

March 04, 2013

Project No. 12-1111-0089

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**SURVEY OF POTENTIAL SOURCES OF CLAY LINER MATERIAL  
FOLLOW-UP LABORATORY TESTING FOR HYDRAULIC CONDUCTIVITY  
PORT HOPE AND PORT GRANBY PROJECTS**

Dear Gary,

This letter presents the results of laboratory hydraulic conductivity tests on composite clayey soil samples from three private borrow pits identified by Golder as potential sources of clay liner material for the Port Hope and Port Granby Projects. The pits are referred to as Westone (Omemee), McGee (Campbellford) and Young (Omemee). A preliminary test pit investigation, including geotechnical laboratory testing for grain size distribution and plasticity, was carried out by Golder for each borrow pit in the Fall of 2012. The results were presented in our draft letter dated December 20, 2012. The hydraulic conductivity testing was performed on clayey soil material collected from the preliminary investigation as a means of further assessing the likelihood that the material is suitable for constructing a soil liner having a hydraulic conductivity  $\leq 1 \times 10^{-7}$  cm/s.

**COMPOSITE SAMPLE PREPARATION**

Table A.1 (Appendix A) lists the individual samples that were collected from test pits at the three borrow pits, together with the results of grain size distribution and plasticity tests. The hydraulic conductivity testing was performed on a composite sample for each borrow pit, prepared by combining what was left of the individual samples listed in Table A.1. Each composite sample was then screened to remove gravel particles larger than 9.5 mm (3/8 inch). This is a normal requirement for laboratory hydraulic conductivity testing, due to the small diameter of the test specimen (i.e., 70 mm diameter). Grain size distribution curves obtained for the composite samples after removal of gravel particles larger than 9.5 mm are presented in Figures 1 to 3 and are summarized in Table 1. Also shown in Table 1 are the results of plasticity and Standard Proctor tests.

**HYDRAULIC CONDUCTIVITY TESTING**

The composite samples were compacted in a 100 mm diameter Standard Proctor mould at Standard Proctor effort with a water content 1% to 2% above the optimum water content. The compacted sample was then



extracted from the mould and trimmed to 70 mm diameter for testing in a flexible wall permeameter according to ASTM Method D 5084 (constant head). The effective confining stress was 150 kPa and the hydraulic gradient was 20.

The results of the hydraulic conductivity tests are presented in Appendix B and are summarized below:

<b><u>Composite Sample</u></b>	<b><u>Hydraulic Conductivity (cm/s)</u></b>
McGee (Campbellford)	$3 \times 10^{-8}$
Young (Omemece)	$3 \times 10^{-8}$
Westone (Omemece)	$4 \times 10^{-8}$

All three composite samples gave hydraulic conductivity values meeting the design criteria of  $\leq 1 \times 10^{-7}$  cm/s. Therefore, the laboratory testing, albeit on a limited number of samples, supports that the clayey material from these borrow pits is suitable for achieving the design hydraulic conductivity.

As recommended in our previous letter, the results of our preliminary testing should be included in the tender documents for the Port Hope and Port Granby Projects as background reference information. The Contractor should develop and complete detailed investigations, testing and test pads to confirm their proposed liner material source and method of liner construction.

Yours truly,

**GOLDER ASSOCIATES LTD.**

Frank Barone, Ph.D., P. Eng.  
Principal  
FSB/jl

Attachments:

Attachment A – List of Test Pit Samples and Laboratory Testing Results

Attachment B - Hydraulic Conductivity Test Results

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**TABLE 1 – CHARACTERISTICS OF COMPOSITE  
 SAMPLES TESTED FOR HYDRAULIC  
 CONDUCTIVITY**

