REPORT

January 31, 2014

PWGSC GIANT MINE

Paste Field Trial
Alternate Binders

Submitted to:
Public Works and Government Services Canada
(PWGSC)
Telus Tower North
5th Floor, 10025 Jasper Avenue
Edmonton, Alberta T5J 1S6

Attention: Brad Thompson

Reference Number: 1314260010-103-R-Rev0

Distribution:

1 Electronic Copy - PWGSC, Edmonton, AB

2 Hardcopies - Golder Associates Ltd.

Golder Associates

Study Limitations

This report was prepared for the exclusive use of Public Works and Government Services Canada (PWGSC) on the Giant Mine Remediation Project. The report, which specifically includes all tables, figures and appendices, is based on measurements and observations made and data and information collected during the on-site trial and laboratory studies conducted by Golder Associates Ltd. (Golder) for PWGSC. The test results are based solely on the ambient conditions of the site and laboratory at the time the measurements and tests were conducted.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

The sample(s) provided for the tests are assumed to be representative of material found at the site. The test data given herein pertains to the sample(s) provided, and may not be applicable to material from other production periods or zones. Assessment of the sample environmental conditions and possible hazards associated with the material composition is based on the results of chemical analysis of samples which are possibly from a limited number of locations. However, it is never possible, even with exhaustive sampling and testing, to dismiss the possibility that part of a site or a production line may remain undetected. The results found from the tests may not be reproducible under the field conditions.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by PWGSC, communications between Golder and PWGSC, and to any other reports prepared by Golder for PWGSC relative to the specific site described in the report, tables, drawings, figures and appendices. ***In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.***

No other party may use or rely on this report or any portion thereof without Golder's express written consent. Any use, which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, Golder should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

Table of Contents

1.0 INTRODUCTION

PWGSC has retained Golder Associates Ltd. (Golder) to carry out field trial testing at the Giant Mine site as part of the Giant Mine Remediation Project (GMRP). The field test described in this report follows an initial field trial performed in October 2013 to understand the behaviour and characteristics of the Giant Mine tailings and Normal Portland Cement (NPC) as the major constituents for the B1-18 stope backfill recipe.

The purposes of this second field trial is to assess the properties of the backfill recipe when adding alternate binder material to the mix with the purpose of reducing the amount and/or costs of normal Portland cement (NPC). The addition of alternative binders, such as cement kiln dust (KD), fly ash (FA) or blast furnace slag (BFS) could potentially have economical advantages if the backfill recipe gains the target strengths within the target timeframes with a reduced use of NPC.

Once an alternative binder has been selected, the behaviour and characteristics of the new backfill recipe has to be assessed to evaluate the following:

- Overall system performance and verification of equipment suitability;
- Process for backfilling drifts (defined as an isolated mine development tunnel which is typically rectangular shaped e.g. 3 m wide by 3 m high) using low slump cemented paste tailings delivered through boreholes i.e. amount of material and flow characteristics plus rest periods to achieve a suitable barricade;
- Suitable multiple mix designs for placement of low slump cemented paste tailings backfill barricades and high slump lightly cemented paste tailings material for bulk filling that will resist liquefaction in the event of a seismic loading; and
- Pumping performance for various backfill mix designs.

During this second field trial, no paste tailings were pumped into any underground workings. A used shipping container, called a sea can, was used to simulate the underground drifts that need to be backfilled and a closed pipeline loop was used to determine the hydraulic properties of the mix. The field trial equipment set up layout is presented in Appendix A.

The entire field trial was conducted inside the superdome structure to minimize the impact of weather conditions on the trial.

2.0 SAMPLE RECEIPT AND PREPARATION

2.1 Sample Receipt

Tailings samples used in the field trial were acquired from the tailings heated storage dome (superdome) located at the tailings pad area at Giant Mine. This material was originally excavated from the South Tailings Pond and stockpiled by contractors for its use during the backfill program for the B1-18 stope in the fall of 2013. The tailings were excavated from previously selected areas within the pond to avoid collecting material with high clay and/or silt contents. The tailings were then screened to remove any large chunks or foreign objects and were placed in the superdome for paste production.

Samples from the flow loop test (described below) were collected and shipped to the Golder Laboratory in Sudbury, ON for material characterization and further unconfined compressive strength (UCS) tests.

3.0 ON-SITE UCS TESTING

The initial step during this field trial was to perform UCS testing on a variety of paste recipes using an assortment of different binder additives including BFS, KD, and FA. The purpose of this testing was to get a base line of the strength achieved with the NPC mix recipe used in production and to assess the three proposed binder types while keeping the binder concentration and slump consistency constant. Based on the results obtained during the UCS campaign, one binder mix was selected to continue with the field trial. The UCS testing matrix is outlined in Table 1.

Table 1: UCS Trial Testing Matrix

Mix	Binder Content (%)	Binder Type	Sample	Slump	Days Curing (Number of Cylinders Required)				Total No. of Cylinders
					1	3	7	28	
1	3%	100% NPC	100% Giant Mine Tailings	7"	3	3	3	3	12
2	3%	70% NPC / 30% FA		7"	3	3	3	3	12
3	3%	70% NPC / 30% KD		7"	3	3	3	3	12
4	3%	90% BFS / 10% NPC		7"	3	3	3	3	12
5	15%	100% NPC	90% Giant Mine Tailings / 10 wt% Aggregate	7"	3	3	3	3	12
6	15%	70% NPC / 30% FA		7"	3	3	3	3	12
7	15%	70% NPC / 30% KD		7"	3	3	3	3	12
8	15%	90% BFS / 10% NPC		7"	3	3	3	3	12

Cylinders were cured at the on-site lab (Mobile Equipment Garage building) in a humid environment until they were ready to be broken. Cylinders were broken using a Sigma-1 GeoTac load frame. The load was measured using a 10,000 lb (45 kN) s-type load cell as per all other UCS test programs.

The UCS Matrix showed above was designed to provide strength values during the first few days of curing as well as strength values for long term curing. The decision on which alternate binder to choose is based on its early strength gain potential. In the quick turnaround times needed on-site during paste production it is most important to note the one and three days break results. These early strength gain goals are primarily focused on the bulk fill paste recipes i.e. 10" slump with low binder content.

The resulting strengths of the cylinders can be seen in Figures 1 and 2 and are summarized in Tables 2 and 3.

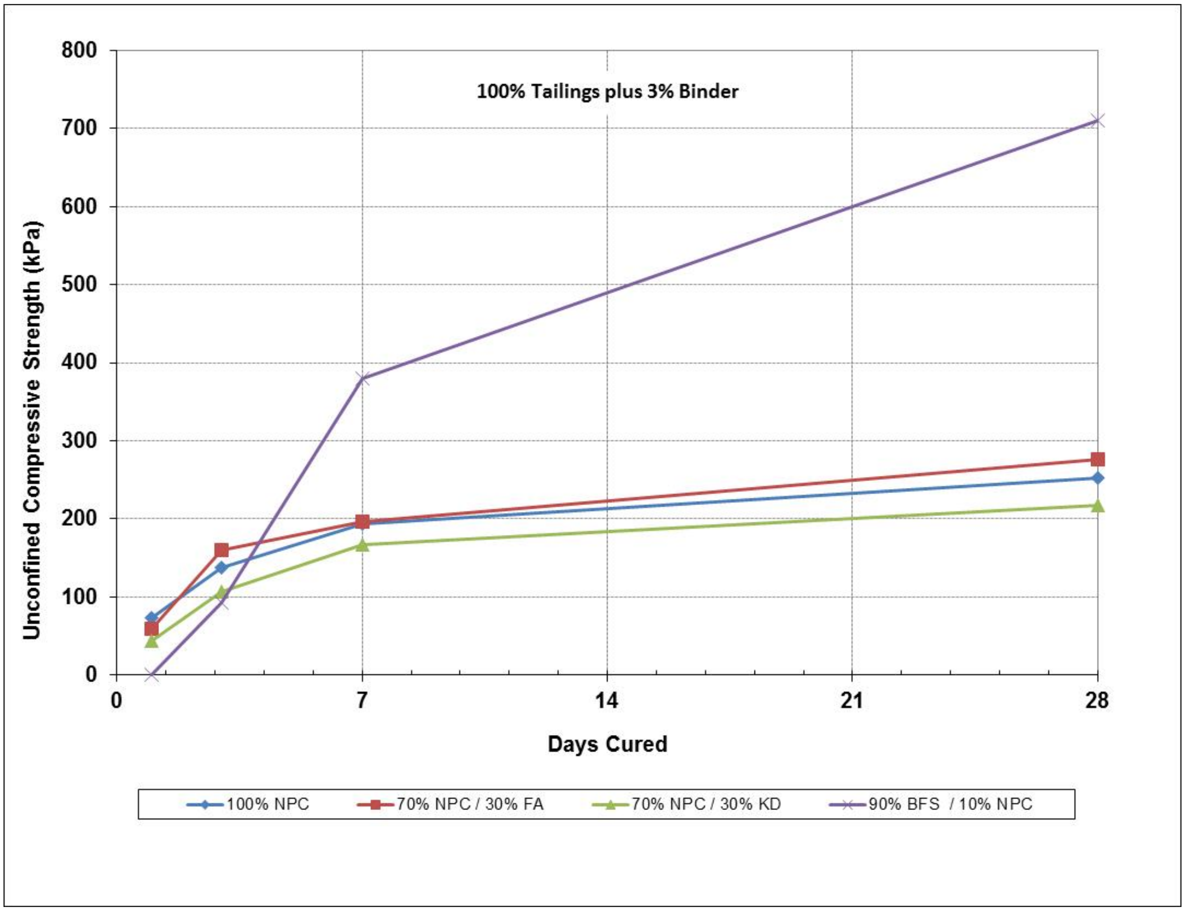


Figure 1: UCS Results- 100% Tailings plus 3% Binder, 7" Slump

Table 2: UCS Trial Testing Results – Paste Mixes with 100% Tailings

Paste Mixes with 100% tailings plus 3% binder					
Mix	**Binder**	**Average Cylinder Strength (kPa)**			
		1-Day	**3-Day**	**7-Day**	**28-Day**
1	100% NPC	73	137	194	252
2	70% NPC / 30% FA	59	161	196	276
3	70% NPC / 30% KD	44	107	167	218
4	90% BFS / 10% NPC	--	92	380	710

