors	CM	30 days prior to start of construction and maintained during construction
Site Wide H&S Plan	Engineer, QA Manager, Contractor, QC Managers and Subcontractors	CM	30 days prior to start of construction and maintained during construction
Site Wide EMP	Engineer, QA Manager, Contractor, QC Managers and Subcontractors	CM	30 days prior to start of construction and maintained during construction
SB Cutoff QC Plan	CM, Engineer, and QA Manager.	Slurry Trench Specialist (Contractor)	30 days prior to start of construction of cutoff and maintained during construction
Instrumentation Cabin Design	CM, Engineer, QA Manager	Contractor	14 days prior to start of instrumentation installation
Work Specific Construction Schedule	CM, Engineer	Contractor	2 weeks prior to mobilization and maintained during construction
Work Specific H&S Plan	CM, Engineer	Contractor	1 month prior to mobilization and maintained during construction
Specific Work Plan	CM, Engineer	Contractor	2 weeks prior to mobilization and maintained during construction
Daily Summary Report	CM, Engineer	Contractor	Within 24 hours.
QA Weekly Report	CM	Engineer	Weekly
Work Completion Report (one for each Contract)	CM, Engineer	Contractor	Within 1 month following completion of work
As-built Report	Owner	Engineer	Within 6 weeks following receipt of Work Completion Report

S1.12.1 Specific Work Plan

The Specific Work Plan shall include the following but not be limited to:

- Proposed construction equipment, procedures, and schedules;
- Procedures for coordinating construction, maintenance and removal of working platforms, mixing pads, and haul roads;
- Equipment set-up and site use layout including storage areas, haul roads and work platform dimensions;
- Any updates or changes as necessary;
- Equipment specifications including: maximum working depth capability of excavator; number and type of backfill mixing equipment; and specifications of slurry mixing equipment; service record for equipment; grouting plant specifications, drill rod and bit diameter, rod length and number for total depth drillable;
- Material properties, sources, and (manufacturer's) certificates of quality;
- Control of drainage, spills, wastes, etc.; and
- Clean-up, spoils disposal, slurry disposal.

S1.13 Completion of the Work

Immediately upon completion of the Work the Contractor shall finalize the Work Completion Report (WCR) that shall provide as a minimum the following:

- Descriptive report;
- Original Construction Record;
- Copies of Meeting minutes, Field Change Notices (FCN), Site Instructions (SI), Request for information (RFI), and any other format that has been part of the Work;
- Original protocols of field or lab tests, duly signed by both parties (Contractor and QA Manager);
- As-Built Drawings based on as-built survey information for foundation preparation, placement for each construction material, grouting records, and instrumentation installation layout in electronic AutoCAD and hard copy format;
- Calculation sheets for actual quantities of work executed, duly signed by both parties (Contractor and Construction Manager);
- Liquidation of the Work;
- Installation details of instrumentation in electronic and hard copy format; and
- Final Safety Report.

S1.14 Preliminary List of Quantities

A list of estimated quantities associated with the overall construction of the dike is provided in Table 5. Note that not all of this work is the responsibility of the Contractor. Estimated quantities are subject to construction method and material properties, and will necessarily vary from actual quantities.

TABLE 5: Estimated Quantities

Material	Quantity
Initial Rockfill Embankment (m^3)	135,000
Excavation (m^3)	
Rockfill	40,000
Lakebed Soil	18,000
Total:	58,000
Coarse Filter (m^3)	
Downstream slope of excavation	6,700
Core "wings"	21,000
Core Backfill (m^3)	
Below 133.6 masl	30,000
Above 133.6 masl	6,200
Total	36,200
Granular Cap (m^3)	25,000
UM+Q Rockfill surfacing (m^3)	50,000
1 m wide Cutoff Wall (m^2)	5,500
Instrumentation	
Drilling required to install instrumentation (m)	310
Trenching with sand backfill (m)	150
Data acquisition system and cabins (ea)	5
Inclinometer casing installations (ea)	3
Thermistors strings (ea)	7
Piezometers (ea)	24
Survey monuments (ea)	29
Survey control monuments (ea)	2
Grouting	**Quantity**
Drilling (m)	7,100
Casing (m)	4,000
Tube-a-Manchette (slotted) (m)	3,800

Tube-a-Manchette (blank) (m)	3,200
WPT testing (hrs)	4,400
Grouting (hrs)	19,000
Cement (Type III or Type HE) (t)	350
Microfine Cement	50

A list of drawings are given in Table 6.

TABLE 6: List of Drawings

Drawing Number		Title	Rev.
2100	00	EAST DIKE LOCATION MAP AND DRAWING INDEX	0
2100	01	EAST DIKE SITE PLAN	0
2100	02	BOREHOLE LOCATION PLAN	0
2100	03	EAST DIKE ROCKFILL SETOUT PLAN	0
2100	04	EAST DIKE ROCKFILL LAYOUT PLAN (1 OF 3)	0
2100	05	EAST DIKE ROCKFILL LAYOUT PLAN (2 OF 3)	0
2100	06	EAST DIKE ROCKFILL LAYOUT PLAN (3 OF 3)	0
2100	10	EAST DIKE TYPICAL SECTIONS AND DETAILS	0
2100	11	EAST DIKE CROSS SECTIONS	0
2100	14	EAST DIKE CENTRELINE PROFILE	0
2100	15	EAST DIKE ABUTMENT DETAIL	0
2100	16	EAST DIKE INSTRUMENTATION PLAN	0
2100	17	EAST DIKE INSTRUMENTATION TYPICAL SECTION AND GROUTING PLAN	0
2100	18	EAST DIKE SEEPAGE COLLECTION SYSTEM - PLAN	HOLD

Drawing Number		Title	Rev.
2100	19	EAST DIKE SEEPAGE COLLECTION SYSTEM – PROFILE AND DETAILS	HOLD
2100	20	EAST DIKE SEEPAGE COLLECTION SYSTEM – SECTIONS (1 OF 2)	HOLD
2100	21	EAST DIKE SEEPAGE COLLECTION SYSTEM – SECTIONS (2 OF 2)	HOLD
2100	22	WEST CHANNEL DIKE PLAN	0
2100	23	WEST CHANNEL DIKE PROFILE AND SECTION	0

Drawing Nos. not used: 2100-07, 2100-08, 2100-09, 2100-12, and 2100-13

S2 FOUNDATION PREPARATION

S2.1 Scope

This section of the specifications provides the technical requirements for foundation preparation and excavation for the East Dike. The section discusses:

- excavation through rockfill and lakebed soils, and at the dike abutments;
- bedrock foundation preparation; and
- on-land foundation preparation.

S2.2 General

Excavation shall be carried out by the Contractor in accordance with the Drawings and Specifications, using ground support and water control measures required for safe and effective operation.

Excavation through rockfill, lakebed and abutment soils will expose bedrock along the centreline of the Cutoff Wall, as shown in the Drawings. Bedrock surface exposed will be treated along the Cutoff Wall alignment.

Temporary drainage and pumping systems shall be provided, operated and maintained by the Contractor as required to direct water away from the surface excavation areas as specified in the Care of Water Section.

The objective of bedrock foundation preparation is to achieve a clean, regular, bedrock surface that will provide optimum contact with the Cutoff Wall using equipment, ground support and water control measures required for safe and effective operation. If the Contractor fails to comply with such requirements, the Engineer may direct the suspension of work until the requirements have been met to the satisfaction of the Engineer.

S2.2.1 Waste Soil and Rock

Waste soil and rock shall be disposed of at areas designated by the CM. Wasted material includes rockfill from the excavation, lakebed soils, and abutment foundation preparation stripping. Except for rockfill excavated from the East Dike embankment, waste materials shall not be deposited into any riverbed, lake, or other water channel and shall not be burned, unless directed by the CM.

S2.2.2 Dimensional Tolerances

All excavations shall be completed to be within 300 mm horizontally and vertically of specified lines and grades unless otherwise specified by the Engineer.

S2.3 Execution

At least 30 days prior to commencing work, the Contractor shall submit to the CM the proposed methods for each part of the Works, including sequencing and stages of protection of excavated surfaces and water handling.

The Contractor shall lay out each excavation subject to inspection by the Engineer, prior to commencing any excavation. The Contractor shall not initiate excavation of any part of the Work until the proposed methodology and construction sequence has been approved by the Engineer.

Surface excavation work may begin only after the necessary infiltration and runoff control measures have been completed in accordance with the Care of Water Section, and the necessary equipment, elements and materials for protection of surface excavations are available at that site.

S2.3.1 In-water Foundation Preparation

Foundation preparation shall be carried out along the Cutoff Wall alignment at the bedrock surface at the base of the lakebed excavation, and continued to on land areas at the abutments.

Foundation preparation shall consist of:

- Surveying or sounding of the base of the excavation through the rockfill, paying particular attention to the footprint of the Cutoff Wall;
- Removing sediment, till, rockfill, soils overlying bedrock, and other deleterious materials including any trees, brush, roots, debris, peat, topsoil, snow and ice that may be present;
- Stripping and scalping/removing loose material, including boulders, overlying bedrock;
- Loading, hauling and dumping such materials in designated areas, as directed by the CM;
- Deep, abrupt irregularities and overhanging surfaces that are difficult to backfill completely shall be removed. All loose rock and pervious materials shall be removed

from the bedrock surface. Angular surfaces shall be smoothed or removed, such that a survey pole, or an excavator bucket without teeth, in contact with the surface may be moved in each direction without hanging up or catching on the rock surface; and
- Cleaning / clearing of debris from the foundation to the satisfaction of the Engineer, as assessed by sonar methods, underwater camera, or other methods.

On-land Foundation Preparation:

Each on-land excavation shall be laid out and subject to inspection by the Engineer prior to commencing any excavation.

Surface excavation work may begin only after the necessary infiltration and runoff control measures have been completed in accordance with the Care of Water section, and the necessary equipment, elements and materials for protection of surface excavations are available at the site.

Foundation preparation shall be carried out within the dike footprint at the abutments. Foundation preparation within the Cutoff Wall footprint shall consist of:

- Removing topsoil, vegetation and other deleterious materials including trees, brush, roots, debris, peat, topsoil, snow and ice;
- Stripping and scalping organic hummocks, ice rich soils, and boulders protruding more than 150 mm above the ground to expose competent mineral soil; and
- Dumping stripped materials into stockpile areas designated by the CM.

S2.3.3 Excavation

The excavation shall meet the minimum dimensions shown on the Drawings. Method of excavation and stability of the excavation shall be the responsibility of the Contractor, with method reviewed by the Engineer. The downstream slope of the excavation must be flat enough to allow stable placement of Coarse Filter, where Coarse Filter is required.

All necessary precautions shall be taken by the Contractor to obtain regular and stable excavation surfaces, which follow the boundary lines and grades shown on the drawings.

Alternative methods such as mechanical cutting of rock surfaces are allowed.

S2.3.4 Excavating by Blasting

Any blasting will be by the Owner.

All operations in connection with transporting, storage and the use of explosives shall be subject to the rules and regulations of governing authorities. Blasting shall be performed using experienced and licensed personnel.

S2.3.4.1 Vibrations Control

Vibrations induced by blasting must not alter the natural state of rock beyond the excavation limits nor the previously grouted rock, fills or already-placed concrete of any permanent structure. Therefore the maximum instantaneous explosive charge, as deduced from the following equation, shall be permanently monitored and not surpassed:

$$SD = D/(W)^{1/2}$$

Where:

SD = Scaled distance
D = Blasting distance, in feet, to the nearest structure requiring protection
W = Maximum instantaneous charge, in pounds

The SD relation will equal 50 when the blasting distance to the structure requiring protection is less than 50 m; when greater, the SD relation to deduce the maximum instantaneous charge will be 65.

S2.3.5 Work Areas

The Contractor shall take the necessary precautions to obtain regular and stable excavation surfaces. A high proportion of equipment work surfaces will be upon the rockfill embankment to be constructed within the lake by the Owner. For such purpose, the Contractor shall inspect the embankment with the CM and QA Manager prior to the trafficking of any heavy equipment. If the embankment requires any remedial work the Owner will carry this out, or alternatively the CM may issue a variation and request the Contractor to carry out such work at the rate tendered by the Contractor in the Tender Documents.

Whenever working close to open excavations, the Contractor shall use appropriate methods and take necessary precautions to avoid damage or disturbance of the banks of the excavation. Any damage caused as a result of negligence by the Contractor shall be repaired at his expense and to the satisfaction of the CM.

Access to the rockfill embankment will be controlled by the CM.

Prior to the Contractor conducting any work, the Owner will install a turbidity barrier and a rockfill embankment in the lake. Once the rock embankment is approximately 300 m long (and still under construction), the Contractor may commence work, or at the approval of the CM.

S2.4 Safety Program

The Contractor shall provide to the CM a detailed Work Specific Health and Safety Plan for each activity specified in this Specification.

The Contractor shall be responsible for the protection and safety of Work, all Contractor personnel, all Subcontractor personnel, plant and materials in each working area. The Contractor shall implement any necessary installation or measures to ensure safety.

S2.5 Quality Control (QC) and Quality Assurance (QA)

- The Contractor shall provide Quality Control (QC), including survey, topography, and lake bed soundings as required in the QC/QA Specification.

- QA inspection shall be carried out by sonar, radar, and/or a dive team working for the QA Manager in order to confirm quantity and the Contractor's QC including whether the specified foundation condition and construction grades and limits are being attained. Results of Bathymetric surveys would be compiled by QA representatives and forwarded to the CM and the Contractor once approved by the QA Manager.

- The Contractor shall provide facilities and labour as required to assist in conducting surveys and sampling for QA.

S3 SOIL BENTONITE CUTOFF WALL

S3.1 Scope

This section of the specification provides the technical information for the construction of a slurry trench Cutoff Wall for the East Dike. The Work includes:

- Furnishing plant, labour, material, and equipment to construct the Cutoff Wall to bedrock surface as much as 8 m below still water line;
- Construction and review of a test section; and
- Construction of the slurry trench and Cutoff Wall.

S3.2 General

S3.2.1 Qualifications

The Contractor, his subcontractor or his consulting advisor will have sufficient competent experienced personnel to construct a soil-bentonite Cutoff Wall by Slurry Trench Method.

In particular, the Contractor shall retain a Slurry Trench Specialist to supervise the construction, slurry preparation, and perform Quality Control. The Slurry Trench Specialist shall have at least ten years of experience and/or five projects in successful construction of slurry walls.

The company name, key contact, and qualifications of the Slurry Trench Specialist's off-site laboratory shall be submitted to the QA Manager. The QC laboratory will have previous experience with slurry wall materials, experienced laboratory technicians, and modern permeability testing equipment.

S3.2.2 Responsibilities

Table 7 summarizes the particular responsibilities of the various parties in the Slurry Wall section of this Specification, in addition to the responsibilities listed in the S1 Administration Specification.

TABLE 7: Slurry Wall Responsibilities

The Contractor is responsible for:	• Excavation and backfill of the Slurry Trench: • Clean up as the work progresses on site; • Maintaining the stability of the excavated trench at all times for its full length and depth, including key into bedrock; • Maintaining slurry densities and levels within specified limits to the satisfaction of the Slurry Wall Specialist; • Providing survey control, and survey for the Work; and • Geotechnical investigation of the core materials at the discretion of the Contractor.
The CM is responsible for:	• Providing disposal location for waste materials; • Delivery of all goods and materials for use on site; and • Storing all goods and materials appropriately on site.
The Slurry Trench Specialist is responsible for:	• Directing the Contractor; • Submitting daily reports to the CM, Engineer and QA Manager; • Ensuring that the mixing of the SB backfill and any stockpiles does not affect the open trench stability; and • Quality of the backfill materials.