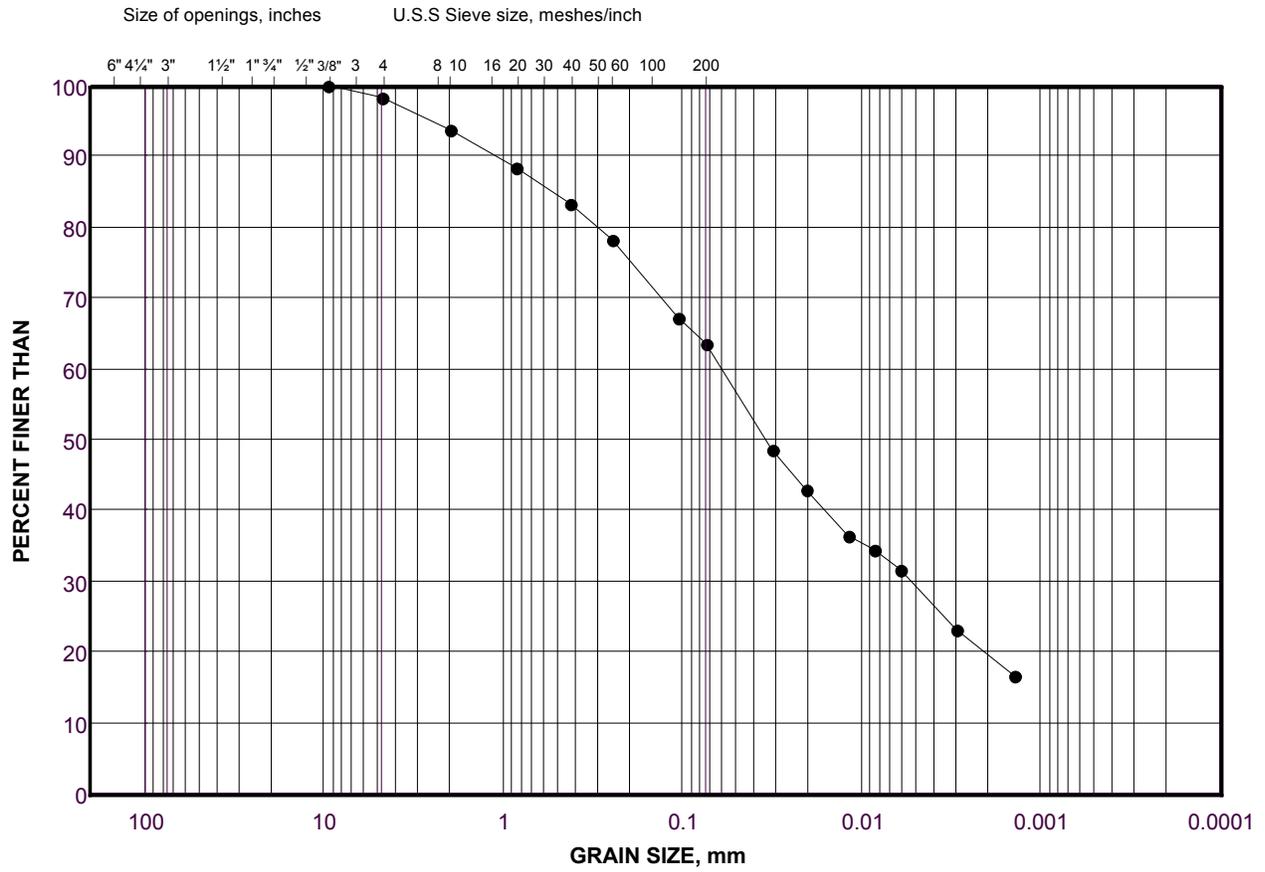
Composite Sample	Grain Size Distribution (%)				Atterberg Limits (%)			Optimum* Water Content (%)	Maximum* Dry Density (Mg/m <sup>3</sup> )
	Gravel (> 4.75 mm)	Sand (0.075 mm – 4.75 mm)	Fines (<0.075 mm)	Clay (<0.002 mm)	PL	LL	PI		
McGee (Campbellford)	1	36	63	19	12.2	19.0	6.8	11.2	1.996
Young (Omeme)	0	12	88	24	15.2	28.3	13.1	17.2	1.812
Westone (Omeme)	7	41	52	15	12.2	19.9	7.7	10.0	2.044

PL = Plastic Limit  
 LL = Liquid Limit  
 PI = Plasticity Index

\* Approximate values based on preliminary (3 to 4 point) Standard Proctor test with a small 100 mm diameter mould.