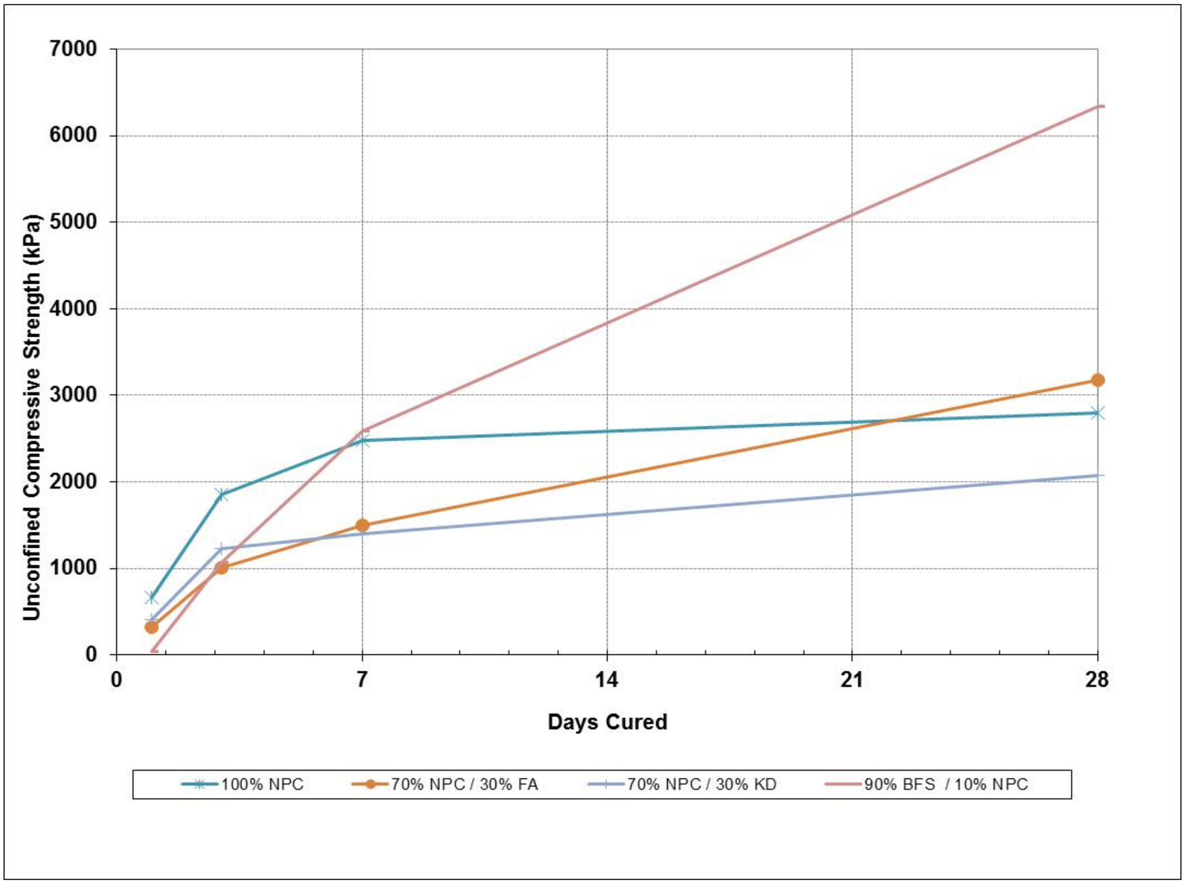


Figure 2: UCS results- 90% tailings, 10% aggregate plus 15% binder, 7" slump

Table 3: UCS Trial Testing Results – Paste Mixes with Aggregate

Paste Mixes with 90% tailings, 10% aggregate plus 15% binder					
Mix	**Binder**	**Average Cylinder Strength (kPa)**			
		1-Day	**3-Day**	**7-Day**	**28-Day**
5	100% NPC	669	1847	2472	2801
6	70% NPC / 30% FA	319	1013	1498	3171
7	70% NPC / 30% KD	407	1231	1400	2073
8	90% BFS / 10% NPC	44	1071	2586	6334

As can be seen in Figure 1 and Table 2 the highest strength during the 1- and 3-day breaks with the 100% tailings mix was obtained with the 70% NPC/30% FA binder. At the same time, the 70% NPC/30% FA with aggregate mix (Figure 2 and Table 3) at the 1-day break reached the second highest strength after KD, but much higher than BFS. As expected, the cylinders prepared with BFS provided the highest strength in the long term, but its relatively slow strength gain makes BFS not an ideal candidate for paste production. Since the vast majority of the paste pours are currently planned with 100% tailings, the selected binder mix to continue the field trial is 70% NPC/30% FA.

4.0 ON-SITE FLOW LOOP TESTING

Flow loop testing provides essential data for the design and operation of pump and pipeline distribution systems. An assessment of the data provides fluid characterization and corresponding rheological properties such as viscosity and yield stress values.

One of the two Reimer mixer trucks used during paste production (Mixer #2) was used to create paste by mixing water, tailings, aggregate, and cement in two different recipes. The paste was then pumped through a positive displacement pump to the field scale flow loop system consisting of 100 mm (4-inch) and 125 mm (5-inch) diameter steel piping. The flow loop was instrumented with a magnetic flow meter and various pressure transmitters. Instrumentation data was collected by a high-speed data acquisition system and laptop computer for data storage. For details on the field trial equipment set up and on the flow loop layout refer to Appendix A.

Flow loop testing was conducted on two paste recipes: one with 100% tailings, and the other with an additional 22% of aggregate. In order to see the effect that binder has on the behaviour of the paste material, 2% binder was added to the first paste mix (bulk fill recipe) while 15% binder was added to the second mix (barricade recipe). The binder added to these mixes was the blend selected from the UCS campaign described above, 70% NPC and 30% FA. A water reducing and cement dispersing admixture (Eucon 727) was also added to the aggregate mix to increase the curing time and ensure that the mixture did not harden in the loop. Both paste mixes targeted 5”, 7”, 8.5”, and 10” slump material.

Individual test runs were performed on each mixture to measure pipeline friction loss at several flow rates. A ‘ramp up’ and ‘ramp down’ technique was used to determine any possible changes in measured pipeline friction loss over time, which would indicate either shear thinning or thickening properties.

In general, the paste mix that showed the highest friction losses was the one containing aggregate. Both paste mixes had the tendency to increase their friction losses as its slumps were lowered.

Samples of each mixture were collected during the flow loop test and were shipped to the Golder Laboratory in Sudbury, ON. Once in the laboratory these samples were tested for pH, specific gravity, particle size distribution (PSD), and further UCS testing.

The pH of the mixture without aggregate and the mixture with aggregate, both without binder, was 8.08 and 8.17 respectively. The specific gravity of these two samples without binder was 2.83 and 2.87 respectively. The particle size D50 for the mixture without aggregate was 116 µm, the D50 of the one with aggregate was 113 µm and the D50 of the aggregate by itself was 8,299 µm.

For the mixture without aggregate, the weight percent solids varied between 79.8 - 77.0% from a 6 - 10.5” slump respectively; and for the mixture with aggregate, the weight percent solids varied between 87.1 - 81.4% from a 5 - 10” slump respectively.

The assessment of the flow loop data, material characterization, and further UCS testing on the flow loop mixes are presented in Appendix B.

4.1 Admixture Calibrations

As explained above, the addition of an admixture (Eucon 727) was required in the paste mix that included aggregate due to its high binder content. The admixture dosage required was calculated to be 100 mL of admixture/100 kg of wet paste. This dosage was calculated using vendor data as well as laboratory testing conducted in the Golder Sudbury Laboratory. The dosage was converted to a total volumetric amount by determining the amount of paste required to fill the loop using the calibrations obtained previously. The resulting volume (~2850 mL) of admixture was slowly added to the paste hopper by hand using a 500 mL volumetric beaker. However, due to high temperatures in the flow loop and a stiffening of the paste mixture an additional 5200 mL of admixture was added to the flow loop (a dosage of approximately 280 mL/100kg of wet paste) over the course of the flow loop testing.

5.0 PILE AND SEA CAN TESTING

Piles and sea can testing were performed using 5" slump paste mixture of 78% tailings, 22% aggregate plus15% of the selected binder (70% NPC/30% FA) to examine whether or not the binder has an effect on the construction and behaviour of remote paste barricades. During these tests, paste was pumped in several lifts over a number of days while slumps, mixer truck counts, lift heights and lengths, temperatures and any qualitative data were recorded.

During sea can testing paste was pumped into the top of a modified sea can in order to simulate the pouring of paste barricades in an underground drift. Several lifts were deposited and data was gathered and used to calculate the volumes, weights, and dimensions of these mock barricades. For a drawing showing the modifications and dimension of the sea can please refer to Appendix C.