S3.2.3 Access

Access to the Work will be provided and coordinated by the CM.

S3.2.4 Storage Area

Storage areas will be assigned within 1 kilometre of either abutment.

S3.2.5 Delivery and Storage of Goods

The CM shall be responsible for the correct addressing of all goods and materials for their use on site.

S3.2.6 Removal of Refuse

The Contractor shall clean up the work area as the Work progresses, removing debris from the work site to the designated disposal area from day to day. When the work is finished all buildings, tools, machinery, rubbish and waste materials shall be disposed of properly and the Contractor shall leave the site in a neat and orderly condition.

S3.2.7 Waste Water

Any waste water from the works shall be directed to locations approved by the CM. The sizing and maintenance of any sumps or lagoons required to carry out the work shall be the responsibility of the Contractor.

S3.2.8 Site Investigation

A site investigation to characterize the condition of core materials shall be conducted by the Contractor prior to construction of the Cutoff Wall at the discretion of the Contractor. Soil conditions for construction of the Cutoff Wall or Slurry Trench shall be subject to approval by the Contractor's Slurry Trench Specialist.

S3.3 Submittals

S3.3.1 Specific Work Plan

The Contractor's Slurry Trench Specialist shall submit to the various parties a detailed plan Specific Work Plan for SB Cutoff Wall construction. The plan shall describe the proposed construction equipment, procedures, and schedules shall be submitted at least 2 weeks prior to start of Cutoff Wall construction. This shall include, but not be limited to, the plan for:

- Schedule and sequence of operations including typical working hours and days; sequence of operations; and maintenance schedule;
- Coordinating the construction, maintenance and removal of working platforms, mixing pads, and haul roads;
- Equipment set-up and site use layout including storage areas, haul roads and work platform dimensions;
- Equipment specifications including: maximum working depth capability of excavator; number and type of backfill mixing equipment; and specifications of slurry mixing equipment;
- Procedure for water-bentonite slurry mixing, transportation and re-circulation;
- Procedure for trench excavation and backfilling;
- Procedure for mixing SB;
- Material properties, sources, and (manufacturer's) certificates of quality for bentonite materials;
- Control of drainage, spills, wastes, etc.; and
- Clean-up, spoils disposal, slurry disposal.

S3.3.2 SB Cutoff Wall QC Plan

A SB Cutoff Wall QC Plan shall be submitted by the Slurry Trench Specialist to the various parties, (CM and Engineer) at least 30 days prior to the start of construction. The QC Plan shall include but not be limited to the following:

- Details of the personnel and their roles and responsibilities;
- The minimum site inspections and quality testing requirements (see QA and QC Requirements Section for minimum testing frequency, tests, surveys and soundings);
- Sampling methods;
- Sampling frequency;
- Location of samples;
- Checklists for each of the works specified; and
- Non-conforming materials and corrective action procedures.

Copies of QC forms (templates) shall be submitted for review and approval by the QA Manager.

S3.3.3 Soundings and As-Built Profile

A record of soundings taken during construction including the depth of the trench, key, and backfill slope obtained each morning, evening and continuously shall be kept to ensure that the trench remains open. The soundings shall be used to generate an as-built profile of the trench, as constructed.

S3.3.3.1 New Bentonite Slurry

A record of plant-mixed bentonite slurry quantities, proportions, properties, and admixtures made during construction shall be kept. Adjustments to the slurry mixture shall be noted.

S3.3.3.2 In-Trench Bentonite Slurry

A record of in-trench bentonite slurry properties made during construction shall be kept. Procedures and admixtures used to modify slurry properties shall be noted.

S3.3.3.3 SB Backfill Material

A record of SB backfill material quantities, properties, and mix adjustments made during construction shall be kept. Location of samples taken for laboratory testing shall be noted.

S3.3.3.4 QC Data

A record of QC samples, tests and test results shall be kept.

S3.4 Materials

S3.4.1 Slurry

Slurry shall consist of a stable colloidal suspension of bentonite in water and shall be controlled in accordance with the most current API Recommended Practice 13B-1, and the following requirements:

- At the time of introduction of the slurry into the trench, the slurry shall contain sufficient bentonite to ensure that the walls of the trench do not collapse. The Contractor is responsible for determining this quantity. Additional bentonite or admixtures may be required depending on the hardness and temperature of the water and the quality of the bentonite.

- The slurry shall have a minimum apparent viscosity of 45 to 55 seconds reading through a Marsh Funnel Viscometer given that the bentonite has had sufficient time to hydrate.

S3.4.2 Bentonite

Bentonite used in preparing slurry shall be pulverized (powder or granular) premium grade sodium cation montmorillonite and shall meet the most current API Specification 13A. Peptizing of the bentonite is not acceptable.

S3.4.3 Water

Fresh water, free of excessive amounts of deleterious substances that adversely affect the properties of the slurry shall be used to manufacture bentonite slurry. The slurry resulting from the water shall always meet the standards of this specification.

S3.4.4 Additives

Admixtures of the type used in the control of oil-field drilling muds such as softening agents, dispersants, and retarder or plugging or bridging agents may be added to the water or the slurry to permit efficient use of bentonite and proper workability of the slurry. The Engineer shall be advised of all additives used.

S3.4.5 SB Backfill

The material for trench backfilling shall be composed of fresh slurry, trench slurry and selected fills obtained from a designated borrow area and/or trench spoils. Trench slurry may be disallowed if additives are not acceptable to the Engineer. The soil shall be friable and free from roots, organic matter, refuse, or other deleterious materials. The backfill shall be thoroughly mixed and reasonably well graded with the properties listed below. The Contractor shall conduct tests on site to determine the proportions of all materials in order to meet these property requirements (by methods described in Specification S6 QC/QA Requirements) :

- The hydraulic conductivity of the SB backfill shall be less than $1x10^{-9}$ m/sec;
- The slump of the backfill shall be 50 to 150 mm; and
- The ratio of bentonite to soil by dry mass shall greater than 1%.

S3.4.6 Dimensions and Alignment

A slurry trench Cutoff Wall shall be constructed to the lines, grades, and cross sections indicated on the drawings. The trench shall have essentially vertical walls, a minimum width of 1.0 m, and shall extend to the prepared bedrock surface.

S3.4.7 Tolerances

The following tolerances shall apply to the slurry trench dimensions and construction.

- The slurry trench shall be essentially vertical. The working platform and/or excavating equipment may be levelled such that trench walls are plumb to within 3% of vertical.

- The depth of the slurry trench shall be measured to the bedrock surface and recorded as both a depth and an elevation to within 2 cm of the actual elevation.

- The slurry trench shall follow the designed alignment within 0.3 m of the centerline. The slurry trench may vary from the designed alignment if approved by the Engineer.

- Construction will not be permitted when the air temperature is below -6^{o}C or when severe weather conditions may compromise the quality of the work.

- Overlaps and changes in direction of the slurry trench shall require an over excavation at least 2 m beyond the centerline of the trench. In cases where the trench must be re-excavated (for example, due to an extended shutdown, cave-in, rework, etc.) the overlap into acceptable backfill shall be at least 3 m.

S3.4.8 Equipment

S3.4.8.1 Trench Excavation

Excavation of the slurry trench Cutoff Wall shall be accomplished by use of any suitable earth-moving equipment, or combination thereof, such as a backhoe, clamshell, chisels, road header attachment, and ripper teeth so the trench can be carried to its final depth of cut continuously along the trench alignment. Subsurface conditions shall be confirmed to the satisfaction of the Slurry Trench Specialist by geotechnical investigation prior to construction (investigation by Contractor). The equipment shall have the capability to excavate at least 2 m deeper than the maximum depth shown on the plans. Special chopping, chiselling or other suitable equipment may be used as necessary to satisfactorily accomplish the required excavation. The width of the excavating tool shall be equal to or greater than the specified minimum width of the slurry trench. Additional equipment such as airlift pumps and slurry desanders shall be used, if required, to clean the trench bottom slurry in accordance with the requirements of the specification. Equipment shall be designed and or used in a manner to minimize material left at the base of the trench. For example, excavator buckets will be smooth, or without teeth, for excavation to the bedrock surface.

S3.4.8.2 Slurry Batching Plant

The slurry batching plant shall include the necessary equipment including a high shear mixer capable of producing a colloidal suspension of bentonite in water, pumps, valves, hoes, supply lines, and all other equipment as required to adequately supply slurry to the trench. Storage ponds or tank shall be provided as needed to store initially mixed slurry to allow hydration, and to retain a reserve in case of substantial slurry loss for example, through underlying pervious zones. Slurry held in storage shall be agitated or recirculated

to maintain a homogeneous mix. All slurry for use in the trench shall be prepared using a suitable mixer. No slurry is to be made in the trench. Mixing of water and bentonite shall continue until bentonite particles are fully hydrated and the resulting slurry is homogeneous.

S3.4.8.3 Backfill Mixing and Placing

Equipment for mixing and placing backfill may consist of any suitable earthmoving or grading equipment, such as bulldozers, or blade graders or backhoes, or blenders such as a pug mill, that are capable of thoroughly mixing the backfill materials into a homogeneous blend having the required gradation and properties and placing the material in the trench as specified. Soil clods shall not exceed 0.2 m in any dimension. Deleterious materials, debris, and oversized particles shall be removed from the backfill before approval by the QA Manager for placement.

S3.5 Execution

S3.5.1 Slurry Trenching

Excavation shall proceed continuously from the starting point to the finishing point. Slurry shall be introduced into the trench at the time trenching begins and shall be maintained in the trench during excavation and until backfilled. The stability of the excavated trench shall be maintained at all times for its full depth, to the satisfaction of the Slurry Trench Specialist. The bentonite slurry shall always be maintained at a level that ensures the stability of the trench. Personnel, equipment, and prepared slurry shall be ready to raise the slurry level at any time.

S3.5.2 Stability

The Contractor shall be responsible for insuring and maintaining the stability of the excavated trench at all times for its full length and depth and shall be responsible for maintaining slurry densities and levels within specified limits. The Contractor shall control surcharges from all excavation and backfilling equipment, waste, berm construction, backfill stockpiles and any other loading situations that may affect trench stability. It is the Slurry Trench Specialist's sole responsibility to ensure that the mixing of the soil-bentonite backfill and any stockpiles do not affect the open trench stability. In the event of failure of the trench walls prior to completion of backfilling, the Contractor shall re-excavate the trench and remove all material displaced into the trench and take corrective action to prevent further deterioration or collapse.

S3.5.3 Key

Unless otherwise directed by the Engineer, the bottom of the slurry trench will be founded on the prepared bedrock surface. The final depth of the trench shall be measured and checked and then provided to the QA Manager for approval immediately following excavation.

S3.5.4 Cleaning Trench Bottom

Upon completion of excavation, any loose material or cuttings shall be removed from the bottom of the trench with the excavation tools or other suitable means such as air lift pumps. If the slurry becomes unworkable, the heavy slurry shall be removed from the trench by airlift pump, clamshell, or other methods approved by the Engineer or the excess solids shall be removed from the slurry by settling ponds, screening, or desanding. The trench bottom shall be cleaned of debris and excess sand sediment backfilling. The trench shall be sounded immediately before placing backfill, and soundings shall be compared to the trench excavation soundings to verify the bottom. At a minimum, soundings shall be taken each morning and each evening and compared to monitor for cave-ins or excessive settlement.

S3.5.5 Backfill Mixing

The backfill shall be mixed beside the trench or in a designated remote location on site. If the backfill is mixed beside the trench, the Owner shall, in coordination with the Slurry Trench Specialist, control and provide sufficient equipment and work platform space to support slurry spills, trench stability, and mixing equipment operation. Unmixed materials shall not be placed or be allowed to fall into the trench. If the backfill is mixed in a remote location, adequate haul roads and the mixing pit or pad shall be built and maintained. The mixing pit or pad shall be lined with compatible soils or cement to prevent contamination from unsuitable materials. In either case, the Slurry Trench Specialist shall be responsible for the quality of the backfill.

Till and/or prepared aggregate materials and bentonite-water slurry and additional bentonite shall be mixed and blended in mechanical blenders or by windrowing, disk harrowing, bulldozing, and blading or by other approved methods by the Engineer. Mixing and blending shall be performed in such a manner as to produce the required gradation of backfill. The backfill material shall be thoroughly mixed into a homogeneous mass, free of large soil clods, lumps or pockets of fines, sand, or gravel. Occasional particles of up to 0.2 m in their largest dimensions will be permitted. Just prior to placing, the backfill

material shall have a slump of 50 to 150 mm. To this end, the materials shall be sluiced with slurry from the trench or with fresh slurry during blending operations. Sluicing with water will not be permitted. Backfill shall be sampled and tested for permeability, density, slump, and gradation after preparation in accordance with Specification S6 QC/QA Requirements.

S3.5.6 Backfill Placement

The backfill shall be placed continuously from the beginning of the trench, in the direction of the excavation, to the end of the trench. The toe of the slope of the trench excavation shall precede the toe of the backfill slope so that the toe of the backfill shall not be closer than 6 m to the toe of the excavation slope, or as required to permit proper cleaning of the trench bottom as approved by the Engineer. Excavation shall not exceed 45 m from the toe of the backfill. Excavation must permit inspection and measurement immediately after completion and prior to backfilling. Placing operations shall proceed in such fashion that the surface of the backfill below the slurry shall follow a reasonably smooth grade and shall not have hollows, which may trap pockets of slurry during subsequent backfilling. Free dropping of backfill material through the slurry will not be permitted. Initial backfill shall be placed by lowering it to the bottom with clamshell bucket or backhoe until the surface of the backfill rises above the surface of the slurry or by lead-in slope. Additional backfill may then be placed in such a manner that the backfill enters the trench by sliding down the forward face of the previously placed backfill. To accomplish this, sufficient backfill shall be piled behind the crest of the existing backfill slope to cause a mud wave action at the face of the backfill. The backfill shall not be dropped or deposited in any manner that will cause segregation.

An acceptable substitute for the initial placing of backfill by the use of a clamshell bucket may be a lead-in trench. The lead-in trench shall begin at a point outside of the limits of work and provide sufficient distance for the backfill face to form, by placing the backfill into the trench, before the toe of the backfill reaches the point where the cutoff is required. The lead-in trench shall be 10 Horizontal: 1 Vertical or flatter.

S3.5.7 Treatment for Top of Backfill

The surface of the backfill shall not be allowed to desiccate prior to placing the final cap. The cap shall consist of a 1 m thick layer of Till or UM+Q rockfill, both placed by the Owner. A temporary covering may be used to protect the backfill prior to placing the final cap. The temporary covering shall consist of at least 0.3 m of uncompacted backfill placed within 1 day after the SB backfill is placed. After a minimum of one week, the temporary

cover may be removed. Any depressions or settlement shall be repaired by placing additional backfill or the permanent cap. Crossings of the Cutoff Wall for equipment will require either trench plates or compacted soil.

Upon completion of backfill placement and before desiccation of the backfill surface can occur, the cutoff trench shall be covered in accordance with the final cap details shown on the Drawings.

S3.5.8 Clean-Up

After completion of the backfill and capping, all remaining excavated material and slurry shall be removed and the surface shall be cleaned and levelled as directed by the Slurry Trench Specialist. Excess slurry shall be disposed by drying, mixing with dry materials or spreading in thin layers on adjacent areas designated by the CM. No slurry shall be left in ponds, and all ponds shall be pumped dry and backfilled in a controlled manner.

S3.6 Quality Control (QC)

The Contractor shall provide Quality Control (QC), including survey, soundings, inspection and materials testing as required in the QC Requirements Section.