# GRAIN SIZE DISTRIBUTION

# FIGURE 1



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			

## LEGEND

SYMBOL	SAMPLE
●	Bag 1 McGee (Campbellford)

Project Number: 12-1111-0089

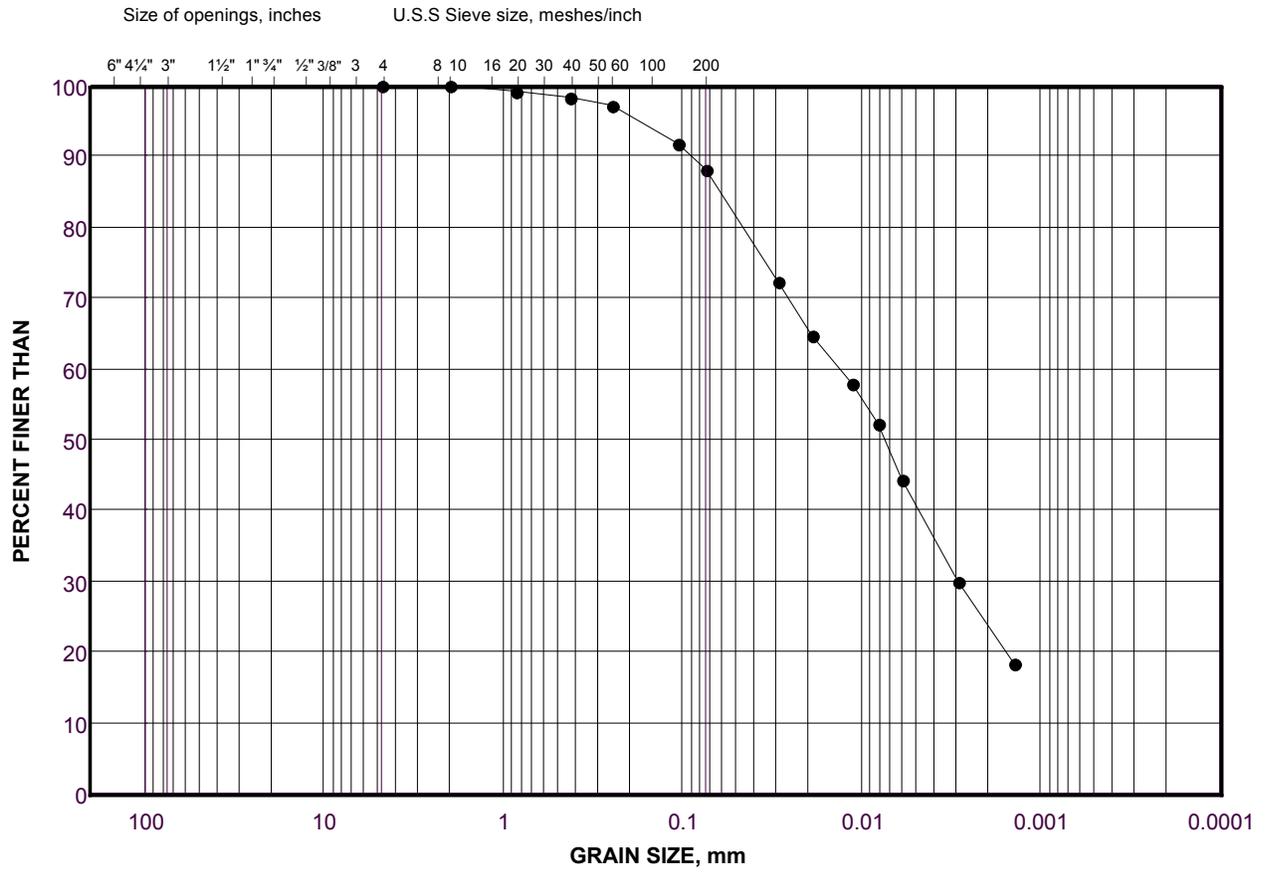
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**Golder Associates**