Pile #1 was done by pumping paste using a boom truck at a height of approximately 3 m above the ground however because the pile was located outside and the weather conditions were approaching -50º C it was not practical to continue with the pile test so the first lift in the sea can was initiated.

During the pouring of the first lift in the sea can the paste froze inside of the boom and the pour was cut short. Due to these technical difficulties the remainder of the testing was moved inside the superdome where operating temperatures were warmer.

Due to the restricted space inside the superdome pile testing was eliminated. Instead paste was pumped into a front end loader, while the recipe was refined. Once satisfied with the recipe each lift was pumped into the sea can. A total of 6 lifts were deposited into the sea can.

When compared to the sea can tests done in October 2013, the lifts of this campaign seemed to stack up quicker and run less horizontally. The paste mix seems stickier than when using 100% NPC as binder material. For more details on the lifts and the resulting data please refer to in Appendix D.

6.0 CLOSURE

If there are any questions regarding this report, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

ORIGINAL SIGNED

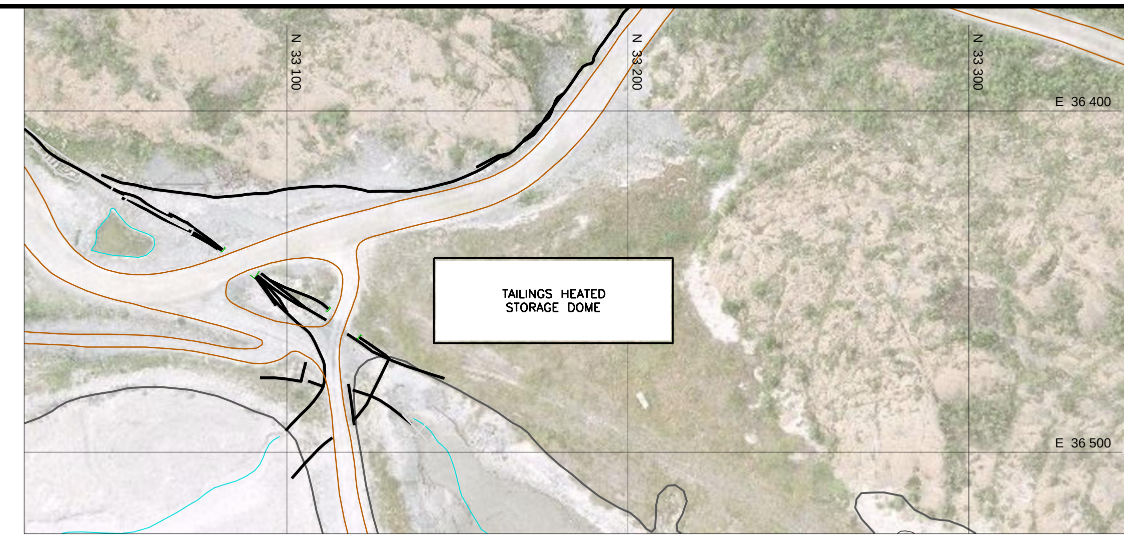
Andrés Quintero
Mechanical Specialist

Sue Longo, P.Eng.
Associate / Mechanical Engineer

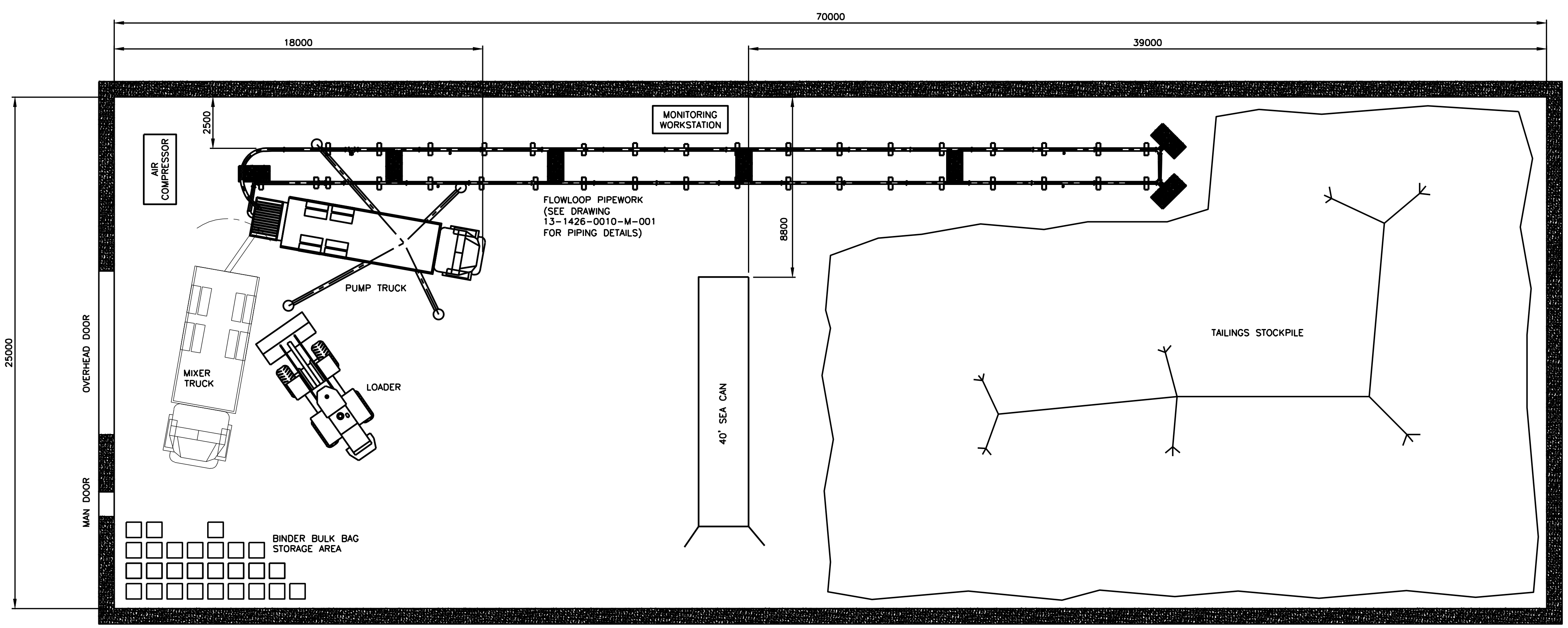
JT/TS/SL/ds/md

APPENDIX A

Field Trial Equipment Set Up Layout



KEY PLAN
LOCATION OF TAILINGS HEATED STORAGE DOME
SCALE= 1:1000



Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada
REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

Golder Associates

0m 1 2 3 4 5
1:125

Revision/	Description/Description	Date/Date
0	AS-BUILT	14-01-17

Client/client
PUBLIC WORKS GOVERNMENT SERVICES CANADA

Project title/Titre du projet
GIANT MINE REMEDIATION PROJECT YELLOWKNIFE, N.W.T.

Approved by/Approuvé par: S.L.
Designed by/Concept par: J.S.
Drawn by/Dessiné par: J.S.
PWGSC Project Manager/Administrateur de Projets TPSGC: DAVE COLBOURNE
PWGSC, Architectural and Engineering Resources Manager/ Ressources Architectural et de Directeur d'ingénierie, TPSGC
Client/client: PWGSC

Drawing title/Titre du dessin
TAILINGS HEATED STORAGE DOME
ALTERNATIVE BINDER FIELD TRIAL
GENERAL ARRANGEMENT
AS CONSTRUCTED

AS CONSTRUCTED

Project No./No. du projet	Sheet/ Feuille	Revision no./La Révision no.
13-1426-0010	1 OF 1	0

APPENDIX B

Flow Loop Data, Material Characterization, Flow Loop Samples UCS

January 31, 2014

PILOT SCALE FLOW LOOP TEST

Giant Mine Backfill Testing - Cemented Tailings

Submitted to:
Public Works and Government Services Canada
(PWGSC)
Telus Tower North
5th Floor, 10025 Jasper Avenue
Edmonton, AB T5J 1S6

Attention: Brad Thompson

REPORT

Reference Number: 1314260010-104-R-Rev0

Distribution:

1 Electronic Copy - Public Works and Government Services Canada

2 Hardcopies - Golder Associates Ltd.

Golder Associates

Study Limitations

This report was prepared for the exclusive use of Public Works and Government Services Canada (PWGSC) on the Giant Mine Project. The report, which specifically includes all tables, figures and appendices, is based on measurements and observations made and data and information collected during the on-site trial and laboratory studies conducted by Golder Associates Ltd. (Golder) for PWGSC. The test results are based solely on the ambient conditions of the site and laboratory at the time the measurements and tests were conducted.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

The sample(s) provided for the tests are assumed to be representative of material found at the site. The test data given herein pertains to the sample(s) provided, and may not be applicable to material from other production periods or zones. Assessment of the sample environmental conditions and possible hazards associated with the material composition is based on the results of chemical analysis of samples which are possibly from a limited number of locations. However, it is never possible, even with exhaustive sampling and testing, to dismiss the possibility that part of a site or a production line may remain undetected. The results found from the tests may not be reproducible under the field conditions.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by PWGSC, communications between Golder and PWGSC, and to any other reports prepared by Golder for PWGSC relative to the specific site described in the report, tables, drawings, figures and appendices. ***In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.***

No other party may use or rely on this report or any portion thereof without Golder's express written consent. Any use, which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, Golder should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Public Works and Government Services Canada (PWGSC) has retained Golder Associates Ltd. (Golder) to perform an on-site flow loop test at the Giant Mine in Yellowknife, NT. The flow loop testing results provide a basis for the design of the tailings pumping and distribution system.