S3.7 Quality Assurance (QA)

QA monitoring and testing will be carried out by the Engineer through his QA Representative, to satisfy himself and AEM that the Work is being carried out in accordance with the Drawings and Specifications. Results of QA testing will not be withheld from the Contractor.

S4 DRILLING AND GROUTING

S4.1 Scope

This section of the specification describes Drilling and Grouting for construction of the East Dike. The Drilling and Grouting consists of all work required to seal fissures in the bedrock foundation and abutments by drilling and grouting holes from a working platform on the crest of the dike into bedrock foundations and abutments to provide a seepage cutoff.

Drilling and grouting shall include the following:

- All Works identified on the Drawings.

- Grouting the bedrock along the dike foundation from the crest of the dike. The scope includes: drilling grout holes, installing and removing casing, water testing grout holes and pressure injecting grout into grout holes for curtain grouting.

- Curtain grouting shall be the drilling of one or more rows of holes and injecting the specified grout mix into the holes to create a low-permeability curtain. In rock, curtain grouting shall use staged working in the holes and shall use the split-spaced closure method.

Climate conditions may require working in enclosed areas on panels of limited length. The Contractor is responsible for any required enclosures or shrouding required.

Limited data is available on bedrock condition along the dike alignment.

S4.2 Provisional Extent of Work

The spacing, depth, orientation and pattern of grout holes, grout mixes, quantity and type may be varied by the Grouting Specialist as a result of conditions revealed as grouting progresses.

Water pressure testing, as directed by the Grouting Specialist, shall be used to control the sequence of work. As such, water pressure testing will be carried out before, during and as the curtain is brought to completion.

S4.3 General

S4.3.1 Weather Conditions

Grouting work can start following completion of the slurry Cutoff Wall, as early as September. Between the months of November and April it is anticipated that the working conditions on site will be particularly challenging, with average temperatures ranging between -15 ^{o}C and -30 ^{o}C, and wind chill potentially taking these ambient temperature down to -50 ^{o}C.

S4.3.2 Responsibilities

Table 8 summarizes the particular responsibilities of the various parties in the Drilling and Grouting section of this Specification, in addition to the responsibilities listed in the S1 Administration Specification.

TABLE 8: Drilling and Grouting Responsibilities

The Contractor is responsible for:	• Drilling and grouting, operating all equipment; • Clean up as the work progresses on site; and • Providing survey control and survey for the Work.
The CM is responsible for:	• Providing disposal location for waste materials; • Delivery of all goods and materials for use on site; • Storing all goods and materials for grouting appropriately on site; and • Mine Operations' aspects related to efficiency of the Work.
The Grouting Specialist is responsible for:	• Technical direction of the work.

S4.3.3 Access

Access to the Work will be provided and coordinated by the CM.

S4.3.4 Storage Area

Storage areas for all goods and materials will be provided by the CM. Cement, superplasticizer, bentonite and other concrete admixtures shall be stored in a heated building and not allowed to freeze.

S4.3.5 Delivery and Storage of Goods

The CM shall be responsible for the correct addressing of all goods and materials for their use on site.

The CM shall take delivery of goods and materials for grouting and store them appropriately on site.

S4.3.6 Water Supply

The CM shall be responsible to provide a water source. The Contractor is responsible for pipes, pumps, storage tanks and equipment to heat the water supply.

S4.3.7 Electronic Monitoring

Grouting will be directed based on measured ground response to grout injection. The Contractor shall supply and operate a "Permeation Grout Monitor" system as manufactured by RST Instruments Ltd. or approved equivalent. Measured flowrate and pressure data shall be digitally recorded.

S4.3.8 Removal of Refuse

The Contractor shall clean up the work area as the Work progresses, removing debris from the Site to the designated disposal area daily. When the work is finished all buildings, tools, machinery, rubbish and waste materials shall be disposed of properly and the site shall be left in a neat and orderly condition.

S4.3.9 Waste Water

Waste water from grouting operations shall be directed to locations approved by the CM. The sizing and maintenance of any sumps or lagoons required to carry out the work shall be the responsibility of the Contractor.

S4.3.10 Electrical Power

The Contractor shall provide generators sufficient for the electrical power needs of the drilling and grouting operations. Diesel for the generator(s) will be supplied by the Owner at no cost to the Contractor.

S4.4 Qualifications and Responsibilities

S4.4.1 Grout Under Direction of Grouting Specialist

The Contractor shall drill, water pressure test, and grout under the technical direction of the Grouting Specialist. Technical direction includes, amongst other things, the sequence of the work, grout pressures, flow rates, and changes to the grout mix. Operation aspects related to the efficiency of the operations shall be entirely the Contractor's responsibility.

S4.4.2 Supervisory Staff and Operatives

The Contractor, his subcontractor or his consulting advisor shall have sufficient competent experienced personnel to drill and grout. The grouting operations manager shall have at least five (5) years experience of similar work. Drillers, grouting operators and grouting foremen shall have at least three (3) years experience in similar work.

S4.4.3 Submittals

S4.4.3.1 Daily Records

The following records shall be maintained on completion of each shift and submitted on a daily basis to the Grouting Specialist by the Contractor:

- Drill hole number, length drilled, size and orientation, drills used, and observations on location, estimated quantity of water inflow intercepted, drilling action and zones of hole instability or voids.

- Orientation survey results for drilled curtain grout holes.

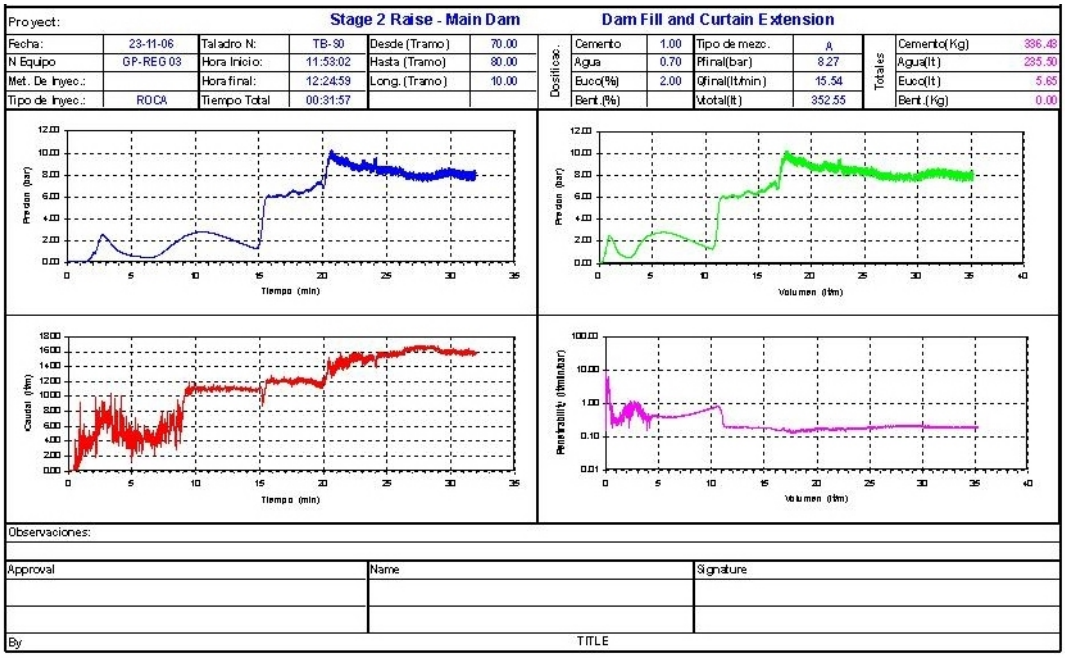
- Grouting records, including quantity, mix, location and injection pressures of all grout placements.

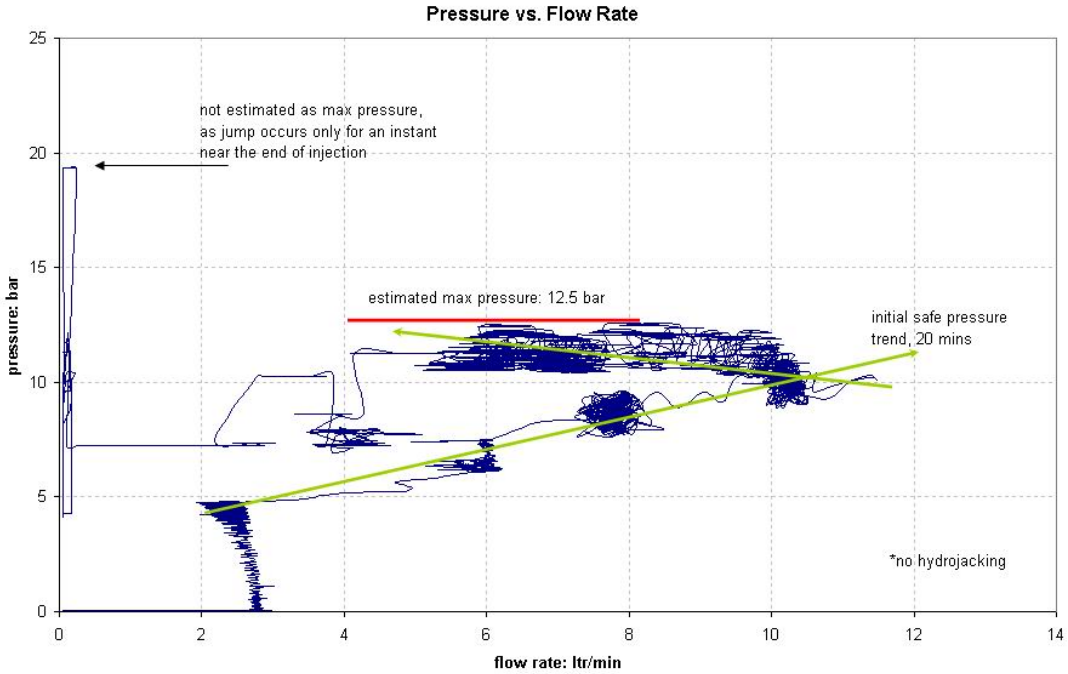
- Results for all grout tests, including details of shift, hole, stage and mix designation for each test. Forms to be used for reporting test results shall be approved by the Grouting Specialist prior to the beginning of field activities.

- Water test and grout injection data comprising record time, pressure, and flow rate for each stage at one second intervals shall be provided to the Grouting Specialist as comma separated ("csv") files readable by a laptop computer within 12 hours of completion of the shift.

- Digital records (time, flowrate and pressure at 1 second intervals) of each water pressure test or grout injection.

- Graphical records per stage of ground response during grout injection, including one plot showing pressure vs. time, volume vs. time, pressure vs. volume, and penetrability vs. volume, and another plot showing just pressure vs. flowrate as shown on the attached screen dumps below:





S4.5 Setting Out and Dimensional Control

S4.5.1 Hole Locations

Grouting shall be carried out through the Cutoff Wall. The grouting centerlines and other key setting out information shall be provided by the Grouting Specialist following completion of the Cutoff Wall.

The Contractor shall provide survey as required by the Grouting Specialist. Primary grout holes shall be set out by survey for the acceptance of the Grouting Specialist prior to drilling.

S4.5.2 Permanence of Markings

Holes for grouting, drainage, checking or exploration shall be tagged in a logical and sequential manner for proper identification.

Each tag shall be installed immediately on completion of drilling and shall have a distinctive color and number as approved by the Grouting Specialist.

S4.5.3 Grout Hole Tolerances

Grout holes shall be collared within 200 mm of nominal locations.

Out of tolerance holes shall be backfill grouted and re-drilled.

S4.6 Materials

S4.6.1 Cement

Cement shall be obtained from one manufacturing source throughout the period of work to ensure consistent quality and compatibility with all concrete materials.

Cement used in grouting shall be Type III high early strength portland cement as per ASTM C150 or C595 (or HE portland cement as per CSA A3000-03 Cementitious Materials Compendium). Cement shall be supplied in standard bags on pallets by the Owner.

Cement shall be less than 3 months old at the time of use in grout unless approved by the Grouting Specialist. Cement that has become partially hydrated during storage shall not be used in grout.

Microfine cement shall be Nittetsu Superfine (SF) or equivalent approved by the Grouting Specialist, and supplied by the Contractor.

Heated storage for the cement is required to prevent the cement from freezing.

S4.6.2 Superplasticizer

Superplasticizer shall be a high-range water-reducing admixture used as a dispersion agent and shall comply with ASTM C494 Type F. Trials are required on site to verify satisfactory performance of specific superplasticizers with the cement used for grouting. Superplasticizer shall be:

Glenium 3030 NS supplied by:
BASF Admixtures Inc.
1800 Clark Boulevard, Brampton, Ontario
Tel: 800-387-5862

or similar, subject to satisfactory grout stability and viscosity being obtained as determined by the Grouting Specialist.

S4.6.3 Bentonite

Bentonite shall be finely ground (less than 200-mesh), premium grade sodium cation montmorillonite (Wyoming sodium bentonite) and shall meet all current API Standard 13A specifications. A suitable material is:

QUIK-GEL, supplied by
Baroid, Industrial Drilling Products
Houston, TX
Tel: 281-871-4612

S4.6.4 Viscosity Modifying Admixtures

Viscosity Modifying Admixtures (VMA's), if used, shall be required to increase the viscosity and prevent washout of the injected grout. VMA's shall comply with ASTM C494. Trial mixes at site will be required to determine the actual mix proportions and requirements for use. The VMA shall be:

Rheomac UW450 supplied by:
BASF Admixtures Inc.
1800 Clark Boulevard, Brampton, Ontario
Tel: 800-387-5862

Or similar, subject to satisfactory grout stability and viscosity being obtained as determined by the Grouting Specialist.

S4.6.5 Accelerators

Because of the anticipated cold (and possibly frozen) bedrock conditions, a non-chloride set time accelerator shall be required to ensure that the water does not freeze before the grout mix sets. The set time accelerator shall comply with ASTM C494 Type C and Type E. Trials are required on Site to verify satisfactory performance of specified accelerators with the cement and other admixtures used for grouting. Accelerator shall be:

Pozzutec 20+ supplied by:
BASF Admixtures Inc.
1800 Clark Boulevard, Brampton, Ontario
Tel: 800-387-5862

Or similar, subject to satisfactory grout stability, viscosity and set times being obtained as determined by the Grouting Specialist.

S4.6.6 Other Admixtures or Modifiers

Other additives could be required, such as retarders, inert fillers, volcanic ash or expanders. Such materials shall be products of proven quality and shall be subjected to the same field trial requirements as other mixes.

Prior to mobilization, all other grout additives shall be proposed by submittal to the Grouting Specialist for approval.

Trial mixes at Site will be required to determine the actual mix proportions and requirements for use.

S4.6.7 Water

Water used in grout mix preparation shall be fresh, clean water from a local source which is free from injurious amounts of oil, silt, soluble chlorides, organic matter, acids, alkalis and other deleterious substances, and conforms to ASTM C1602. Water used for mixing shall be heated and held at temperature ranging between 10 ^{o}C and 15 ^{o}C.

S4.6.8 Materials Storage

Cement, superplasticizer, bentonite and other concrete admixtures shall be stored in heated, weather tight buildings or containers to provide protection from rain, dampness, and contamination.

S4.7 Equipment

S4.7.1 Rock Drills

Drilling equipment shall be capable of installing/retrieving steel casing through cutoff and overburden materials and a minimum 200 mm into bedrock, to a depth of 10 m. Steel casing may be replaced by PVC or other casing following completion of installation.

Drilling equipment shall also be capable of drilling grout holes through the installed casing a further 50 m into bedrock. Grout holes in bedrock shall have a minimum internal diameter of 50 mm.