Date: 01-Mar-13

# GRAIN SIZE DISTRIBUTION

# FIGURE 2



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			

## LEGEND

SYMBOL	SAMPLE
●	Bag 2 Young (Omeme)

Project Number: 12-1111-0089

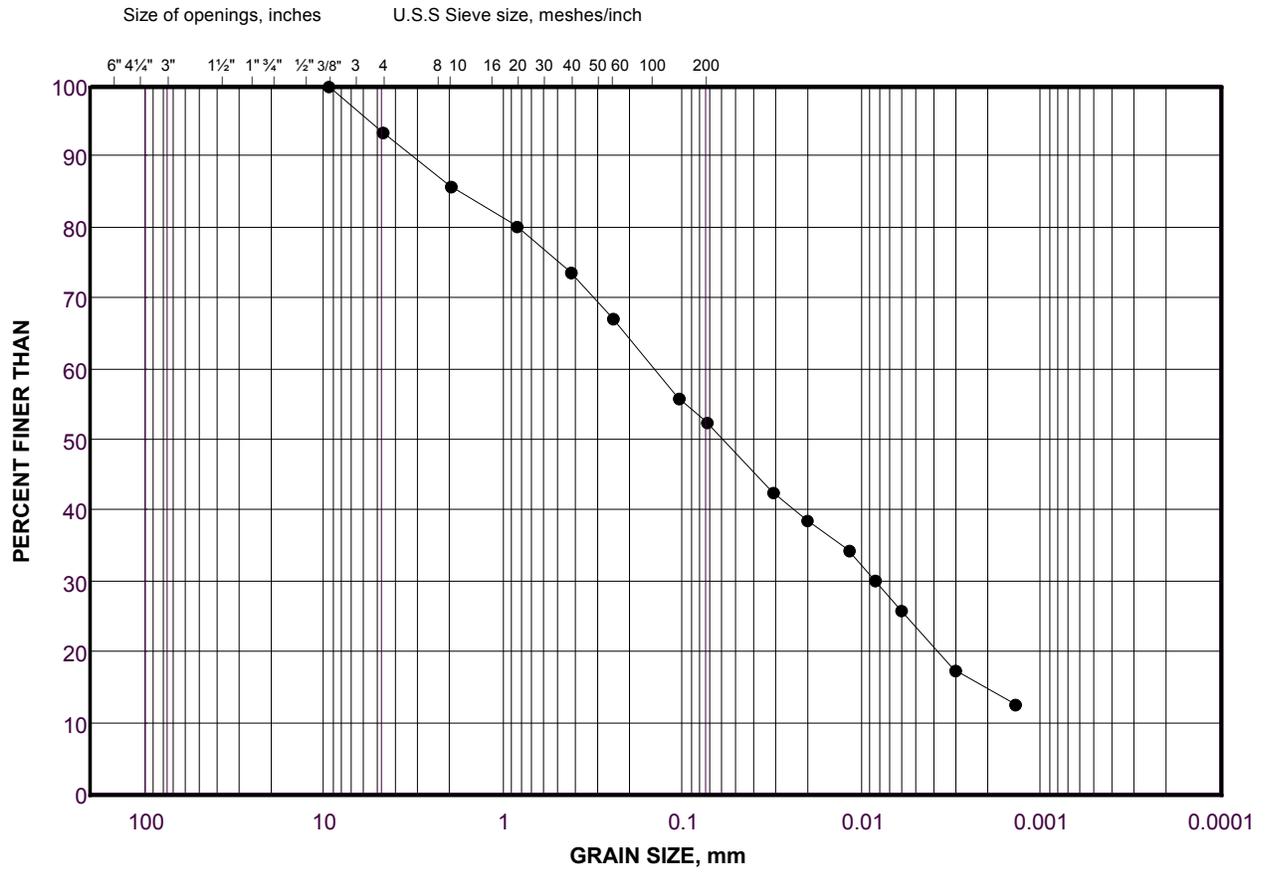
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**Golder Associates**