Transport properties are a function of a number of parameters including tailings characteristics (mineralogy, PSD, chemical composition, slurry pH), slurry densities, volumetric flow rates, temperature, pipeline diameter, degree of shear, pipeline layout. These tests conducted at Giant Mine covered a range of consistencies typical for paste backfill, using cemented material.

The preceding flow loop test work, completed in October 2013, assessed the flow properties of uncemented material. The subject flow loop in this report utilized the same tails, aggregate/tails material mixtures along with added binder to determine the resultant transport properties of the cemented mix.

2.0 SCOPE OF SERVICES

Golder's scope of services included the following.

- On-site flow loop testing:
  - providing instrumentation;
  - monitoring and recording of data; and
  - analysing and reporting of data.
- Bench scale lab testing:
  - material testing; and
  - analysing and reporting of data.

3.0 FLOW LOOP TESTING

3.1 Flow Loop Setup

An instrumented flow loop was constructed by LPR Concrete, RTL Construction, and Golder personnel to determine the transport characteristics of high solids content paste backfill. The loop was a closed circuit pipeline powered by a diesel engine piston pump, specifically a Concord CCP-40X-170 boom truck pump. The pump was capable of delivering up to 170 m^3/hour.

Industrial, high accuracy flush mount pressure transmitters (Endress+Hauser PMC71), provided by Golder, designed for up to 41 bar (600 PSI) were installed in predetermined sections of straight pipe. Pressure data was recorded and the pressure differential between the units was calculated to determine unit pressure gradients. The unit pressure gradients are related to material density, flow velocities and pipeline diameters.

Observations photos are presented in Appendix A.

A magnetic flow meter (Endress Hauser Model Promag 55S) was also provided by Golder for the flow loop test. During the commissioning of the flow loop, using water, the flow meter was used to determine the delivery volume per stroke of the positive displacement pump. As a supplemental check, the efficiency of the pump was also estimated using the number of strokes required to fill the flow loop, a known volume. This was found to be 81.2% which was the result of 14strokes required to fill the 0.992 m^3 loop.

3.2 Test Mixes

Testing was conducted on December 14, 2013 (Day 1) for the cemented tailings paste sample and December 15, 2013 (Day 2) for the cemented tailings and aggregate paste sample.

The tailings from the South Pond that had been stockpiled in the heated dome were transferred into a Reimer mixer truck and the moisture content adjusted to a measureable slump of approximately 5" (125 mm). The material initially used to fill the flow loop on Day 1 and Day 2 had a measured slump of 6" (152 mm) and 5" (125 mm) respectively. A sample of the tailings was collected to determine the moisture content of the starting material. Samples were also collected to determine the moisture content for each of the pulp densities for which flow loop data was collected.

Several paste backfill mixes were prepared from tailings stockpiled and stored onsite next to the flow loop in the South tailings pond storage dome. Table 1 presents the details for each mix tested.

Table 1: Flow Loop Mix Details

Day	Slump (mm)	Material	Binder	Solids Content (%)
1	152 (6")	100% South Pond Tailings	2% (70%NPC/ 30%FA)	81.2
	178 (7")			79.9
	210 (8.25")			78.4
	267 (10.5")			76.9
2	125 (5")	78% South Pond Tailings / 22% Aggregate	15% (70%NPC/ 30%FA)	87.1
	152 (6")			85.3
	203 (8")			84.3
	254 (10")			81.4

Notes: NPC = Normal Portland Cement
FA = Fly Ash

Moisture determinations during the flow loop were completed by Golder's on-site laboratory personnel. Each mix was pumped at variable rates from approximately 20% of maximum flow up to the maximum flow rates possible with the supplied pump. Targeted minimum flow velocity through the Diameter Nominal (DN) 125 mm (National Pipe Size (NPS) (5")) pipe was around 0.5 m/sec to minimize the potential for sliding bed to occur.

3.3 Material Properties

Samples collected during the flow loop test were tested for pH, specific gravity and particle size distribution. Results are presented in Tables 2 to 4 and on Figures 1 to 3.

3.3.1 pH of Samples

Table 2: pH of Samples Received

Sample	pH
13-1426-0010 South Pond Tailings	8.08
13-1426-0010 South Pond Tailings + Aggregate	8.17

3.3.2 Specific Gravity

The specific gravity (SG) of the sample was determined using vacuum de-aired water. Each slurry sample was also vacuum de-aired prior to SG measurement.

Table 3: Specific Gravity Results

Sample	Average
13-1426-0010 South Pond Tailings	2.83
13-1426-0010 South Pond Tailings + Aggregate	2.87

3.3.3 Particle Size Distribution

The particle size distribution (PSD), Specific D-values (% passing a sieve opening). The PSD of the samples were similar to the sample(s) as tested in our Sudbury laboratory in previous phases.

Table 4: Particle Size Distribution

Sample	D10	D30	D50	D60	D80
	(µm)				
13-1426-0010 Aggregate	3438	6281	8299	9308	11936
13-1426-0010 South Pond Tailings	7	45	116	130	188
13-1426-0010 South Pond Tailings + Aggregate	7	41	113	143	561