Drilling equipment shall be capable of installing/retrieving casing and drilling grout holes inclined vertically through to horizontally. All steel casing must be retrieved following the completion of grouting activities.

Water or foam flush shall be used as appropriate. Dry drilling (air flush) shall not be carried out.

S4.7.2 Water Heaters

Water heaters used to pre-heat mix water shall be of the West Coast Drilling Inc. propane water line heater variety or suitable alternative, as approved by the Grouting Specialist.

S4.7.3 Grout Mixers

Grout mixers shall be of the high-speed, high-shear ("colloidal") type operating at a mixing speed of more than 1,500 rpm, capable of thoroughly mixing the water, cement, bentonite and superplasticizers into a stable colloidal suspension. The nominal required capacity is 200 L of grout per batch.

Grout mixers shall be equipped with bag-splitters so that grout is mixed using whole bags of cement. Grout mixers shall be equipped with water meters for batching the mix water, and each grout plant shall have available three 250 mL graduated cylinders for batching superplasticizers and one, 1,000 g maximum weight, electronic, digital scale with an accuracy of ± 0.1 g for batching bentonite.

Paddle mixers shall not be used.

S4.7.4 Grout Holding Tanks (Agitators)

Grout holding tanks shall be of about 500 L capacity and equipped with paddles rotating at about 100 revolutions per minute. The lowest paddle shall be set within about 50 mm of the base of the tank.

Holding tanks shall be provided with a 0.15 mm sieve to screen solids or hardened grout from being discharged into the holding tank by the grout return line.

S4.7.5 Grout Pumps

Grout pumps shall be of the variable speed, progressing cavity (Moyno or Mono) type with a maximum delivery pressure of 20 bars at a sustained flowrate of 15 L/min. The rotation speed of each progressive cavity pump shall be controlled by a dial-pot voltage regulator (*i.e.* rate of injection shall be controlled by the rotation speed of the pump, not by re-circulation lines and valves).

Piston pumps (even if fitted with pressure surge chambers) shall not be used for grout injection.

S4.7.6 Pumps for Water Pressure Testing

Water pressure testing pumps shall be capable of delivering a sustained flowrate of 200 L/min at a maximum pressure of 8 bars.

S4.7.7 Grout Pipes

Pipes and hoses used to circulate grout from holding tank to point of injection shall have a maximum internal diameter of 25 mm and shall be rated for a safe working pressure of at least 30 bar. There shall be no sudden reductions in pipe diameter that might cause grout blockages. Fittings and connections on grout pipes and hoses shall be rated to 30 bar safe working pressure and shall include safety chains.

S4.7.8 Valves

Valves to be used in-line with the injection lines shall be of the diaphragm type.

Plug cock valves and ball valves shall only be used for fully-open/fully-closed functions.

S4.7.9 Single Packers

Provide single packers for pressure grouting.

Single packers shall be capable of isolating a part of a grout hole to enable only the lower portion of the hole to be pressure grouted.

Single packers shall be sized based on the choice of grout hole diameter and method of drilling.

In general pneumatic packers shall be used for down hole work. Mechanical packers shall be used for grout injection at the top of the hole during consolidation grouting.

The maximum allowable leakage of grout past the packer shall be 0.1 L/min at a grout pressure of 20 bars at ground surface.

S4.7.10 Double Packers

Double packers shall be provided for water tests. Double packers shall be capable of isolating a 2 m long portion of the grout hole and allowing water to be pumped into that isolated section. The supply of water to the injection point shall not be subject to significant head loss below the hole collar.

Double packers shall be sized based on the choice of grout hole diameter and method of drilling. Double packers shall be actuated by compressed nitrogen and the required compressed gas supplies, lines, regulators and pressure gauges shall be supplied. When sealing a section of grout hole the actuation pressure shall be at least 10 bars greater than the pressure used in the water test.

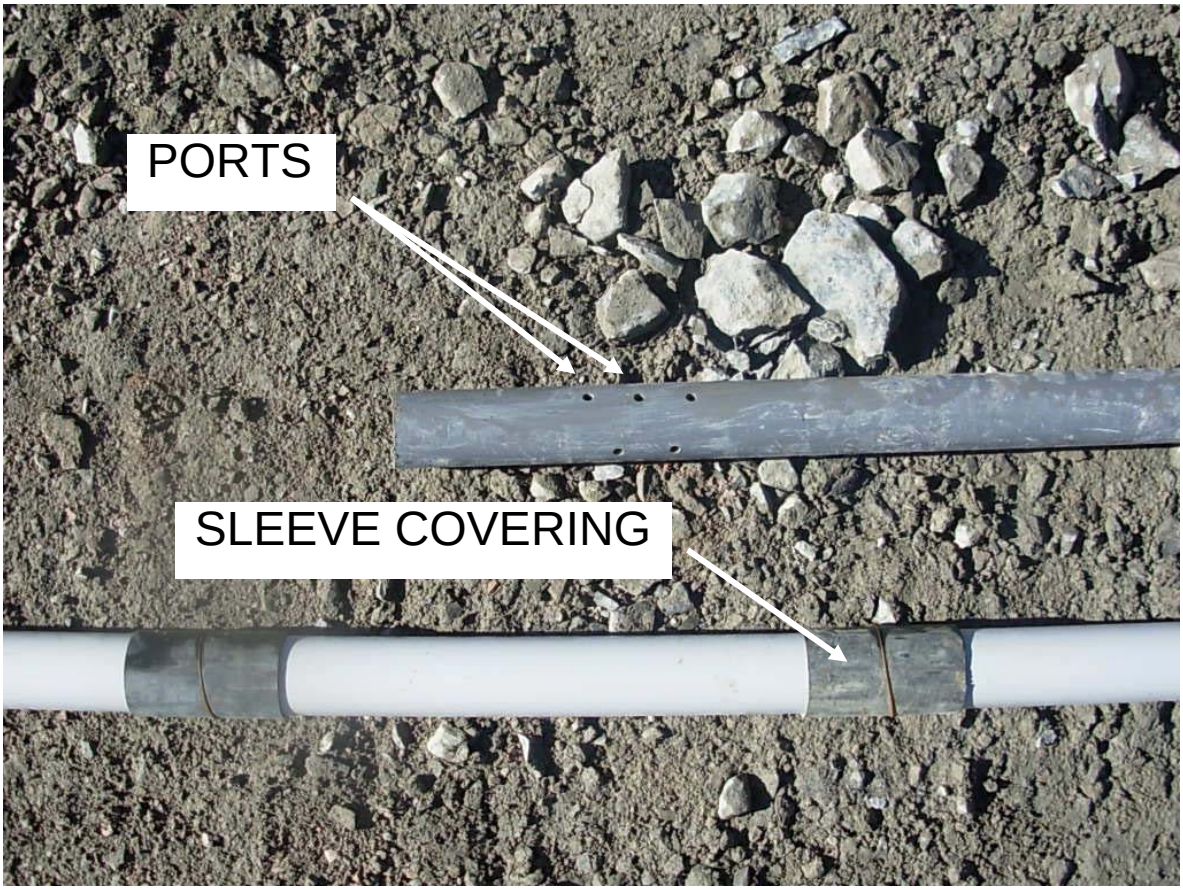
S4.7.11 Tube-a-manchette

Grouting of the upper bedrock and Cutoff Wall/bedrock contact will be by tube-a-manchette, or by a suitable method approved by the Grouting Specialist and subject to field trial.

Tube-a-manchette (sleeve port) pipe shall be fabricated of threaded, nominal 50 mm diameter Schedule 40 PVC pipe, or suitable alternative as approved by the Grouting Specialist.

Port configuration shall be comprised of ten, 5 mm diameter holes spaced in an alternating 3 x 2 pattern equidistant around the circumference of the tube-a-manchette (*i.e.*, every 40 mm), as shown in the photo, and spaced at regular intervals of 30 cm to 50 cm centre-centre along the length of the tube-a-manchette interval drilled, or equivalent as approved by the Grouting Specialist

Sleeve coverings shall be 20 mm in length and held stationary during the installation and backfill grouting process by tie-wire, zip-ties or equivalent as approved by the Grouting Specialist.



S4.7.12 Sleeve Port Packers

Sleeve Port Packers shall be selected by the Contractor to suit their choice of sleeve port (tube-a-manchette) pipe. Sleeve Port Packers shall be adjustable such that one to four adjacent ports may be injected with grout at the same time and as directed by the Grouting Specialist.

S4.7.13 Pressure Transducers

Pressure transducers shall be of 25 bar maximum pressure and of the 4-20 mA type. Transducers shall have an accuracy of better than 1% FSD (Full Scale Deflection). Pressure transducers shall be mounted on the grout line tee at the hole collar, and shall be protected from the grout using an in-line gauge saver. Only one hole shall be monitored with each pressure transducer.

S4.7.14 Pressure Gauges

Bourdon-type pressure gauges shall be provided at each grout pump discharge and at each hole collar. Gauges shall be protected from grout using gauge savers independent of those used for the pressure transducers. Gauges shall have a minimum face diameter of 75 mm and shall be available with a 25 bar maximum pressure range.

S4.7.15 Flow Meters

Flow meters shall be of the electromagnetic type. Flow meters shall have a full scale capacity of 100 L/min and shall be capable of resolving flows as low as 0.3 L/min with an accuracy of ± 0.1 L/min. The flow meters shall provide an electronic signal of the 4-20 mA type.

S4.7.16 Calibration Checks

Pressure transducers and pressure gauges shall be calibrated against a reference pressure gauge every week, or more frequently if the Grouting Specialist instructs.

Flow meters shall be calibrated every week.

Pressure transducers, pressure gauges and flow meters shall be re-calibrated if deviations are greater than ± 5%.

S4.7.17 Recording Equipment

The output of the pressure transducer (pressure) and flow meters (flow rate, total injected volume) shall be recorded and displayed on a data acquisition system, with the display visible close to the hole collar and adjacent to the pressure control valve. Graphical output capabilities shall be the same as those presented in this specification.

Data acquisition systems shall record time, pressure, and flow rate for each grout stage at one second intervals and these records shall be provided to the Grouting Specialist as comma separated (“csv”) files readable by a personal computer within 12 hours of completion of the shift.

Data acquisition systems shall also provide a RS232 output of pressure and flow rate to enable the Grouting Specialist to carry out real-time analysis of ground response to grout, if required, by connecting a laptop computer to the data acquisition system.

S4.7.18 Uninterruptible Power Supplies and Electrical Protection

Data acquisition systems shall be powered by uninterruptible power supplies with surge and spike suppression.

Flow meters and pressure transducers shall be protected from electrical power surges and voltage spikes.

S4.7.19 Shelters

During periods of cold weather, the Contractor shall provide an enclosed, heated working area (Quonset Hut) of sufficient size to carry out the specified works on a panel-by-panel basis. Each panel will be a minimum of 50 m in length.

When not located within a Quonset Hut, temporary portable shelters shall be provided by the Contractor to protect data acquisition systems from rain, sun, snow, wind and freezing temperatures. Typical enclosures are shown on the following figure for reference.

S4.7.20 Radios

Sufficient handheld radios shall be provided by the Contractor so that grouting operators can communicate with the grout mixing station and with the grouting operations supervisor.

S4.7.21 Equipment Reliability

It is essential that grouting of a hole or stage of a hole shall continue smoothly until refusal of grout occurs. If grouting is interrupted through equipment breakdown or other delays, grouting of that hole and stage shall be terminated, if required by the Grouting Specialist, and all operations carried out in connection with that hole or stage as applicable shall not be measured for payment. Stand-by equipment of the same type as that specified above shall be provided by the Contractor to allow the grouting program to continue uninterrupted.

S4.7.22 Other Equipment

Hoses, pipes, wrenches, valves and all other equipment and small tools necessary for the drilling and grouting shall be provided by the Contractor.

S4.7.23 Spares

Sufficient spares shall be provided so that all equipment can be readily kept in full working order.

In particular, a sufficient number of mixers shall be available, ready for immediate use, to produce grout at rates required by the hole or holes being grouted and without interruption due to mixer breakdown.

S4.7.24 Water Pressure Testing Equipment

Water pressure testing shall be carried out using equipment dedicated to water testing and independent of the grouting operations.

The pump for water pressure testing shall be as specified in Section 4.7. The monitoring equipment shall be as specified in Section 4.7. Data files shall be provided to the Grouting Specialist on completion of the testing.

S4.7.25 Grouting Testing Equipment

Per operating mix plant, the Owner shall provide one Marsh Funnel, five 500 mL graduated plastic cylinders, one mud balance, one Lombardi cohesion plate, and two thermometers for use by the Grouting Specialist for quality control testing of the grouts.

S4.8 Grouting of Rock

S4.8.1 Methodology

Grouting of rock foundations will comprise of drilling and grouting of the curtain using the split-spaced closure method. Primary hole spacing shall be 6m or as directed by the Grouting Specialist.

Curtain and consolidation grouting will generally be upstage with packer, unless ground conditions require downstage working. If downstage working is required, it shall be instructed by the Grouting Specialist. Stages shall be 5 m length unless directed otherwise by the Grouting Specialist.

Depending on weather conditions or as directed by the Grouting Specialist, grouting activities and closure will be carried out panel-by-panel, with closure in one panel being achieved before work is initiated in the next.

S4.8.2 Performance Criterion

The cutoff shall have a target hydraulic conductivity of 4 Lugeons (1 Lugeons =$1x10^{-7}$ m/s) with no single test greater than 7 Lugeons as determined by water pressure testing in boreholes drilled into the installed grout curtain.

S4.8.3 Drilling

Holes at the Cutoff Wall shall be drilled at locations as directed by the Grouting Specialist.

Holes through the Cutoff Wall shall be cased with Sch. 40 steel pipe socketed 200 mm minimum into rock. Steel casing may be replaced by PVC or other casing following completion of installation.

S4.8.4 Restriction on Drilling

Holes may not be drilled within 8 m of a grouted hole until at least 8 hours has elapsed after completion of grouting of that hole. If frequent communication between holes occurs, the minimum working distance requirements may be increased by the Grouting Specialist.

All primary holes can be drilled as most convenient. No secondary hole shall be drilled until its adjacent primary holes have been grouted.

S4.8.5 Protection and Cleaning of Drill Holes

Thoroughly wash all holes immediately before grouting the hole to remove cuttings, sediments, sludge and other loose material. Wash by injection of water at the bottom of the hole for five minutes or until return water is clear.

Protect cleaned holes from becoming clogged or obstructed using standpipes, rubber stoppers or similar means, until the holes are completely grouted. Drill holes shall be re-cleaned if clogging or obstruction occurs.

Grout hole casing shall be protected against damage prior to grouting.

S4.8.6 Removal of Water from Grout Holes

An air compressor and airline of sufficient capacity to be capable of blowing water or unset grout out of grout holes by the airlift technique shall be available on site. Water or unset grout shall be blown out of grout holes as required by the Grouting Specialist.

S4.8.7 Upstage Working

Upstage working shall comprise drilling the grout hole to full depth, washing and cleaning the hole, setting the packer at the top of the lowest stage, then grouting that stage. Provided that the target injection pressure is attained with grout refusal, grouting may continue by moving the packer to the next stage above after 10 minutes has elapsed and continuing to inject grout.

If the target pressure is not attained or, if the final grout flow rate when the volume limit of 1,500 L is reached is greater than 5 L per minute, then work shall stop on that hole until 6 hours have elapsed, unless otherwise instructed by the Grouting Specialist.

S4.8.8 Downstage Working

Downstage working shall comprise drilling the depth of a grout stage, washing and cleaning the hole, seating the packer at surface, injecting the grout, removing the packer, and washing the hole, completing these six operations before commencing the next stage.