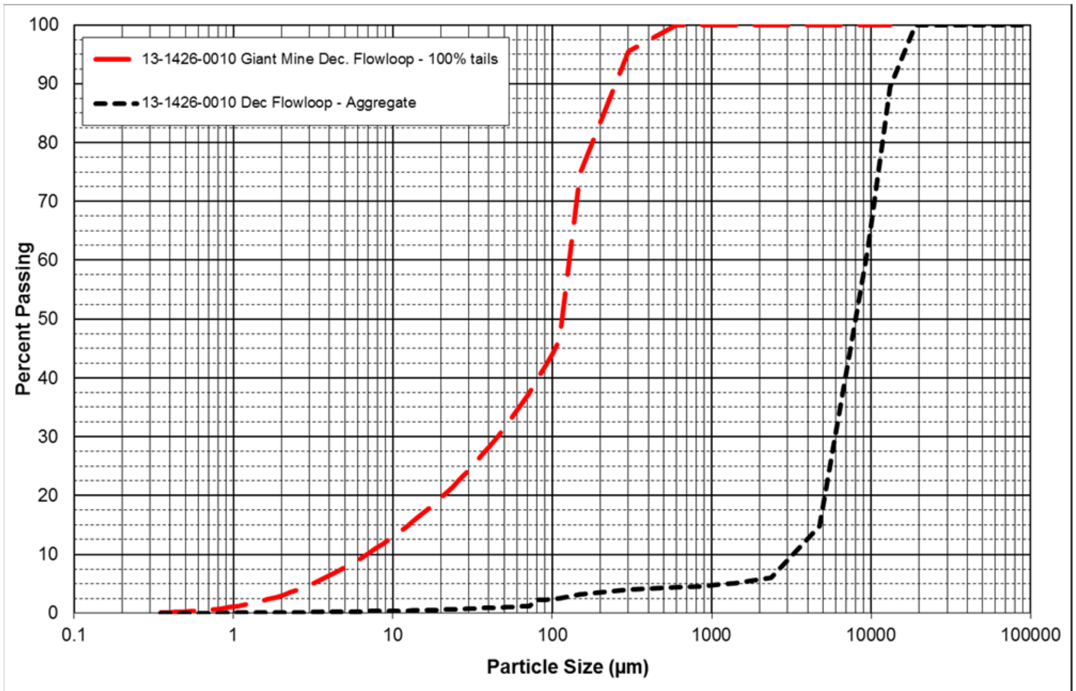


Figure 1: Particle size distribution

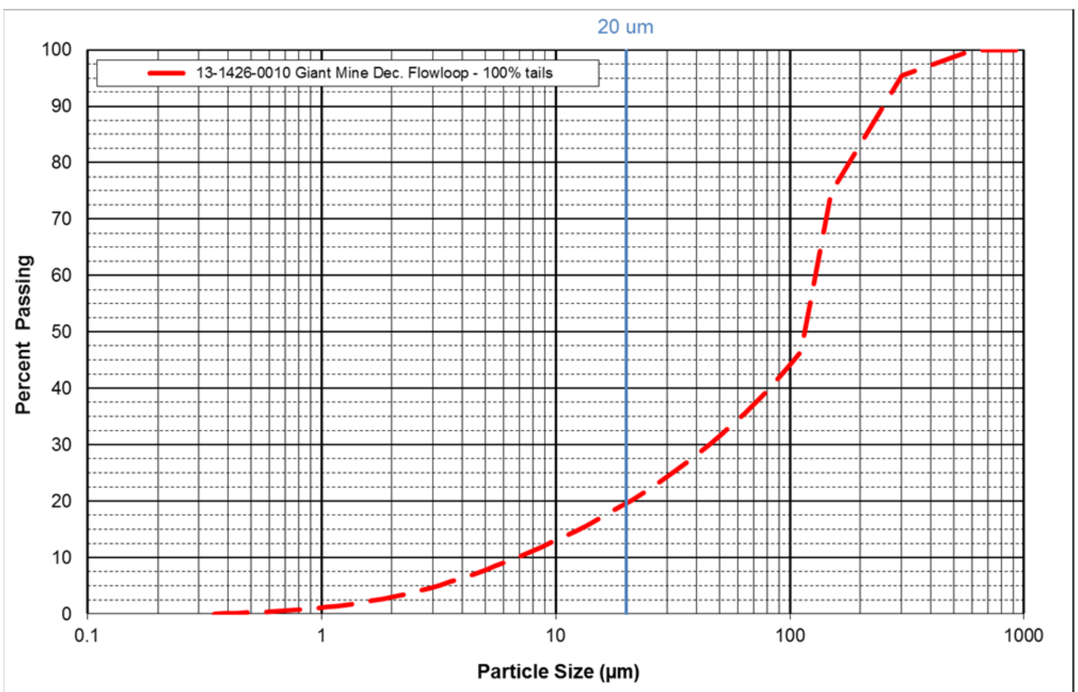


Figure 2: Particle size distribution – South Pond tailings flow loop

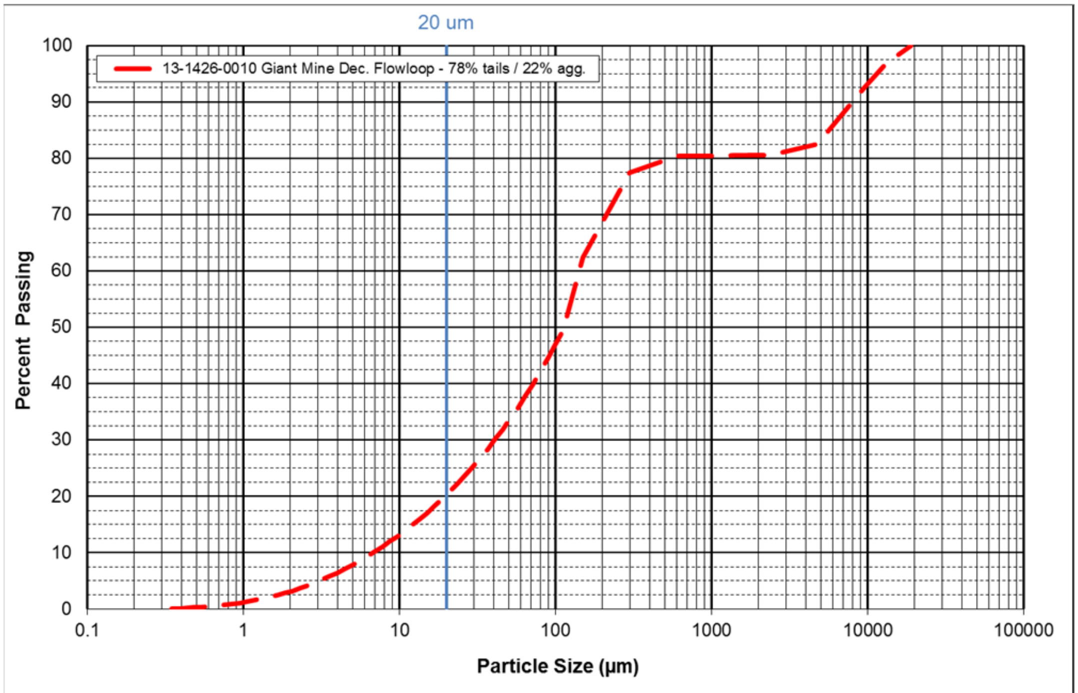


Figure 3: Particle size distribution – South Pond tailings + aggregate flow loop

3.4 Flow Loop Test Results

3.4.1 70%NPC / 30%FA Cemented Paste

Flow loop testing of the cemented paste samples occurred on Day 1 of the flow loop test. The Reimer mixer truck was loaded using an excavator. Once the material was prepared to the target slump, it was discharged via a chute to the concrete pump.

The system was first charged with the thickest material, 152 mm (6") slump, and progressively diluted until 267 mm (10.5") slump was achieved. At the above slumps and each additional interval outlined in Table 1, full data sets were recorded consisting of pressure loss recordings at varying flow rates. To understand possible changes in flow properties (shear sensitivity) from the beginning to end of each run, pressure losses for the ramp up and ramp down were measured.

The results are presented in Table 5 and on Figures 4 to 7.

Table 5: 70%NPC / 30%FA Cemented Paste Pressure Losses

Slump	DN 125 mm (NPS 5") Pipe		DN 100 mm (NPS 4") Pipe	
	Range of Flow Velocities and Rates	Range of Pressure Losses (kPa/m)	Range of Flow Velocities and Rates	Range of Pressure Losses (kPa/m)
152 mm (6")	0.3 – 1.7 m/s	6 - 25	0.5 – 2.4 m/s	14 - 46
	13 – 73 m^3/hr		13 – 73 m^3/hr	
178 mm (7")	0.5 – 1.9 m/s	8 - 20	0.7- – 2.6- m/s	15 - 35
	22 – 79 m^3/hr		22 - 79 m^3/hr	
210 mm (8.25")	0.5 – 1.7 m/s	7 - 14	0.7 – 2.4 m/s	12 - 23
	20 – 73 m^3/hr		20 – 73 m^3/hr	
267 mm (10.5")	0.6 – 1.9 m/s	5 - 7	0.9 – 2.7 m/s	7 - 11
	26 – 81 m^3/hr		26 – 81 m^3/hr	

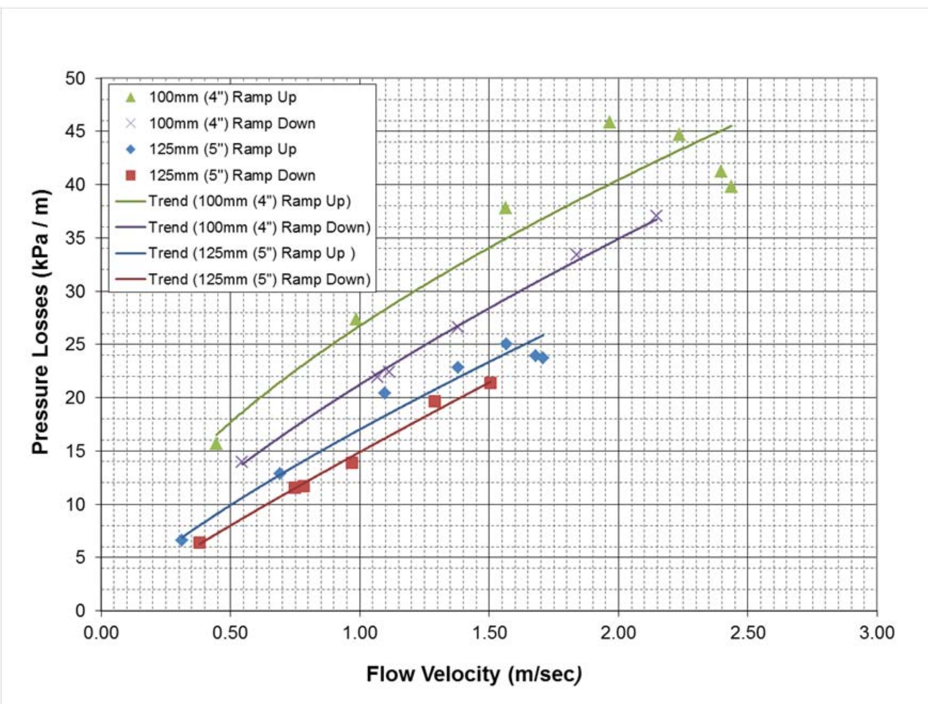


Figure 4: 152 mm (6") slump – 81.2wt% solids, pressure losses vs. flow velocities

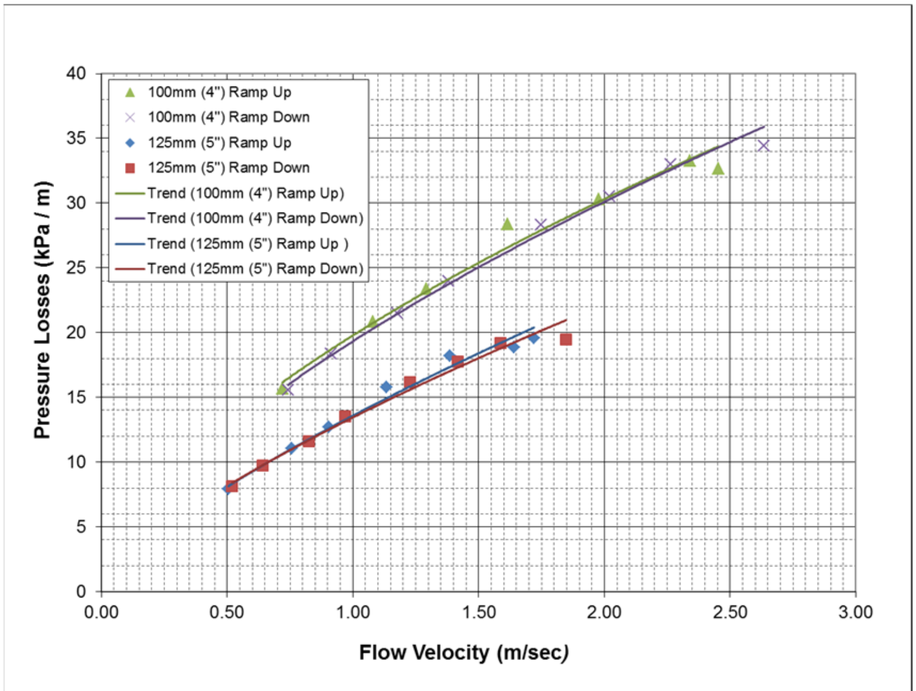


Figure 5: 178 mm (7") slump - 79.9 wt% solids, pressure losses vs. flow velocities

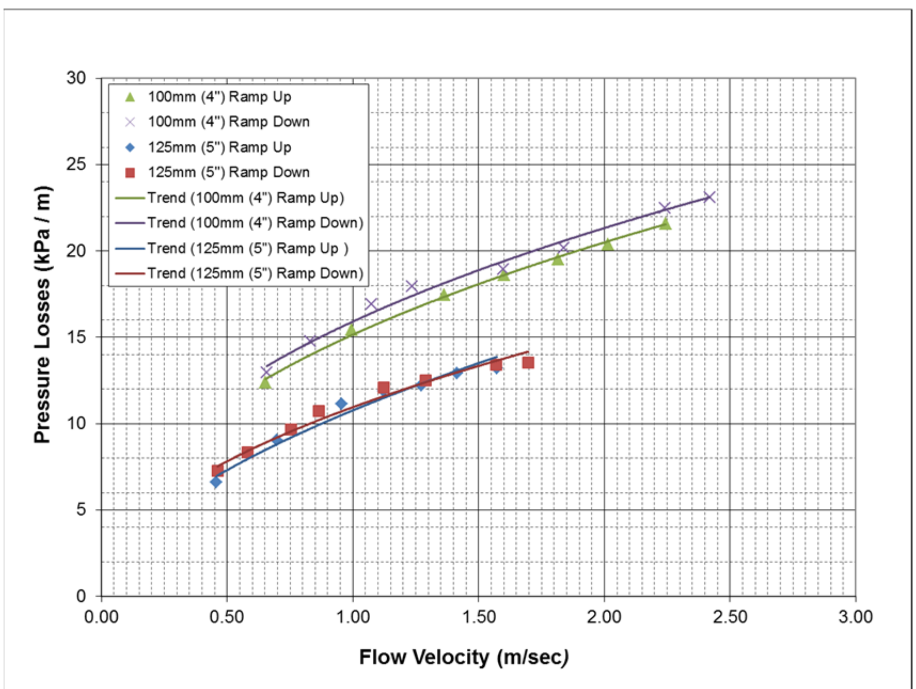


Figure 6: 210 mm (8.25") slump - 78.4 wt% solids, pressure losses vs. flow velocities

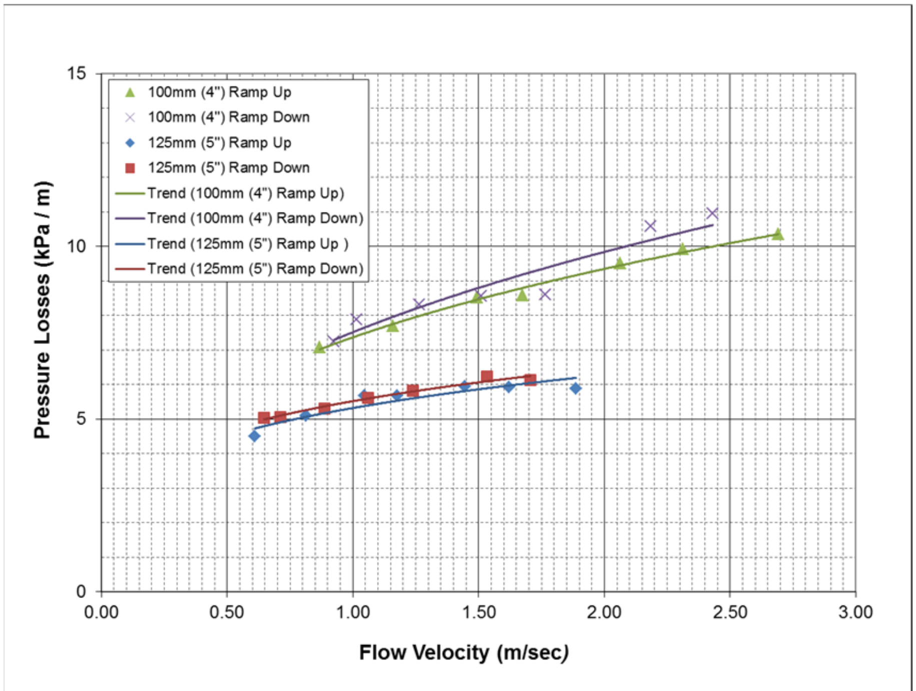


Figure 7: 267 mm (10.5") slump – 76.9 wt% solids, pressure losses vs. flow velocities

3.4.2 70%NPC / 30%FA Cemented Paste + Aggregate

Flow loop testing of the cemented paste and aggregate samples occurred on Day 2 of the flow loop test. A blend of 78 wt% South Pond Tailings and 22 wt% aggregate was prepared using the Reimer mixer truck and added slowly to the pump hopper as the paste circulated through the system. An additive (Eucon 727, mfn. Euclid Chemical Company) was employed to retard the set time of the binder within the loop. Because flow loop material is recycled (re-run through the loop) for an extended period of time, the additive is a must to ensure that the exothermic chemical process of the binder does not play a role in the pressure loss data during the loop trials. A total of 8,050 mL of chemical retardant was added to the mix during the course of the test trials on Day 2.

As with the previous cemented tailings testing, pressure losses for flow rate ramp up and ramp down were measured. The results are presented in Table 6 and on Figures 8 to 11.

Table 6: 70%NPC / 30%FA Cemented 22% Aggregate Paste Pressure Losses

Slump	ND 125 mm (NPS 5") Pipe		ND 100 mm (NPS 4") Pipe	
	Range of Flow Velocities and Rates	Range of Pressure Losses (kPa/m)	Range of Flow Velocities and Rates	Range of Pressure Losses (kPa/m)
125 mm (5")	0.6 – 1.3 m/s 23 - 54 m^3/hr	21 - 36	0.8 – 1.8- m/s 23 - 54 m^3/hr	37 - 56
152 mm (6")	0.6 – 1.3- m/s 23 – 56 m^3/hr	16 - 38	0.8 – 1.9 m/s 23 - 56 m^3/hr	24 - 51
203 mm (8")	0.4 – 1.8- m/s 19 - 77 m^3/hr	14 - 25	0.6- – 2.6 m/s 19 - 77 m^3/hr	–19-31
254 mm (10")	0.4- – 2.0 m/s 18 – 85 m^3/hr	11 - 18	0.6 – 2.8 m/s 18 – 85 m^3/hr	15 - 24

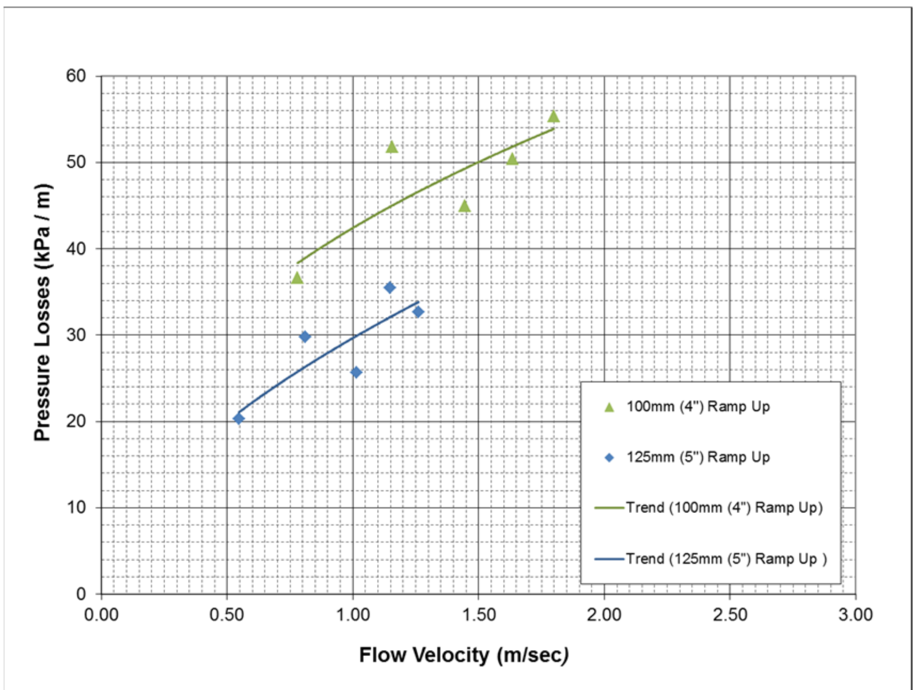


Figure 8: 125 mm (5") slump with aggregate – 87.1 wt% solids, pressure losses vs. flow velocities

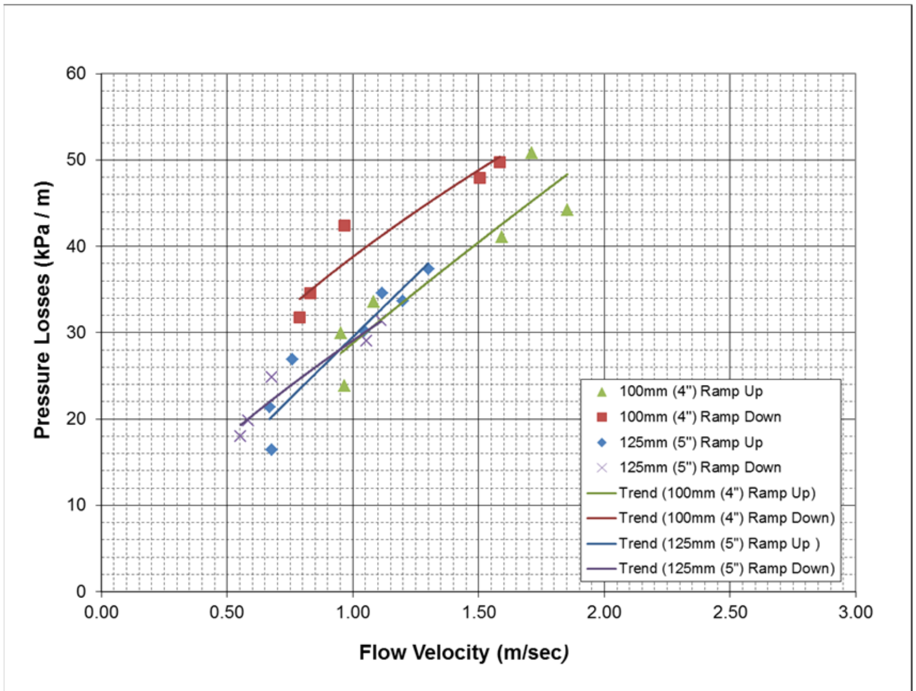


Figure 9: 152 mm (6") slump with aggregate – 85.3 wt% solids, pressure losses vs. flow velocities