Work shall commence in the stage nearest the surface and shall proceed down the hole until the final depth is reached.

At least 8 hours shall elapse between completing a stage and commencement of work on the next deeper stage.

After completion of the final stage, the hole shall not be washed and instead backfilled with grout.

S4.8.9 Split Spacing

The process of progressively closing a grout curtain by locating, drilling and grouting holes approximately at the midpoint between two other holes previously drilled and grouted. The spacing of the holes drilled and grouted may vary considerably from section to section, depending on conditions encountered. Deviation in spacing shall be at the direction of the Grouting Specialist.

S4.8.10 Closure Sequencing

Higher sequence holes shall not be started until both the adjacent prior holes have been completed. For example, a secondary hole shall not be drilled until grouting has been completed on both the adjacent primary holes.

S4.8.11 Panel-by-panel Sequencing

Depending on weather conditions or as directed by the Grouting Specialist, grouting activities and closure will be carried out panel-by-panel, with closure in one panel being achieved before work is initiated in the next.

Each panel will be a minimum of 50 m length, and shall overlap the previous panel by a minimum of 6 m.

S4.8.12 Water Pressure Testing

A water pressure test consists of measuring the rate at which water is accepted by bedrock for five periods of five minutes each. The pumping pressures to be used shall be supplied by the Grouting Specialist prior to testing.

Water pressure tests shall be carried out on 5 m long stages of cleaned grout holes. Generally, water pressure tests will be carried out in selected holes prior to grouting and in secondary holes to determine the adequacy of the grout curtain. Water pressure tests will be carried out independent of grouting operations.

The location and number of water pressure tests shall be determined by the Grouting Specialist. No such test shall be performed adjacent to a borehole grouted less than 8 hours previously.

S4.8.13 Grout Mix

The following grout mixes are proposed to initiate the grouting program:

Casing Grout

Water	200 L
Cement	100 kgs
Bentonite	7.5%
Superplasticizer	0 mL
7-day UCS value	~ 1 MPa

Mix A

Water	70 L
Cement	100 kg
Bentonite	0.0 kg
Superplasticizer	400 mL (0.9%)
Marsh Cone	30 seconds (nominal)

Mix B

Water	70 L
Cement	100 kg
Bentonite	0.0 kg
Superplasticizer	0 mL
Marsh Cone	35 seconds (nominal)

Mix C

Water	70 L
Cement	100 kg
Bentonite	0.6%
Superplasticizer	0 mL
Marsh Cone	45 seconds (nominal)

Mix D

Water	70 L
Cement	100 kg
Bentonite	1.2%
Superplasticizer	0 mL
Marsh Cone	60 seconds (nominal)

The above quantities shall be adjusted to match the cement weight such that the mix comprises a unit number of bags of cement.

Mixing shall be carried out by first introducing the water into the mixer followed by the superplasticizer and the dry bentonite. The water bentonite mixture shall be thoroughly mixed for three minutes before the cement is added. Mixing shall then continue for sufficient time to give a stable, uniform slurry.

Grout shall be continuously agitated during pumping and grouting.

S4.8.14 Trial Mixes

The grout mixes given are provisional mixes. Trials shall be carried out using the mixers and a standard batch size to verify that the mix gives the required grout quality. The Grouting Specialist shall require changes to the mix if required so that the specified grout viscosity and bleed parameters are obtained.

All grout shall have less than 5% bleed (bleed shall be measured over a two-hour period and shall comprise the decantation of clear water at the top of a 500 mL grout cylinder).

S4.8.15 Modifying Grout During Injection

The grout mix may be modified as grouting of a hole progresses depending on ground response and as directed by the Grouting Specialist. Mix A shall generally be used.

Modifications will most likely occur if high take zones are encountered and will likely comprise first the omission of the superplasticizer from the grout mix (to achieve an approximately 35 second Marsh cone grout), followed by an increase in bentonite content using the previously established standard mixes.

Possible modified mixes shall be batched and tested prior to the start of grouting.

S4.8.16 Grout Injection

The rate of injection shall be controlled by the rotation speed of the pump (*i.e.* using a dial-pot voltage regulator to vary or control the rotational speed of the positive displacement helical screw).

Pumping of the grout mix shall be at a steady flow rate of no more than 2 L/min./m, which results in a gradual pressure increase as the mix penetrates into rock discontinuities.

Grout shall be injected at the pressures and mix proportions as specified by the Grouting Specialist.

Grouting shall take place continuously until grout refusal occurs or the instructed volume limit of 1,500 L for that stage is reached, unless otherwise instructed by the Grouting Specialist.

Grout refusal for a given stage shall be a flow rate of less than 2.5 L/min per 5 m stage and measured over a 10 minute period (or 0.5 L/min/m for 10 minutes) at the target pressures for the stage, as directed by the Grouting Specialist.

Any sudden loss of pressure or a sudden increase in grout take shall be immediately reported to the Grouting Specialist.

S4.8.17 Pressure Control

Grout injection shall be carried out by pressure control.

Grout shall be injected at a gradually increasing flow rate to a maximum of 10 L/min per 5 m stage or less until the target pressure is reached, at which time the flow rate shall be progressively reduced to maintain the target pressure with continued grout injection until refusal, as defined above.

Injection pressures shall be measured adjacent to the hole collar.

Initial specified target pressures at the mid-point of a stage are calculated as 0.2 bar per meter measured vertically from the working platform to the top of bedrock, plus 0.5 bar per meter from the bedrock surface. The minimum pressure required at mid-stage is 1 bar above the hydrostatic head from the water level, and the maximum is 20 bar.

Target pressures shall be evaluated by the Grouting Specialist based on the results of the water pressure tests and the ground response to grout and the target pressures shall be modified to suit the ground conditions.

S4.8.18 Grout Volume Limit

The maximum volume of grout injected per 5 m stage shall be 1,500 L unless otherwise instructed by the Grouting Specialist.

If the target pressure mentioned in Section 4.8.19 is not attained, or if the final grout flowrate when the volume limit of 1,500 L is reached is greater than 2.5 L/min, then:

- work shall stop on that hole,
- a period of 6 hours allowed to elapsed; and
- the same stage should then be re-injected.

S4.8.19 Additional Grout Holes

Secondary and higher order grout holes shall be required on either side of an existing grout hole if the grout take of any one stage in that hole is higher than 200 L/m. Additional grout holes should be completed to a depth of one stage beyond the noted high take, unless otherwise directed by the Grouting Specialist.

S4.8.20 Communication Between Grout Holes

Grouting of any hole resulting in connection to an un-grouted hole shall be immediately reported to the Grouting Specialist. Multi-point injection shall then proceed in the connected holes.

S4.9 Tube-a-manchette Grouting

Systematic tube-a-manchette grouting will be used to grout the upper bedrock and contact between the base of the Cutoff Wall and the bedrock interface or by suitable method approved by the Grouting Specialist, subject to a field trial. The following procedure or equivalent approved by the Engineer will apply. Tube-a-manchette casings shall be installed on minimum of 3 m centres, regardless of whether or not both primary and secondary grout holes in bedrock are required.

As such, permeation grouting below the slurry Cutoff Wall will be carried out as outlined below:

- A 115 mm diameter casing will be installed through the Cutoff Wall, the zone of closely fractured bedrock, and a minimum of 200 mm into "competent" bedrock.

- Drilling, water pressure testing and bedrock grouting activities (using stable grout mixes) will be carried out within an approximately 90 mm grout hole, through the casing and to a depth of a minimum of 10 m vertical distance below the soil/bedrock interface.

Across the cutoff/bedrock interface, permeation grouting will be carried out as follows:

- Upon completion of each grout hole within the "competent" bedrock, a 50 mm diameter, Sch. 40 PVC, tube-a-manchette (TAM) will be installed from the top of the grout column, through the fractured zone and across the cutoff/bedrock interface, a distance of 0.5 m above the base of the slurry Cutoff Wall. The portion of the TAM above the noted required overlap with the slurry Cutoff Wall shall be comprised of solid (i.e., un-perforated) 50 mm diameter PVC.

- The annular space between the tube-a-manchette and the wall of the grout hole shall be backfilled with the specified Casing Grout, through the bottom port of the installed TAM (i.e., using the TAM itself as the tremmie tube).

- The installed casing shall be extracted once the grout hole has been backfilled with the Casing Grout. Following extraction, the annular space shall be re-topped up through the bottom port, until Casing Grout exits the collar of the grout hole. It may be necessary to carry out backfill grouting in several stages depending if the drilled materials cave into the grout hole during extraction of the casing.

- Grout (including Casing Grout) shall be flushed from any installed TAM, by deflating the packer(s) and flushing with clean water, at the completion of any stage of injection. Once the flush water returning to the collar is clean, the next stage above (or upstage) of the previously grouted interval may be injected.

- At the completion of grouting operations in any installed TAM, because of the potential for standing water to freeze within the TAM, the remaining water shall be air-lifted from the installed TAM and the interior of the TAM blown dry.

- The casing grout of each completed TAM installation shall be allowed to cure for a minimum of three (3) days before breaking of the cured casing grout.

- Water pressure testing and TAM grouting (using Type III cement and microfine cements if necessary) will be carried out via the installed sleeve port pipe, **after** the bedrock grout curtain has been completed.

Following the completion of both the bedrock and TAM grouting, inclined confirmation grout holes, orientated such that they cross the zones of highest takes, will be cored, water pressure tested and pressure grouted (if necessary).

S4.10 Quality Control (QC) and Quality Assurance (QA)

The Owner and Contractor shall provide survey and topography as required in the QA and QC Section. The Contractor is responsible for layout of the work. The Owner is responsible for quantity and verification. QC inspection shall be carried out by the Grouting Specialist as required in the QA and QC Section.

QA inspection shall be carried out by the QA Manager to confirm the QC results including whether the specified extents and limits are being attained and construction materials are meeting the required specifications.

The Owner shall provide facilities and labour as required, if available, to assist in conducting tests and sampling for QC and QA.

S5 INSTRUMENTATION

S5.1 Scope

This section of the specification describes the requirements for installation of instrumentation for the East Dike. The requirements include equipment and application software for the data acquisition, transmission and processing system.

All instrumentation will be supplied by the Contractor. The main items include installation of:

- vibrating wire piezometers, specifically "Model 4500MLP Piezometer" by Geokon, or equivalent;
- multiple bead thermistor strings;
- survey monuments and survey prisms along crest of the dike;
- survey control monuments;
- slope inclinometer casings; and
- prefabricated cabins for housing instrumentation terminals and data acquisition equipment.

The Contractor has the option of supplying alternate piezometers and readout instruments, subject to approval by Engineer prior to mobilization of equipment to site.

The work shall include the installation and testing of instrumentation, including all labour, materials and equipment to complete the design as shown on the Drawings. The Contractor will be responsible for protection of all instruments, leads, and connectors from damage and displacement during progress of the work, and shall provide markers and barricades as necessary.

S5.2 General

S5.2.1 Location and Installation Procedures for Instrumentation

The locations for the dike instrumentation are shown on the Drawings. Installation procedures are provided in this Section. The location of all instruments and installation will be subject to approval by the QA Manager.

Installation of the instruments shall be carried out in accordance with the Drawings, Specifications and the instructions of the equipment manufacturer. The Contractor shall be responsible for proper installation, testing, protection, and maintenance of instrumentation during construction.

Readings of each instrument shall be taken to verify correct functioning, and an initial set of readings shall be taken immediately after installation. Fill shall not be placed over the instruments or leads until the instruments have been tested and initial readings have been taken.

All cable conduits shall be marked with identification tags at intervals of 15 m, or closer if required. In addition, each instrument shall be marked with the identification given to it on the Drawings. Cable conduits shall be installed in maximum practicable lengths to minimize joints. Any necessary cutting, splicing and coupling shall be performed in accordance with the recommendations of the manufacturer.

Open ends of all incomplete lines of tubing, conduits and casing shall be sealed to keep the inside of tubes, conduits and casings free from foreign matter.

No traffic or equipment shall pass over any part of any instrument, leads or connections until at least 600 mm thickness of compacted material cover has been installed. The Contractor shall be responsible for protection of all instruments, leads and connections from damage and displacement during the progress of the Work, and shall provide markers and barricades as necessary.

S5.2.2 Electrical Protection and Safety

New and existing instrumentation shall be connected to the data acquisition system and it shall be confirmed that the system provides the following minimum protection for all electrical equipment:

- Over-voltage peak suppressor;
- Alternating current filter to eliminate interference; and
- Grounding system for lightning protection.

S5.2.3 Cabins and Accessories

All cabins, supports and accessories necessary for installation and protection of instruments shall be supplied by the Contractor.

All cabin and support structures shall be protected from corrosion and shall be finished and painted.

S5.2.4 Voltage and Electrical Frequency

Facilities requiring permanent electrical power, including battery chargers, shall be configured to operate at 110 V alternating current at 60 Hz.

S5.3 Equipment and Installation

All equipment shall be provided by the Contractor to install, operate and maintain the instrumentation. The instrumentation shall be protected with end caps and protective casing. All grouting equipment shall be provided by the Contractor including but not limited to tremie lines, grout pump and grout mix.

S5.3.1 Grout Mix

The vibrating wire piezometers, inclinometers and thermistors shall be installed using the following grout mix:

Water	660 L
Cement	100 kg
Bentonite	40 kg

The above quantities shall be adjusted to match the cement weight such that the mix comprises a unit number of bags of cement.

Mixing shall be carried out by first introducing the water into the mixer followed by the cement. The water cement mixture shall be thoroughly mixed before the bentonite is added. Mixing shall continue until a stable, uniform slurry is achieved.

Grout shall be continuously agitated during pumping and grouting.

S5.3.2 Geokon Multi-Level Vibrating Wire Piezometers (MLP)

S5.3.2.1 General

Vibrating wire piezometers shall include all equipment, leads, connection boxes, tubes, fluids, cement-bentonite grout, grout pump, grout tremie pipe, conduits and

accessories necessary for installation and operation. The piezometer, leads and connection boxes shall be provided by Geokon Inc and the piezometer shall be specifically "Model 4500MLP Piezometer" (MLP) by Geokon, or equivalent. Data reading shall be carried out manually during construction of the Work and automatically thereafter.

Each MLP shall be capable of measuring water pressure over a range between 0 and 350 kPa, with a resolution of 0.025%, and accuracy of 0.1% over its entire range.

The spring loaded mechanism of the MLP shall be suitable for a nominal borehole size of 100 mm.

The connector boxes shall have capacity for simultaneous installation of all leads from the piezometers shown on the Drawings.

S5.3.2.2 Installation

MLP shall be installed according to the manufacturer's instructions, within the dike fill and foundation at elevations shown on the Drawings or as directed by the Engineer. Prior to installation, the piezometer shall be immersed in de-aired water in accordance with the manufacturer's instructions.

Prior to installation of MLP, a 100 mm diameter borehole shall be drilled at the location and to the elevations shown on the Drawings. The MLP shall be placed in the hole to the elevation shown on the Drawings. After the spring has been triggered the hole shall be grouted with cement-bentonite.

Leads from the instruments to the connector boxes shall be routed through PVC conduits installed into trenches, as shown on the Drawings or as required by the Engineer. The PVC conduit shall be protected from impact and damage during construction by hand-tamped sand backfill.

Installation of the piezometers shall be completed by connecting the leads to the connector boxes within the instrumentation cabin.

S5.3.3 Inclinometers

S5.3.3.1 General

The inclinometer casings shall be Slope Indicator brand, 85 mm diameter casing with CPI couplers. Inclinometer installations shall include inclinometer casing with self-aligning coupling, and all necessary materials and equipment for installation and operation in accordance with the manufacturer's specifications. Readings shall be taken with a probe and dedicated mobile read-out unit equipped with memory and software for subsequent data acquisition and processing by microcomputer.