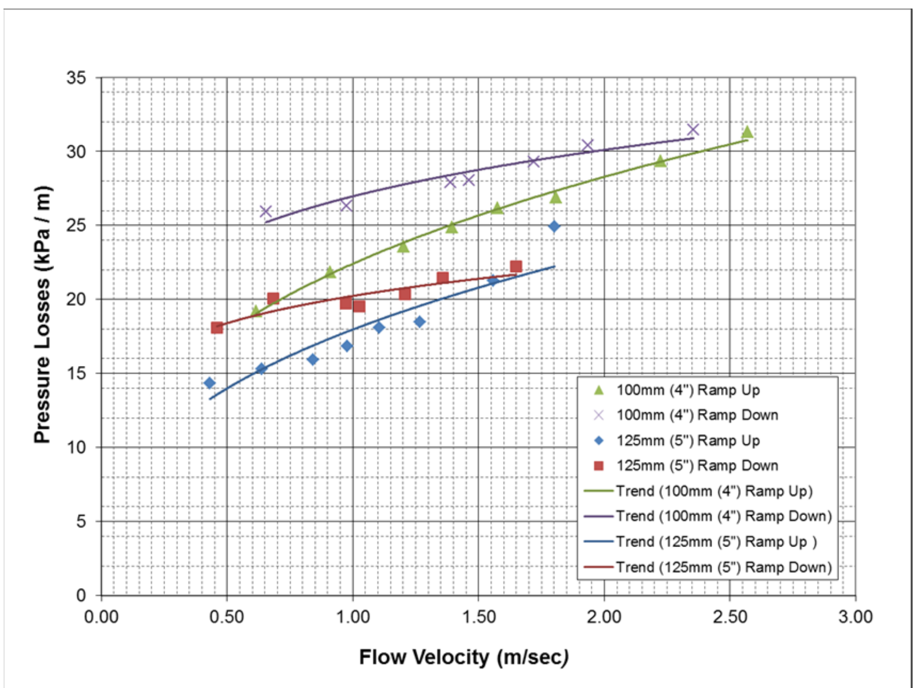


Figure 10: 203 mm (8") slump with aggregate – 84.3 wt% solids, pressure losses vs. flow velocities

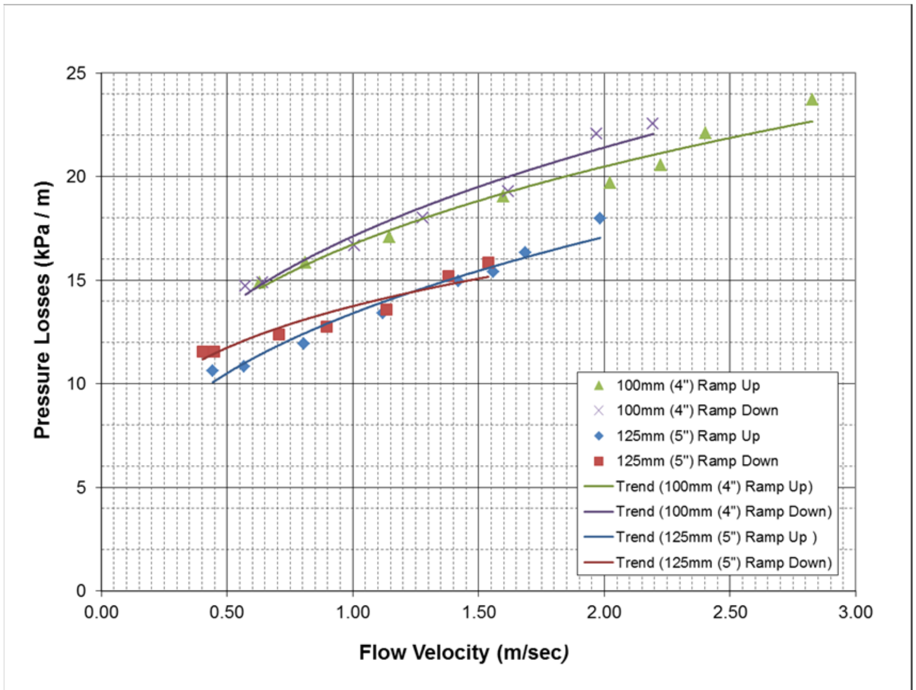


Figure 11: 254 mm (10") slump with aggregate – 81.4wt% solids, pressure losses vs. flow velocities

3.4.3 Unconfined Compressive Strength Testing

Unconfined compressive strength (UCS) testing was carried out using a Sigma 1 GeoTac digital load frame. The load was measured using s-type load cells. Depending on strength, either a 10 kN or 45 kN (2,000 lb or 10,000 lb) load cell was utilized.

The cured cylinder was placed between two platens and during testing the bottom platen advanced at a rate of 2 mm (0.08 inch) per minute. The load was continuously monitored and the peak load was automatically recorded by the instrument.

The UCS program was carried out to assess the backfill strength using 76 x 152 mm (3'' x 6'') cylinders. The cylinders were cured in a humid environment maintained at 15 to 30°C. Three cylinders per curing period were cast and the results were averaged. The results are presented in Tables 7 and 8.

Table 7: 70%NPC / 30%FA 2% Binder UCS Results

Time of Casting	Slump	Average UCS (kPa)				Average Bulk Density (kg/m^3)
		Curing 1 day	Curing 3 days	Curing 7 days	Curing 28 days	
Dec 14-13	7" (178 mm)	112	226	264	315	2201
Dec 14-13	10.5" (267 mm)	44	N/A	62	103	2145

Table 8: 70%NPC / 30%FA 15% Binder 22% Aggregate UCS Results

Time of Casting	Slump	Average UCS (kPa)				Average Bulk Density (kg/m^3)
		Curing 1 day	Curing 3 days	Curing 7 days	Curing 28 days	
Dec 15-13	8" (203 mm)	N/A	N/A	N/A	4001	2283
Dec 15-13	10" (254 mm)	N/A	N/A	N/A	3160	2401

** 8" slump Avg. bulk density omitting 3 day cylinder mass
** 10" slump Avg. bulk density omitting 7 day cylinder mass

4.0 CLOSURE

If there are any questions regarding this report, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Mark Labelle
Process Laboratory Manager

ORIGINAL SIGNED

Sue Longo, P.Eng.
Associate / Mechanical Engineer

ML/SL/ds/md

APPENDIX A

Observation Photos

Client : PWGSC Giant Mine	**Project Number : 13-1426-0010**
Site Name : South Pond Tailings Dome (Day 1)	

Photograph 1

December 14-15 flowloop layout.

Photograph 2

Concord CCP-40X-170 pump truck pump cylinder spectacle plate. Pre-check to verify plate's smoothness and effective efficiency of pumping unit.

Golder Associates

Client : PWGSC Giant Mine	Project Number : 13-1426-0010
Site Name : South Pond Tailings Dome (Day 1)	

Photograph 3

Concord CCP-40X-170 pump truck pump cylinder spectacle plate and swing tube. Pre-check to verify gap size between tube and cylinder affecting pumping efficiency.

Photograph 4

Initial leak test of flow loop piping with water. Several joints requiring re-taping to eliminate leakage.

Client : PWGSC Giant Mine	Project Number : 13-1426-0010
Site Name : South Pond Tailings Dome (Day 1)	

Photograph 5 December 14-15 flowloop feed line, return line and stand pipe setup.	
Photograph 6 December 14-15 flowloop pressure transducer #2 (left) and #3 (right).	

Client : PWGSC Giant Mine	**Project Number : 13-1426-0010**
Site Name : South Pond Tailings Dome (Day 1)	

Photograph 7

Pressure transducer #3 as installed (December 14)

Photograph 8

December 14-15 flowloop DAQ set-up.

Client : PWGSC Giant Mine	Project Number : 13-1426-0010
Site Name : South Pond Tailings Dome (Day 1)	

Photograph 9	
Sample flowloop slump test (152 mm, 6”). Flowloop #1 Day 1	
Photograph 10	
Sample flowloop slump test (152 mm, 10.5”). Flowloop #4 Day 1	

Client : PWGSC Giant Mine | **Project Number : 13-1426-0010**

Site Name : South Pond Tailings Dome (Day 2)

Photograph 11

Loader transporting tailings from stockpile to Reimer mixer truck.

Photograph 12

Post-calibration mix sample prepared in raised screw feeder chute and discharged through bottom to 5 gal. sample pails.

Golder Associates

Client : PWGSC Giant Mine	Project Number : 13-1426-0010
Site Name : South Pond Tailings Dome (Day 2)	

Photograph 13	
Sample pail collected, labelled and shipped to Sudbury lab for further testwork.	
Photograph 14	
Initial feed of material into pump truck hopper.	