The measurement probe shall be of stainless steel, metric, with a distance of 500 mm between wheels, with a detection range of plus or minus 50 degrees from vertical, with a maximum error of plus or minus 0.02 degrees over its entire range. The probe shall be provided with a 50 m length of cable, mounted on a cable reel, marked each 0.5 m. A pulley assembly shall be used to facilitate readings.

The dedicated mobile read-out unit shall be powered by rechargeable batteries. The unit shall include storage for at least 10,000 data points and an outlet for connection to a computer or printer.

The top of the completed inclinometer shall be equipped with a locked steel protective cover, to prevent entry of foreign matter into the inclinometer casing.

Inclinometer casings will be filled with non-toxic antifreeze to lake level.

S5.3.3.2 Installation

Inclinometer shall be installed within the Cutoff Wall as shown on the Drawings, and the annulus will be grouted using a tremie line from the base of the installation, until grout return is observed at surface.

One month before commencing installation, the proposed method of anchoring and constructing the inclinometers shall be submitted by the Contractor to the QA Manager.

S5.3.4 Survey Monuments and Prisms

S5.3.4.1 General

Survey monuments and prisms shall be installed on the crest of the dike, as shown on the Drawings. Each survey monument shall be equipped with a pin or point, to facilitate reading by total station equipment. Readings shall be taken manually.

Survey control monuments shall be installed at locations specified on the Drawings. Survey control monuments shall be Type D monuments detailed in US Army Corps of Engineers EM1110-1-1002 Engineering and Design Survey Markers and Monumentation.

S5.3.5 Themistor Strings

S5.3.5.1 General

Thermistor strings shall include all equipment, leads, connector boxes, conduits and accessories necessary for installation and operation. Data reading shall be carried out manually during construction of the Work and automatically thereafter. Each thermistor string shall have the following:

- Length of each thermistor cable as shown on Drawings;
- Node located on each thermistor string as shown on Drawings;
- Cable to be heavy duty, direct burial rated 22 gauge, water-blocked instrumentation cable;
- Thermistor to be rated for a temperature range of at least -50°C to 50°C; and
- Thermistor to be accurate to within 0.2°C.

The connector boxes shall have capacity for simultaneous installation of all thermistor leads shown on the Drawings.

S5.3.5.2 Installation

Themistor strings shall be installed according to the manufacturer's instructions, within the dike fill and foundation at locations and elevations shown on the Drawings.

Leads from the instruments to the connector boxes shall be routed through PVC conduits installed into trenches, as shown on the Drawings. The PVC conduit shall be protected from impact during construction by hand-tamped sand backfill.

The installation of the thermistor string shall be completed by connecting the lead to the connector boxes within the instrumentation cabin.

S5.3.6 Instrumentation Cabins

The instrumentation cabin shall be installed at instrumentation section locations shown in the Drawings. Such cabins shall be suitable for relocation.

Two weeks prior to installation, the details of the proposed cabins shall be submitted by the Contractor to the QA Manager.

S5.3.7 Data Acquisition and Processing Equipment

S5.3.7.1 Scope

The data acquisition system and processing system for the instrumentation shall be supplied. The personnel selected by the CM to handle and operate the equipment and software shall be trained for operations and maintenance.

S5.3.7.2 Functional Requirements

The equipment must allow:

- Acquisition, verification, processing and display of the data obtained from the geotechnical instruments; and
- Sequential data recording complete with date and time, to allow retrieval of all data from any time.

S5.3.7.3 Data Acquisition and Storage Unit

The data acquisition and storage unit will receive data from the geotechnical instrumentation at time intervals selected by the operator. The unit shall be installed within the instrumentation cabin. Data shall be stored for subsequent transfer to a computer for processing. Data shall be recorded with corresponding legend, date and time.

S5.3.7.4 Computer Equipment and Software

A PC notebook computer system and a colour printer complete with system software and specialized software used for data transfer, evaluation, storing, processing and display shall be provided.

S5.4 Quality Control (QC) and Quality Assurance (QA)

The Owner and Contractor shall provide survey and topography as required in the QA and QC Section. The Contractor is responsible for layout of the work. The Owner is responsible for quantity and verification.

QC inspection shall be carried out by the QC Manager and/or personnel as required in the QA and QC Section.

QA inspection shall be carried out by the QA Manager and/or personnel as required to confirm the QC results including whether the specified location and construction materials meet the specifications and drawings.

The Owner shall provide facilities and labour as required to assist in conducting tests and sampling for QC and QA.

S6 QUALITY CONTROL (QC) AND QUALITY ASSURANCE (QA) REQUIREMENTS

S6.1 Scope

This section of the specification defines the requirements for the Quality Assurance and Quality Control for the construction of the East Dike.

The section includes:

- Equipment list for the field laboratory;
- Minimum quality control site inspections and testing requirements;
- Minimum quality assurance site inspections and testing requirements;
- Checklists for quality control of the major construction activities; and
- Non-conforming materials and corrective action procedures.

S6.2 Site Inspection and Testing

The tasks of the Contractor, CM, and the QA and QC Managers for construction activities are listed in Table 10. These are in addition to the responsibilities listed in S1 Administration.

TABLE 10: QA/QC Responsibilities

Activities	Tasks		
	Contractor/QC Manager	**QA Manager**	**CM**
Survey	• Provide qualified surveyor and modern equipment in good repair. Survey as required to layout the work and as requested by the QC/QA Managers to verify Work; • Lay out survey for Dike fill and Cutoff Wall alignment and chainages conforming with drawings; • Provide protection of the survey stakes; and • As-built survey	• Review survey lines and chainage and layout; • Review survey data provided by Contractor; • Determine need for adjustments in field; • Approve quantities; and • Approve layout for fill placement. • Bathymetry quantity surveys by singlebeam sonar	
Borrow Source Materials Sources and Storage	• Ensure materials meet specifications; • Surface water management; and • Control material segregation.	• Perform QA testing including gradations, moisture content; • Perform visual inspection of materials; • Approve suitability of borrow material and storage area for construction; • Approve quantities; and • Documentation including photographic records.	
On Land Foundation Preparation and Excavations	• Specify removal methods for unsuitable materials; • Surface water management; • Prepare sumps, pumps and lines for dewatering; • Report unusual conditions; • Survey lines conform with drawings; • Plan excavation and waste material disposal; • Provide excavation records; • All in-situ material loosened from excavation removed from cutoff trench.	• Review proposed waste storage areas; • Check surficial features to determine ground ice conditions; • Observe foundation preparation; • Documentation including photographic records; • Review survey lines and locations; • Review proposed excavation methods and blasting methods/pattern; • Observe foundation excavation; • Inspect trench and prepared foundation area prior to fill placement; • Report problems; • Review as-built survey report; • Documentation including photographic records; and • Bathymetry survey.	• Identify storage areas for waste materials.

Activities	Tasks		
	Contractor/QC Manager	**QA Manager**	**CM**
Turbidity Barrier	• Perform QC testing including turbidity measurements.	• Perform QA testing including visual inspection; • Review survey data provided by CM; and • Documentation including photographic records.	• Ensure turbidity curtain is installed correctly and is not damaged; • Ensure curtain is anchored; and • Survey location of turbidity curtain.
Dike Fill Placement	Ensure placement and extent as per drawings; • Provide on-land topography, • Plan material storage and waste material disposal; • Ensure fill materials conform with specifications; • Report any unusual conditions; • Survey extent of any unusual conditions; • Surface water management; and • Perform as-built survey.	• Review survey lines and locations; • Provide underwater surface soundings; • Inspect excavation and prepared foundation area prior to fill placement; • Inspect fill surface prior to subsequent fill placement; • Perform QA/QC testing including gradations of placed material, moisture content; • Underwater survey and inspection prior to and after placement of Coarse Filter on downstream slope of excavation, • Inspection of excavation following placement of Coarse Filter, prior to placement of core backfills, • Inspect fill quality and extents; • Approval of suitability of fill materials prior to placement; • Report problems; • Review as-built survey report and approve quantities; and • Documentation including photographic records.	
Foundation Preparation	• Specify removal methods for unsuitable materials; • Provide soundings of lake bed surface; and • Report unusual conditions.	• Review and approve survey data for lake bottom; • Confirm and approve bedrock surface by visual inspection, inspection by sonar and by underwater camera	• Identify storage areas for waste materials.
Cutoff Wall Construction	• Ensure placement and extent as per drawings; • Plan material storage and waste	• Review survey lines and locations; • Perform QA testing; • Inspect Cutoff Wall material;	

Activities	Tasks		
	Contractor/QC Manager	**QA Manager**	**CM**
	material disposal; • Ensure Cutoff Wall materials conform with specifications; • Perform QC testing and provide results; • Report any unusual conditions or problems and provide resolutions; • Survey extent of any unusual conditions; and • Perform as-built survey.	• Report problems; • Review as-built survey report; and • Documentation including photographic records.	
Drilling and Grouting	• Plan material storage and waste material disposal; • Ensure grouting equipment and materials conform with specifications; • Provide real-time pressure, injection rates and volume records for grouting process; • Report any unusual conditions; • Survey extent of any unusual conditions; and • Perform as-built survey and grout hole orientation surveys.	• Review survey lines and locations; • Perform QA/QC testing; • Inspect grouting equipment and materials; • Monitor injection process including real-time pressures, injection rates and volume; • Report problems; • Review as-built survey report; and • Documentation including photographic records.	•
Instrumentation Installation	• Provide instrumentation, supporting equipment,software, operating manuals, and demonstration to mine staff; • Provide instrumentation casings; • Provide energy sources for applicable instrumentation; • Report any unusual conditions; • Survey extent of any unusual conditions; and • Perform as-built survey.	• Review survey lines and locations; • Perform QC/QA testing; • Inspect instrumentation, supporting equipment and software; • Report problems; • Review as-built survey report; and • Documentation including photographic records.	•
Final Site Clean Up			• Inspection.

S6.2.1 Underwater Survey

Requirements for underwater survey to be completed by the QA Manager include:

1) Prior to placement of rockfill:

    a. Initial survey of East Dike footprint by singlebeam sonar to provide lakebed surface profile and excavation quantities.

2) Following placement of rockfill, excavation of trench, and preparation of the bedrock surface:

    a. Singlebeam survey of excavated trench within rockfill to determine dimensions, geometry and location of the slope toe.

    b. Sidescan/Sector Sonar and/or underwater camera imagery of exposed bedrock surface within the excavated trench to inspect surface smoothness and prospect for submerged objects such as large boulders.

3) Following placement of the Coarse Filter.

    a. Singlebeam survey of emplaced Coarse Filter surface to document Coarse Filter placement and dimension.

    b. Sidescan sonar and/or underwater video survey of Coarse Filter surface to observe placement.

The Contractor and the CM will allow time for in-lake survey and adjust the construction procedure and schedule as required.

The underwater survey will be the basis for measurement of quantities for payment, and for approval of the work by the QA Manager. The QA Manager will provide survey results to the CM and Contractor, along with either approval of the work, or notice of deficiency.

Approvals by the QA Manager are required for: excavation geometry, bedrock surface preparation, Coarse Filter placement, bedrock surface is clear following Coarse Filter placement, and prior to placement of Core Backfill.

S6.2.2 Field Laboratory

The Owner shall provide a proper facility/location for performing the required testing in addition to suitable testing equipment, maintained in good repair, properly calibrated at all times.

The following should be provided in the field laboratory as a minimum:

- ASTM Gradation Sieves and shaker;
- Hydrometer and Hydrometer jar -2;
- Oven for moisture content and density;
- Aluminium moisture boxes- 4;
- Stainless steel mixing bowls – 3 large round and 3 large rectangular;
- Scale for density and moisture content;
- Sample splitter – 1 large and 1 standard;
- Split Standard Proctor mold with hammer and straight edge;
- Tool set including screwdrivers, chisels, hammers, etc;
- Brush, soft bristle;
- Wash bottle;
- Round bottom scoops – 1 large and 1 small;
- Timers – 2 – 1s resolution to 24 hours, electronic;
- Mechanical analysis stirrer for hydrometer testing;
- Concrete cylinder casings for grout strength testing (50 mm dia. x 100 mm height);
- 10 L Sample buckets and lids;
- Crates for shipping samples;
- Marsh funnel and cup – 1 set per grout plant;
- Mud balance – 1 per grout pant;
- Lombardi cohesion plate – 1 per grout plant;
- Thermometer- 2 per grout plant, graded in Celsius;
- 500 mL - Graduated cylinders - 5 per grout plant;
- 250 mL – Graduated cylinders – 3 per grout plant;
- Electronic, digital scale – 1,000 g max. weight, accuracy ± 0.1 - 1 per grout plant;
- pH tape – 1 set; and
- Slump cone and rod – 1 set.

In addition the Owner shall provide calibration certificates to the QC Manager.

The Slurry Trench Specialist will provide his own equipment for testing bentonite slurry and SB Backfill.

S6.2.3 Minimum Field Testing for QA/QC

The quality assurance and quality control minimum testing requirements and frequency are listed in Tables 11 and 12. At a minimum, all the required testing to document the construction quality shall be performed. The minimum quality control criteria for the SB Cutoff Wall construction is given in Table 13.

Characterization of different rock types, segregation, and placement during construction with respect to geochemistry is the responsibility of the Owner.

TABLE 11: Construction QC Testing
(Minimum Submittal Frequencies)

Item	Testing or Monitoring	
	Type	**QC Frequency**
Pre-Construction		
Turbidity Barrier (by Owner)	Visual Observation	Continuously
	Water Quality	Daily
Borrow Material Storage	Visual Observation	Continuously
Fill Placement		
Till (by Owner)	Gradation (stockpile and as placed)	1 every 500 m^3
	Moisture Content (stockpile only)	1 every 500 m^3
	Visual inspection	Continuously
Core Backfill (by Owner)	Gradation (stockpile and as placed)	1 every 500 m^3 [B]
	Visual inspection	Continuously [B]
Coarse Filter (by Owner)	Gradation (as stockpile and as placed)	1 every 500 m^3 [B]
	Visual inspection	Continuously [B]
UM+Q Rockfill (by Owner)	Visual Gradation [A]	Continuously
IV Rockfill and IF Rockfill [C] (by Owner)	Visual Gradation [A]	Continuously
Foundation Preparation and Excavation		
Care of Water (by Owner)	Visual Observation	Continuously

Item	Testing or Monitoring	
	Type	**QC Frequency**
Location and Extents	On-land Survey	Before and after foundation preparation and excavation
	In-water Survey	Before rockfill placement After excavation to bedrock and before Coarse Filter placement, After Coarse Filter placement on downstream face of abutment
Cutoff Wall Construction		
Slurry Trench Specialist will perform QC activities as per SB Cutoff Wall section.		
Instrumentation		
Instrumentation Installation	Visual Observation	During Installation
Drilling and Grouting		
Location and Extents	Grout Hole Collar Survey	Each Hole
Equipment Calibration	Calibration Checks (pressure transducer and gauges)	1 per week against a reference pressure gauge
	Calibration Checks (flow meters)	1 per week against a known volume container.
Grout Mix	Marsh Funnel	1 at the initiation of injection of every stage, and thereafter, at every change of mix.
	Lombardi Cohesion	1 at the initiation of injection of every stage, and thereafter, at every change of mix.
	Mud Balance	1 at the initiation of injection of every stage, and thereafter, at every change of mix.
	Bleed	1 at the initiation of injection of every stage, and thereafter, at every change of mix.
	Mix Water and Grout Mix Temperature	1 at the initiation of injection of every stage, and thereafter, at every change of mix.
	Strength Testing	2 sets of 6 cylinders per grout mix used per week.