Client : PWGSC Giant Mine	**Project Number : 13-1426-0010**
Site Name : South Pond Tailings Dome (Day 2)	

Photograph 15

Initial feed of fairly thick material into pump truck hopper to achieve starting slump of 5" (125 mm)

Photograph 16

Return line into hopper. Used as a sample point.

Client : PWGSC Giant Mine	**Project Number : 13-1426-0010**
Site Name : South Pond Tailings Dome (Day 2)	

Photograph 17

Euchlid's Eucon 727 add-mix binder retardant used to prolong the set-up period of binder in high cement applications.

Photograph 18

Addition of add-mix into hopper (600ml beaker).

Golder Associates

Client : PWGSC Giant Mine	Project Number : 13-1426-0010
Site Name : South Pond Tailings Dome (Day 2)	

Photograph 19

Sample flowloop slump test (125 mm, 5”).

Flowloop #1 Day 2

Photograph 20

Sample flowloop slump test (152 mm, 6”).

Flowloop #2 Day 2

Client : PWGSC Giant Mine	Project Number : 13-1426-0010
Site Name : South Pond Tailings Dome (Day 2)	

Photograph 21	
Sample flowloop slump test (204 mm, 8”). Flowloop #3 Day 2	
Photograph 22	
Sample flowloop slump test (254 mm, 10.5”). Flowloop #4 Day 2	

END OF DOCUMENT

Golder Associates

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

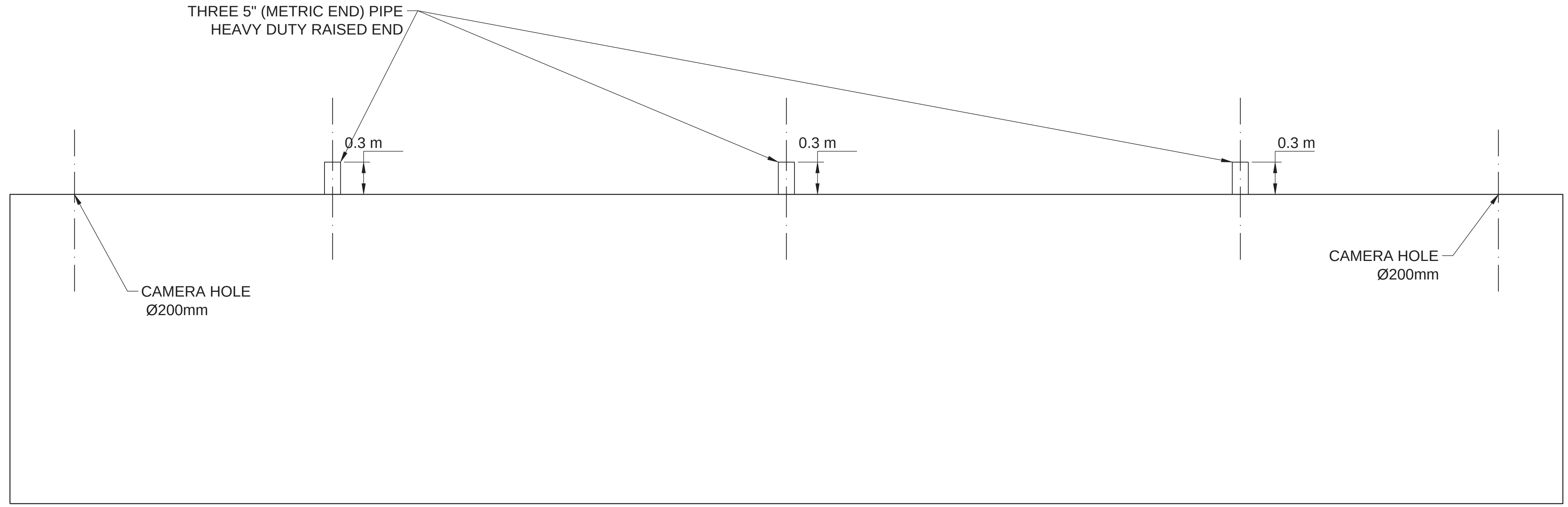
Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

Golder Associates

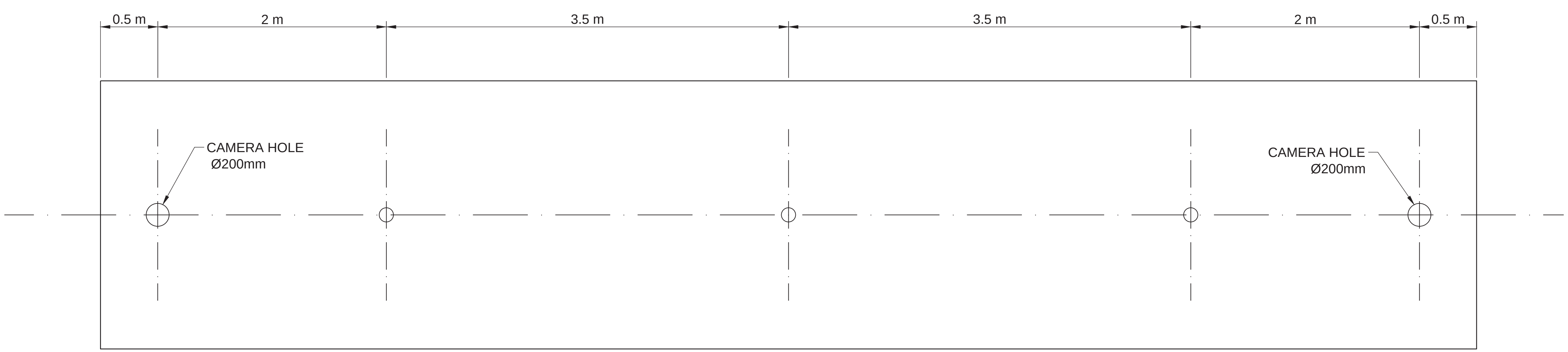
APPENDIX C

Pile and Sea Can Testing

APPENDIX C



SEA CAN - SECTION VIEW
SEE SCALE A



SEA CAN - TOP VIEW
SEE SCALE A

AS CONSTRUCTED

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

Golder Associates

Revision/Revision	Description/Description	Date/Date
A	ISSUED FOR REVIEW	2013-10-03

Client/client
PUBLIC WORKS GOVERNMENT SERVICES CANADA

Project title/Titre du projet
GIANT MINE
REMEDIATION PROJECT
YELLOWKNIFE, N.W.T.

UNDERGROUND

Approved by/Approuve par: SL
Designed by/Concept par: AQ
Drawn by/Dessine par: TAK
PWGSC Project Manager/Administrateur de Projets TPSGC: DAVE COLBOURNE
PWGSC, Architectural and Engineering Resources Manager/Ressources Architectural et de Directeur d'ingénierie, TPSGC
Client/client: PWGSC

Drawing title/Titre du dessin
PASTE FIELD TRIAL
SEA CAN MODIFICATIONS

Project No./No. du projet: 13-1426-0010
Sheet/Feuille: 1 OF -
Revision no./La Révision no.: A

CADD FILE LOCN: P:\2013\13-1426-0010 PWGSC GIANT MINE - GAL BURNABY\MECHANICAL\13-1426-0010-FG-0041 SEA CAN MODIFICATION.DWG

PWGSC - A1 - 841X594

sea can modifications

APPENDIX D

Pile and Sea Can Testing Summary Sheet

Project No.	13-1426-0010
Date:	17-Dec-13
Revision Number:	A

PGWSC
GIANT MINE REMEDIATION PROJECT
PASTE FIELD TRIAL - ALTERNATE BINDER
PILE AND SEA CAN TESTING - SUMMARY SHEET

Golder Associates

Lift Number	Pour Date	Pour Time (min)	Slump (in)	Moisture Content (wt%)	Paste Specific Gravity	Weight of Tailings (kg)	Average Length of Lift (m)	Height of Paste Stack (m)	Volume of Paste Pumped (m^3)	Notes
Pile Test (78% Tailings, 22% Aggregate plus 15% Binder)										
Lift 1	11-Dec	20.00	3.75"/5"	80.29%	2.15	2145	3.66	0.36	1.00	Conical, fairly consistent paste, slump tightened during pour
Sea Can Test (78% Tailings, 22% Aggregate plus 15% Binder)										
Lift 1	11-Dec	3.00	3.75"/5"	80.29%	2.15	410	1.80	0.29	0.19	Conical lift, pour cut short due to blockage in pump, lift did not reach walls of sea can. Slump assumed to be the same as pile #2 values
Lift 2	16-Dec	10.06	3"/4.75"	80.51%	2.16	2772	4.50	0.41	1.28	Pour has reached walls of sea can, paste has deposited more on left side of sea can, paste is squishy and sticky, but firm when dimensions were measured
Lift 3	16-Dec	11.80	4.75"/5.75"	79.84%	2.14	2657	5.54	0.59	1.24	Lift fairly symmetrical, paste sticky and wet when dimensions measured
Lift 4	16-Dec	10.15	4"/8"	79.50%	2.13	3533	8.81	0.61	1.66	Paste firm but sticky, FA blend seems sticky and oozes, does not flow, doesn't develop same footprints as NPC
Lift 5	17-Dec	14.38	4.25"/5.5"	80.06%	2.14	2880	6.49	0.9	1.34	Paste very soft, squishy, and wet, toe of lift does not reach toe of last lift
Lift 6	17-Dec	11.62	5.5"/5.5"	79.73%	2.13	2657	unknown	1.09	1.24	

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861