Notes: A. Maximum particle size to be visually controlled during fill placement. Samples will not be taken.
B. As placed. Sampled from under water, not on crest.
Testing shall comply with standards listed in Table 2. Gradations shall comply with limits provided in Specification S8 Fill Placement. Grout testing results shall comply with Specification S4 Drilling and Grouting.

TABLE 12: Construction QA Testing

Item	Testing or Monitoring	
	Type of Testing or Monitoring	**QA Frequency**
Pre-Construction		
Turbidity Barrier	Visual Observation	Continuously
Borrow Material Storage	Visual Observation	Continuously
Foundation Preparation and Excavation		
Care of Water	Visual Observation	Continuously
Location and Extents	On-land Survey	1 every 5 QC survey by GPS
	In-water Soundings	Point soundings at 5 m spacings to confirm QC surveys
Cutoff Wall Construction		
Water for Slurry Mixing	pH	Observe 1 every 5 QC tests
	Hardness	Observe 1 every 5 QC tests
	Total Dissolved Solids	Observe 1 every 5 QC tests
Initial Bentonite Slurry	Viscosity	Observe 1 every 5 QC tests
	Density	Observe 1 every 5 QC tests
	Bentonite Content	Observe 1 every 5 QC tests
In-Trench Bentonite Slurry Material	Density	Observe 1 every 5 QC tests
	Viscosity	Observe 1 every 5 QC tests
SB Material	Slump Cone	Observe 1 every 5 QC tests
	Gradation	Observe 1 every 5 QC tests
	Density	Observe 1 every 5 QC tests
Location and Extent	Trench Continuity	Observe 1 every 5 QC tests
	Soundings	Observe 1 every 5 QC tests
Fill Placement		
Till	Gradation	1 every 5 QC tests
	Moisture Content	1 every 5 QC tests
	Visual inspection	Continuously

Item	Testing or Monitoring	
	Type of Testing or Monitoring	**QA Frequency**
Core Backfill	Gradation (stockpile and as placed)	1 every 5 QC tests
	Visual inspection	Continuously
Coarse Filter	Gradation (stockpile and as placed)	1 every 5 QC tests
	Visual inspection	Continuously
Rockfill	Visual Gradation[1]	Continuously
Instrumentation		
Instrumentation Installation	Visual Observation	Continuously
Drilling and Grouting		
Location and Extents	Grout Hole Collar Survey	1 every 10 QC tests
Equipment Calibration	Calibration Checks (pressure transducer and gauges)	1 every 5 QC tests
	Calibration Checks (flow meters)	1 every 5 QC tests
Grout Mix	Marsh Funnel	1 every shift, per grout plant carrying out injection grouting (day shift and night shift)
	Lombardi Cohesion	1 every shift, per grout plant carrying out injection grouting (day shift and night shift)
	Mud Balance	1 every shift, per grout plant carrying out injection grouting (day shift and night shift)
	Bleed	1 every shift, per grout plant carrying out injection grouting (day shift and night shift)
	Mix Water and Grout Mix Temperature	1 every shift, per grout plant carrying out injection grouting (day shift and night shift)
	Strength Testing	1 every 5 QC tests

Testing shall comply with standards listed in Table 2. Gradations shall comply with limits provided in Specification S8 Fill Placement. Grout testing results shall comply with Specification S4 Drilling and Grouting. Slurry trench construction shall follow Table 13.

Increased testing frequencies shall be instituted if observations of normal testing frequency results indicate potential problems. Additional testing may be warranted when:

- The material repeatedly fails to meet specifications;
- The degree of compaction is doubtful;

- The materials appear to differ from those specified;
- Less than the required number of compaction equipment passes are made;
- The material moisture contents differ from those specified;
- The lift thicknesses differ from those specified; or
- Adverse weather conditions occur.

S6.2.4 SB Cutoff Wall Construction Quality Control

The Slurry Trench Specialist shall provide Quality Control including inspection and materials testing and the Owner shall provide survey and soundings. The Slurry Trench Specialist shall incorporate in the SB Cutoff Wall QC Plan, the minimum testing frequency given in Table 13.

TABLE 13: Slurry Trench QC Testing Plan
(Minimum submittal frequencies)

Property	Requirement	Minimum QC Test Frequency	Test Method	Comment
Water for Slurry Mixing				
a. pH	6 to 9	1 per source	API RP 13B-1	May be modified for potable source or if treated with additives
b. Hardness	< 250 ppm	1 per source	API RP 13B-1	
c. Total Dissolved Solids	< 500 ppm	1 per source	EPA 600	
New Bentonite Slurry				
a. Viscosity	45 to 55 marsh seconds	2 per shift	API RP 13B-1	
b. Density	> 1025 kg/m^3	2 per shift	ASTM D4380	
c. Bentonite content	> 4%	1 per shift	Weight-Volume	Demonstrate
In-Trench Bentonite Slurry				
a. Density	1025 to 1250 kg/m^3	2 per shift	ASTM D4380	Also > 240 kg/m^3 less than SB
b. Viscosity	> 40 seconds	2 per shift	API RP 13B-1	
SB Backfill Material				Subject to approval by Slurry Trench Specialist
a. Slump Cone	50 to 150 mm	1 per shift	ASTM C143	
b. Gradation	Per design mix	1 per 250 m^3	ASTM D1140	Laboratory or Field Test
c. Density	240 kg/m^3 > In-trench Slurry	1 per shift	ASTM C138 or D4380	
d. Permeability	$<10^{-9}$ m/s	1 per 25 m trench or per 350 m^3, which ever is more tests	ASTM D5856-95	

S6.2.4.1 Trench Continuity

It shall be demonstrated by the Contractor to the satisfaction of the Engineer that the trench is continuous and the minimum specified depth. The QA Manager or representative will be available onsite to verify these measurements. Trench continuity shall be assured by the action of movement of the trench excavation equipment such that the digging tools can be passed vertically from top to bottom of the trench as well as moved horizontally along the axis of the trench without encountering unexcavated material. Depth of the final excavated trench shall be demonstrated by direct measurement to the satisfaction of the Engineer.

S6.2.4.2 Materials

- Bentonite - Certificate of Compliance with the specification shall be obtained from the manufacturer for each shipment of bentonite delivered to the site.

- Water - Water for slurry mixing shall be tested once each month.

- Prepared Backfill - SB backfill shall be tested prior to placement in the trench by conducting tests to determine slump and gradation. Laboratory testing of the backfill for gradation and permeability shall be conducted as per Table 13. Permeability testing shall be performed to verify the prepared material meets the specification. Permeability determinations may follow placement.

- New Bentonite Slurry - A complete series of tests shall be conducted from the mixer or tank containing fresh slurry ready for introduction in the trench as per Table 13.

- In-Trench Slurry - Slurry in the trench shall be tested at least twice per shift. Samples shall be obtained from the mid-depth of the trench near the toe of backfill slope.

S6.2.4.3 Soundings

Soundings shall be taken every 5 m along the trench centerline using a weighted tape, cable or other device. Soundings shall be recorded to the nearest 0.15 m. Soundings shall record the following:

- Bottom of Excavation: The elevation of the trench bottom shall be determined subject to approval by the Engineer.

- Bottom of Excavation Prior to Backfilling: Soundings shall be used to monitor for sidewall collapse and accumulation of sediments.

- Profile of Backfill Slope: The SB backfill slope and trench bottom shall be sounded at the beginning and end of each shift and converted to an as-built drawing. This drawing shall be reviewed daily as an indication of trench collapse, excessive settlement or sloughing.

S6.2.4.4 Documentation

Results of all tests performed shall be recorded on forms acceptable to the Engineer and signed by the Slurry Trench Specialist. These forms will be available to the Engineer at all times for his inspection. Copies of all QC documents will be submitted daily to the QA Manager.

As-Built profile drawing of the trench bottom and backfill slope shall be continuously maintained by the Contractor. The profile shall indicate the extent of excavation and backfill at the end of each working day. The daily profile shall be drawn in an electronic format or by hand, as directed by the QA Manager.

S6.2.5 Deficient Work or Materials

The extent and nature of deficient work or materials shall be determined through additional tests, observations, review of records and test results or other means that are deemed appropriate. The identifier of the deficient work and materials shall fill out a deficiency resolution document. The CM shall hold a deficiency resolution meeting. After the extent and nature of the deficiency has been ascertained, the CM shall institute corrective actions required to meet the Specifications and Drawings. Areas that have been reworked shall be further retested. All retests must verify that the entire defective area has been corrected prior to additional work being performed in that area.

S6.3 Documentation

The QA Manager shall document all testing and that all QA requirements have been addressed and satisfied. Further, the QC Manager shall provide field reports, data sheets and checklists to substantiate that requisite monitoring tasks have been implemented. The QA and QC Managers shall maintain a job site file of plans, specifications, checklists, test procedures, daily and weekly reports, logs and other project relevant documents.

S6.3.1 Daily Summary Report

Daily record keeping by the QC Manager shall at a minimum include:

- Date, project name and location;
- Parties on-site participating in meetings and discussions;
- Daily summary, reporting meetings and/or discussions with the CM summarizing QC daily activities;
- Daily Construction activities;
- Daily weather observations including precipitation and temperature;
- Compaction equipment (type and weight) and typical number of passes;
- Equipment used to place and spread materials;
- Daily field test results data sheets;
- Laboratory test results data sheets;
- Equipment calibration or recalibration forms as applicable; and
- Design and specification modification/clarification documentation.

S6.3.2 QA Weekly Summary Report

The QA Weekly Reports are prepared by the QA Manager and summarize the daily activities and, where applicable, will include:

- Date, project name and location;
- Parties on-site participating in meetings and discussions;
- Summary of meetings and discussions attended;
- Identification of borrow source and the associated optimum moisture content/maximum dry density;
- Documentation of all observations of construction and QA/QC activities/test results;
- Methods used to correct construction deficiencies;
- Summary of construction progress;
- Summary of QA/QC activities and test results, including an indication of passing and failing tests; and
- Summary of problems and their resolutions.

S6.3.3 Construction Deficiency Resolution Forms

Construction problem and resolution documents shall reference specific observations and test result data forms. These documents shall include the following information:

- A detailed description of the problem, non-conformance or deficiency;
- A location identified by co-ordinates and probable cause for the problem;
- Detailed description of how and when the problem was identified;
- Detailed description of how the problem, non-conformance or deficiency was solved or corrected;
- Reference to results of any retests performed; and
- Detailed description of measures implemented to prevent recurrence of the problem.

These documents shall be incorporated as part of the Daily Summary Report. Any modifications or to the design plans or specifications shall be by the Engineer. Any resulting modification or clarification to procedures used to complete the Work shall be approved by the CM.

S6.3.4 Site Checklists

QC checklist forms shall be used for documenting the construction activities. The QC checklist shall be signed by the CM and the QC Manager. The checklists shall include the following information:

- Date;
- Shift inspected;
- Tests performed;
- Location inspected with chainage;
- Fill material;
- As-built survey conducted;
- Dewatering measures provided;
- Remarks; and
- Deviations and rectifications.

The following examples are attached:

- East Dike construction checklist – Foundation Preparation and Excavation;
- East Dike construction checklist – Fill Placement;
- East Dike construction checklist – Drilling and Grouting; and
- East Dike construction checklist – Instrumentation.

Foundation Preparation and Excavation

EAST DIKE CONSTRUCTION CHECKLIST - FOUNDATION PREPARATION and EXCAVATION

From Sta. Offset	SHIFT: NIGHT : ☐ DAY : ☐	DATE :	SHEET OF
To Sta. Offset	LOCATION: :		
EQUIPMENT:			

DESCRIPTION

NO.	ITEMS TO BE INSPECTED	INSPECTED BY QC Manager	INSPECTED BY QA Manager
1.	Survey lines and layout checked to ensure the locations conform with the drawings		
2.	Storage areas planned for disposal of removed materials		
3.	Occurrence of snow and ice removal method in place		
4.	Occurrence of boulders and removal method in place		
5.	Occurrence of hummocks and scalping method in place		
6.	Occurrence of surface and ground water and its impact mitigation in place		
7.	Presence of other unsuitable materials and removal method in place		
8.	Soil frozen or thawed and measures taken		
9.	Blasting requirement to remove unsuitable material and safety measure checked		
10.	Adjustment made to suit design in field		
11.	Final walkover inspection before re-sloping or fill placement		
12.	“As-excavated” survey conducted		
13.	Final sounding conducted of lake bottom surface		

REMARKS :

DEVIATIONS : (Attach list if necessary)

DATE OF RECTIFICATION :

SURVEY VERIFICATION	ACCEPTED BY QA Manager :	ACCEPTED BY OWNER :
NAME: _____	NAME: _____	NAME: _____
SIGNATURE : _____	SIGNATURE : _____	SIGNATURE : _____
DATE _____	DATE _____	DATE _____

Fill Placement

EAST DIKE CONSTRUCTION CHECKLIST- FILL PLACEMENT					
From Sta.	Offset	SHIFT: NIGHT : ☐	DAY : ☐	DATE :	SHEET OF
To Sta.	Offset	LOCATION:			
EQUIPMENT :					
DESCRIPTION :					

NO.	ITEMS TO BE INSPECTED	INSPECTED BY Construction Manager	INSPECTED BY QA Manager
1.	Survey lines and layout conform with the drawings		
2.	Fill materials stockpiled meet the specification requirements		
3.	Dewatering measure provided		
4.	Required soil tests performed		
5.	Required visual inspection of stockpiled materials performed		
6.	Required visual inspection of placed materials performed		
7.	Snow and loose materials removed from the surface		
8.	Weather condition meets the requirements during fill placement and compaction		
9.	Fill materials contain no frozen chunks		
10.	Adequate control of segregation of fill materials		
11.	No snow or ice trapped during placement		
12.	Final trench inspection performed before backfill		
13.	As-built survey conducted		

REMARKS :

DEVIATIONS : (Attach list if necessary)

DATE OF RECTIFICATION :

SURVEY VERIFICATION	ACCEPTED BY QA Manager :	ACCEPTED BY OWNER :
NAME: _____	NAME: _____	NAME: _____
SIGNATURE : _____	SIGNATURE : _____	SIGNATURE : _____
DATE _____	DATE _____	DATE _____

Drilling and Grouting

EAST DIKE CONSTRUCTION CHECKLIST- DRILLING AND GROUTING				
From Sta. Offset		SHIFT: NIGHT : ☐ DAY : ☐	DATE :	SHEET OF
To Sta. Offset		LOCATION:		
EQUIPMENT :				
DESCRIPTION :				
NO.	ITEMS TO BE INSPECTED		INSPECTED BY QC Manager	INSPECTED BY QA Manager
1.	Survey lines and layout conform with the drawings			
2.	Dewatering measures provided for surface and groundwater			
3.	Required grouting tests performed			
4.	As-built survey conducted			
REMARKS :				
DEVIATIONS : (Attach list if necessary) DATE OF RECTIFICATION :				
SURVEY VERIFICATION NAME: _____ SIGNATURE : _____ DATE _____		ACCEPTED BY QA Manager : NAME: _____ SIGNATURE : _____ DATE _____		ACCEPTED BY OWNER : NAME: _____ SIGNATURE : _____ DATE _____

Instrumentation

EAST DIKE CONSTRUCTION CHECKLIST- INSTRUMENTATION				
From Sta. Offset		SHIFT: NIGHT : ☐ DAY : ☐	DATE :	SHEET OF
To Sta. Offset		LOCATION:		
EQUIPMENT :				
DESCRIPTION :				
NO.	ITEMS TO BE INSPECTED		INSPECTED BY Construction Manager	INSPECTED BY QA Manager
1.	Survey lines and layout conform with the drawings			
2.	Instrumentation equipment and methods acceptable			
3.	Instrumentation details provided in as built			
4.	As-built survey conducted			
REMARKS :				
DEVIATIONS : (Attach list if necessary) DATE OF RECTIFICATION :				
SURVEY VERIFICATION NAME: _____ SIGNATURE : _____ DATE _____		ACCEPTED BY QA Manager : NAME: _____ SIGNATURE : _____ DATE _____		ACCEPTED BY OWNER : NAME: _____ SIGNATURE : _____ DATE _____

S7 CARE OF WATER

S7.1 Scope

This section of the specification describes care of water for the construction of East Dike. The care of water consists of all work required to control water from any sources, including groundwater, surface water and precipitation, in order to complete the Work in accordance with the Drawings and Specifications, and in accordance with the Site Wide Environmental Monitoring Plan, the Site Wide Health and Safety Plan, and all environmental and Health and Safety controls established by the Owner.

Care of water shall include the following:

- Managing water before, during and after: excavating; preparing, and constructing foundation and abutments; placing dike fills; designated waste areas, use and construction of access roads, and stockpiles; constructing seepage collection works; and undertaking any other part of the Work.

- Dewatering foundations and associated working areas. The Contractor shall provide, operate and maintain any channels, flumes, drains, culverts, sumps, pumps and other drainage facilities and equipment necessary to divert water away from or to remove water from areas required to be used for construction of the Work and/or as required to meet environmental or safety requirements.

- Constructing and maintaining any embankments and other protective works required to divert water away from areas required for the Work, and where applicable, removing such structures upon completion of the Work.

- Diverting and controlling surface runoff occurring along the abutments at the edge of the crest and toe.

S7.2 General

Surface water shall be temporarily diverted and managed during construction of the Work. Any channel, ditch, dike or other facility required to divert surface water from any area required to complete the Work shall be constructed. All pumps, hoses, culverts and any other equipment required to dewater and maintain all parts of the construction site free from water shall be furnished, installed, maintained and operated.

The Contractor shall adequately operate and maintain temporary diversion and protective works and pumping stations. These shall also be readily accessible at all times.

The Contractor shall remove dikes and other temporary works promptly, when they are no longer required at the direction of the CM. Materials from such removal shall be hauled to disposal areas designated by the CM.

S7.3 Execution

The Work shall not commence until appropriate Care of Water measures have been designed, submitted to the QA Manager for review and approval by the Engineer and CM, and implemented.

Care of Water systems shall include, but not necessarily limited to: embankments, trenches, ditches, and lined channels to divert or collect surface water runoff; pipes, drains and sumps to manager groundwater; and pumping systems.

S7.3.1 Dewatering Foundations

Excavations on land shall be dewatered in advance, to ensure that the Work is carried out in safe and dry conditions. Proposed methods for preventing and controlling seepage shall be submitted to the CM for approval as part of the Specific Work Plans.

S8 FILL PLACEMENT

S8.1 Scope

This Specification provides the technical information for the fill placement and compaction for construction of the East Dike at Meadowbank Gold Project in Nunavut Territory of Canada.

S8.2 General

Fill placement shall be carried out in accordance with the Drawings and Specifications, using ground support, water control measures, and turbidity controls required for safe and effective operation.

Temporary drainage and pumping systems shall be operated and maintained as required to direct water away from the on-land fill placement areas as specified in Care of Water Specification S7.

S8.2.1 Access

Access to the Work will be provided and coordinated by the CM.

S8.2.2 Waste Soil and Rock

Waste soil and rock shall be disposed of by the Contractor in an area designated by the CM.

Waste materials shall not be deposited into any riverbed, lake or other water channel and shall not be burned.

S8.2.3 Borrow Sources

The various borrow sources shall be tested prior to the start of construction and through construction as detailed in the Quality Control (QC) and Quality Assurance (QA) Requirements Specification S6.

S8.2.3.1 Rockfill Material

UM+Q Rockfill, IF Rockfill and IV Rockfill shall be supplied by the Owner. Owner will classify materials with respect to geochemical characteristics and designate which materials are potentially acid generating (PAG) and non-potentially acid generating (NPAG).

The Owner is solely responsible for the classification, segregation and appropriate use of PAG and NPAG materials.

Placement of PAG materials will be limited to 1 m below water surface. PAG materials shall not remain exposed to atmosphere.

S8.2.3.2 Coarse Filter

Filter materials shall be stockpiled in the crusher area. The storage area for the Coarse Filter material shall be inspected by the QC Manager prior to storage. Handling, stockpiling, and sampling of Coarse Filter materials shall be done to prevent segregation and contamination.

S8.2.3.3 Core Backfill

Core Backfill material shall be stockpiled in the crusher area. The storage area for the Core Backfill materials shall be inspected by the QC Manager prior to storage. Handling, stockpiling, and sampling of Core Backfill materials shall be done to prevent segregation and contamination.

S8.2.3.4 Till

The primary Till material borrow source will be the on-land area of the Third Portage peninsula, within the footprint of the Third Portage Pit. Prior to approval of a borrow source, the gradation of the Till material shall be checked for filter compatibility against the Core Backfill gradation and approved by the Engineer. Other borrow sites may be considered subject to gradation testing and moisture testing and approval of the Engineer.

S8.3 Fill Materials

S8.3.1 IV Rockfill

IV Rockfill will be used to build the rockfill embankment as shown on the Drawings.

IV Rockfill shall be run of mine material consisting of sound, hard, durable, well graded rock fragments free from ice, frozen chunks, organic matters, debris and other deleterious materials.

S8.3.2 IF Rockfill

IF Rockfill will be used in the upstream rockfill embankment 1 m below the still water level as shown on Drawings.

IF Rockfill shall be run of mine material consisting of sound, hard, durable, well graded rock fragments free from ice, frozen chunks, organic matters, debris and other deleterious materials.

S8.3.3 UM+Q Rockfill

Rockfill UM + Q will be placed as a surfacing material.

UM+Q Rockfill material shall be run of mine material consisting of sound, hard, durable, well graded rock fragments free from ice, frozen chunks, organic matters, debris and other deleterious materials.

S8.3.4 Coarse Filter

Coarse Filter will be placed between Core Backfill and Rockfill, as required by the design.

Coarse Filter shall be from IV Rockfill, screened to meet the design specification. Coarse Filter shall fall within the gradation limits in place on the dike, as shown in Table 14. Coarse Filter shall be free of clay, organic matters, debris, cinders, ash, refuse, snow, ice and other deleterious material, subject to the satisfaction of the Engineer.

TABLE 14: Gradation Limits for the Coarse Filter

Size (mm)	Percent Passing (%)
200	100
152.4	86-100
76.2	35-100
25.4	5-40
12.7	0-18
4.76	0-9
2	0-5

S8.3.5 Core Backfill

Core Backfill will be placed along Cutoff Wall centreline.

Core Backfill shall be crushed material from IV Rockfill. Core Backfill shall fall within the gradation limits in place on the dike as shown in Table 15. Core Backfill shall be free of organic material, debris, cinders, ash, refuse, snow, ice and, other deleterious material subject to the satisfaction of the Engineer.

TABLE 15: Gradation Limits for Core Backfill

Grain Size (mm)	Percent Passing by Mass (%)
50	100
25.4	66-100
12.7	46-100
4.76	23-68
0.425	0-20
0.075	0-15

S8.3.6 Till for Soil Bentonite

Till for use in the soil-bentonite Cutoff Wall shall be of free of organic material, debris, cinders, ash, refuse, snow, ice, boulder sizes and other deleterious material subject to the satisfaction of the Engineer.

Recommended gradation limits are provided in Table 16.

TABLE 16: Gradation Limits for Till

Grain Size (mm)	Percent Passing by Mass (%)
152.4	100
76.2	91-100
25.4	75-91
12.7	65-84
4.76	53-73
0.425	33-48
0.075	20-35

Alternative materials may be used for Cutoff Wall construction, subject to filter compatibility with Core Backfill material, Cutoff Wall performance criteria provided in Specification S3 SB Cutoff Wall, and the approval of the Engineer.

S8.4 EXECUTION

A turbidity barrier shall be erected and in place prior to construction as described in Turbidity Barrier Specification S9.

Construction of structures shall be to the lines, grades and cross-sections shown on the Drawings using only suitable materials approved by the Engineer.

Rockfill slope angles shown on drawings are assumed and actual performance may vary.

Equipment suitability, methods of working, rate of progress and quality of work shall be demonstrated during the initial stages of the Work. In the event that the work performance is unsatisfactory for either quality or schedule requirements, there shall be immediate implementation of such changes as are required to ensure the required quality and scheduled completion of the Work.

Accumulation of water, snow, ice or other deleterious material(s) shall be prevented on the surface of the fill or foundations.

Material placement shall cease when satisfactory work cannot be carried out due to rain, snow, unsatisfactory materials or any other unsatisfactory conditions.

During placement of materials, mixing of the materials from adjoining zones shall be prevented. Segregation during transportation, dumping and spreading of material shall be avoided so that the material placed meets the grading requirements as specified.

S8.5 Examination

Prior to commencing construction, the Contractor shall thoroughly examine other Work upon which his Work is dependent and report any deficiencies discovered to the CM.

S8.6 Topographic Survey and Initiation

Before the Work starts, topographic and bathymetric survey of the surface work areas shall be carried out to establish the base plans for layout and quantity calculations.

The responsibility of surveys and soundings of topography lies with the Owner. Complete reports of surveys and topographic measurements shall be provided to the QA Manager within 2 days of survey completion.

The Contractor is responsible for the correctness and exactness of their work.

S8.7 Dimensional Tolerances

Minimum position of all fill areas shall be given by the specified lines and grades on the Drawings. The acceptable tolerances for the material types, unless otherwise approved by the Engineer, are:

- The minimum spacing between the Coarse Filter and the upstream rockfill is 5 m;
- Cutoff wall width will be a minimum of 1 m, and will have a minimum of 1 m of Core Backfill on either side of the cutoff wall;
- Coarse Filter materials shall be equal to or greater than the minimum thickness shown on drawings; and
- Fill materials may experience settlement during and post construction. Settled areas shall be brought to grade by placing additional appropriate fill material in the settled area.

S8.8 Fill Placement and Compaction

Fill materials placed through water shall not require compaction, with the exception of Core Backfill. Fill materials placed on land shall be compacted at the direction of the Engineer.

Methods for placement of Rockfill, Coarse Filter, and Core Backfill (with Coarse Filter wings) will require trials at the beginning of the construction and are subject to approval by the Engineer.

S8.8.1 IV Rockfill and IF Rockfill

Rockfill shall be placed by “bulkheading,” which consists of dumping short of the advancing rockfill face and then pushing the rockfill into the water with a bulldozer or other appropriate means deemed suitable by the Engineer.

The final top surface of the IF Rockfill within the embankment shall be 1 m or more below the lake surface.

S8.8.2 UM+Q Rockfill

UM+Q Rockfill shall be spread with a bulldozer or other appropriate means deemed suitable by the Engineer.

There shall be no nesting of oversize stones and no existence of significant voids in the placed material.

The UM+Q Rockfill shall be placed in a maximum uncompacted lift thickness of 1,000 mm.

S8.8.3 Coarse Filter on Excavation Slope

Coarse Filter material shall be placed on the downstream side of the excavation as shown on the Drawings.

Coarse Filter placement shall be minimum 50 m behind the advancing excavation until the excavation is complete, subject to survey and QA approval. The slope of the rockfill embankment on which the Coarse Filter will be placed shall be surveyed to check initial surface slopes.

Coarse Filter material shall be placed to minimize segregation: by excavator bucket to minimize drop height and sorting, or as directed by the Engineer.

The Coarse Filter shall be a minimum of 1 m thickness measured perpendicular to the rockfill slope.

Use of Coarse Filter against the downstream slope of the excavation is required, unless approved in writing by the Engineer.

S8.8.4 Core Backfill and Coarse Filter Wings

Core Backfill shall be placed between the Coarse Filter on the downstream face of the excavation and the upstream face of the excavation in the rockfill.

Core Backfill placement shall be minimum 50 m behind the advancing Coarse Filter face until the advancing Coarse Filter face is completed, surveyed, and approved by the QA Manager. Core Backfill will not be placed until the bedrock surface at the base of the excavation is inspected and approved by the QA Manager.

Trials shall be carried out to optimize the Core Backfill and Coarse Filter "wings" placement procedure to the satisfaction of the Engineer prior to Core Backfill placement. The leading edge of material placed in the excavation will be Core Backfill to ensure a continuous section, with no penetration by Coarse Filter materials or materials that might cause slurry loss during Slurry Trench construction.

Compaction or densification of the Core Backfill shall be carried out, with the final condition of the Core Backfill subject to the satisfaction of the Slurry Trench Specialist and the Engineer. Methods for compaction or densification of Core Backfill will be trialed during construction, and are subject to approval by the Engineer.

A geotechnical investigation of the placed dike core backfill shall be carried out following completion of compaction, consolidation, or densification, and the results will be made available to the Slurry Trench Specialist.

S8.9 Quality Control (QC) and Quality Assurance (QA)

The Owner and Contractor shall provide survey and topography as required in Quality Control (QC) and Quality Assurance (QA) Requirements Specification S6. The Contractor is responsible for layout of the work. The Owner is responsible for quantity and verification.

All foundation surfaces shall be approved prior to fill placement by the QA Manager. All fill surfaces shall be approved by the QA Manager prior to subsequent fill placement of different materials. QC inspection shall be carried out by the QC Manager and/or personnel as required in Quality Control (QC) and Quality Assurance (QA) Requirements Specification S6.

QA inspection shall be carried out by the QA Manager and/or personnel to confirm the QC results including whether the specified fill placement, construction grades and limits are being attained and construction materials are meeting the required specifications.

The Owner shall provide facilities and labour as required to assist in conducting tests, soundings, surveys and sampling for QC and QA.

S9 TURBIDITY BARRIER

S9.1 Scope

This specification describes the requirements for supply and installation of a turbidity barrier for the construction of the East Dike at the Meadowbank Gold Project in Nunavut Territory of Canada.

S9.2 General

A turbidity barrier shall be placed upstream and downstream of the East Dike construction as specified in the Drawings.

S9.3 Materials

The turbidity barrier shall consist of the following:

Panels	600 g/m^2 weight polyester reinforced vinyl;
Connectors	shackled and bolted load lines with reinforced PVC pipe for fabric closure;
Flotation device	200 mm of expanded polystyrene (28 kg/m minimum buoyancy);
Ballast	8 mm galvanized chain; and
Anchors	1 m^3 concrete cubes or rock equivalent

S9.4 Dimensions

The depth of the barrier will generally extend to 1.0 m above the lake bed surface except where the water depth is less than 2 m. The maximum curtain depth for the East Dike is 5 m.

S9.5 Execution

The barrier shall be placed prior to any construction related disturbances and may only be removed after the completion of the construction of the adjacent rockfill embankment and water between the embankment and the turbidity barrier has total suspended solids levels at pre-construction levels.

S9.6 QUALITY CONTROL (QC) AND QUALITY ASSURANCE (QA)

The Owner shall provide survey and topography as required in Quality Control (QC) and Quality Assurance (QA) Requirements Specification S6

QC inspection shall be carried out by the QC Manager and/or personnel as required in Quality Control (QC) and Quality Assurance (QA) Requirements Specification S6.

QA inspection shall be carried out by the QA Manager to confirm the QC results including location and performance.

The Owner shall provide facilities and labour as required to assist in conducting tests and sampling for QC and QA.