Date: 01-Mar-13

# GRAIN SIZE DISTRIBUTION

FIGURE 3



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			

## LEGEND

SYMBOL



SAMPLE

Bag 3 Westone (Omeme)

Project Number: 12-1111-0089

Checked By: \_\_\_\_\_

**Golder Associates**

Date: 01-Mar-13



# ATTACHMENT A

## List of Test Pit Samples and Laboratory Testing Results

**TABLE A.1  
LABORATORY TESTING RESULTS**

Name of Supplier	Pit Location	Sample Number	Sample Depth (m)	Natural Water Content (%)	Percent Gravel (4.75 mm - 75 mm) (%)	Percent Sand (0.075 mm - 4.75 mm) (%)	Percent Fines (<0.075 mm) (%)	Percent Clay Size (<0.002 mm) (%)	Atterberg Limits		
									PL (%)	LL (%)	PI (%)
Westone Aggregates	Esker Road, Omemee	12-1, Sa# 1	0.90-1.20	12.9	18	32	42	8	13.3	22.6	9.3
		12-2, Sa#1	1.80-2.10	12.9	17	29	43	11	13.4	24.5	11.1
		12-3, Sa# 1	0.60-0.90	6.1	18	40	36	6	10.8	16.8	6.0
		12-5, Sa#1	0.90-1.20	10.6	27	40	29	4	12.7	18.2	5.5
Mcgee	Faux Road, Campbellford	12-9, Sa# 1	0.60-0.90	13.0	42	30	22	6	13.7	22.6	8.9
		12-9, Sa#2	1.80-2.10	12.6	18	36	35	11	11.3	18.7	7.4
		12-9, Sa#3	3.40-3.70	10.2	20	35	32	13	10.0	18.1	8.1
		12-10, Sa#1	0.90-1.20	18.1	28	8	52	12	14.8	23.1	8.3
		12-10, Sa# 2	2.10-2.40	13.2	3	14	66	17	14.9	21.3	6.4
		12-10, Sa#3	3.70-4.00	16.9	0	3	63	34	16.1	31.8	15.7
		12-11, Sa#1	1.20-1.50	10.1	13	39	37	11	11.0	17.7	6.7
		12-11, Sa#2	2.40-2.70	9.8	8	31	52	9	11.4	18.3	6.9
		12-11, Sa#3	3.70-4.00	7.9	34	28	30	8	10.2	17.8	7.6
		12-12, Sa#1	0.60-0.90	10.8	11	39	38	12	13.9	22.3	8.4
		12-12, Sa#2	2.10-2.40	10.3	9	40	38	13	10.2	16.1	5.9
		12-12, Sa#3	3.40-3.70	10.8	12	37	37	14	11.1	18.0	6.9
		12-13, Sa#1	0.80-1.10	7.1	14	39	35	12	11.8	19.6	7.8
12-13, Sa#2	2.30-2.60	11.6	8	38	40	14	10.6	18.5	7.9		
12-13, Sa#3	3.80-4.10	7.9	21	35	33	11	9.9	16.6	6.7		
Robert Young Construction Ltd	Mt. Horeb Road, Omemee	12-14, Sa#1	0.60-0.90	21.2	2	6	59	33	17.2	35.3	18.1
		12-14, Sa#2	1.80-2.10	17.2	0	11	52	37	13.9	27.3	13.4
		12-16, Sa#1	0.90-1.20	22.2	0	9	58	33	16.6	33.3	16.7
		12-16, Sa#2	2.70-3.00	16.0	0	12	68	20	13.5	24.4	10.9

Notes:

PL = Plastic Limit  
 LL = Liquid Limit  
 PI = Plasticity Index



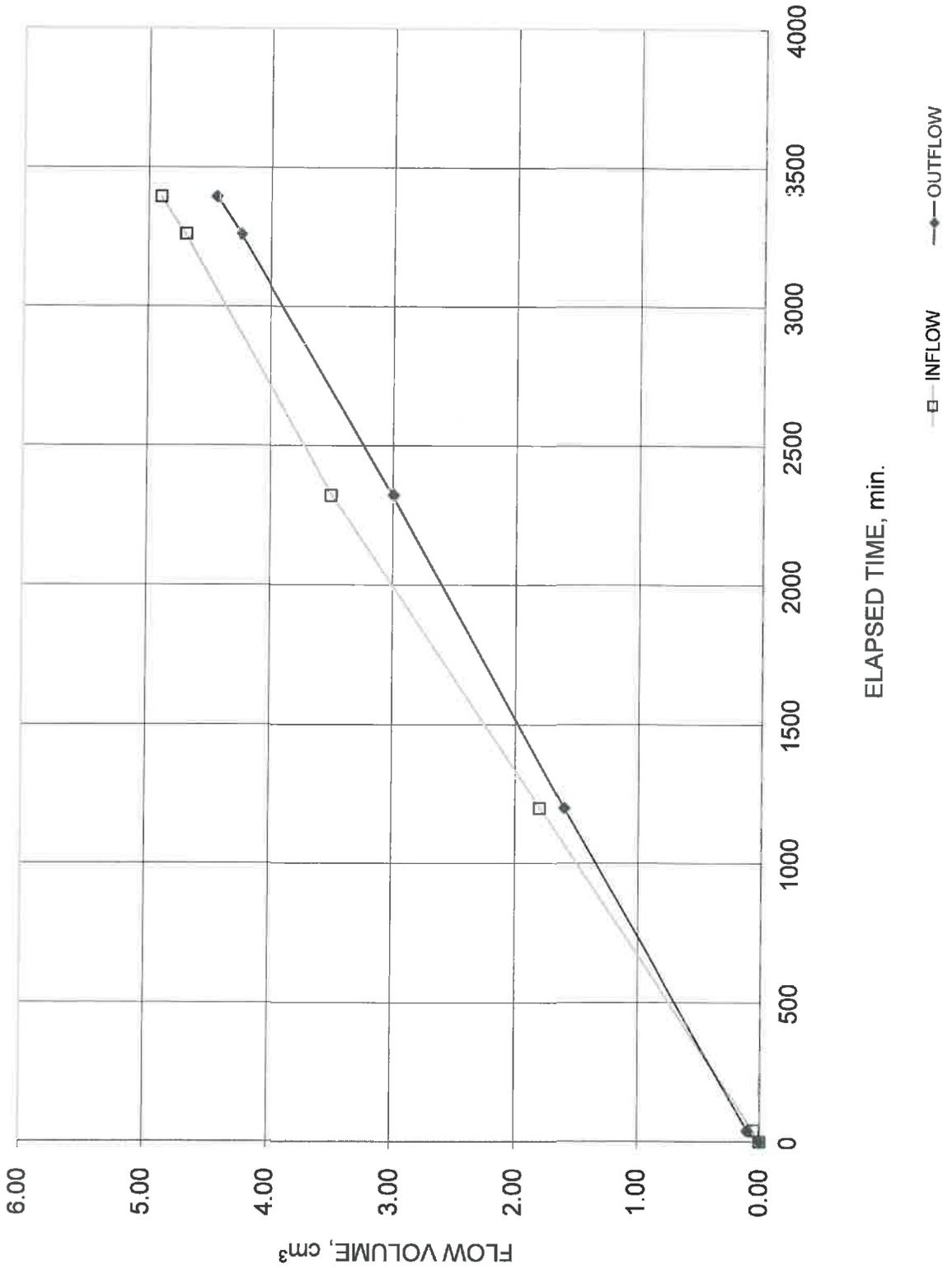
# ATTACHMENT B

## Hydraulic Conductivity Test Results



# HYDRAULIC CONDUCTIVITY TEST

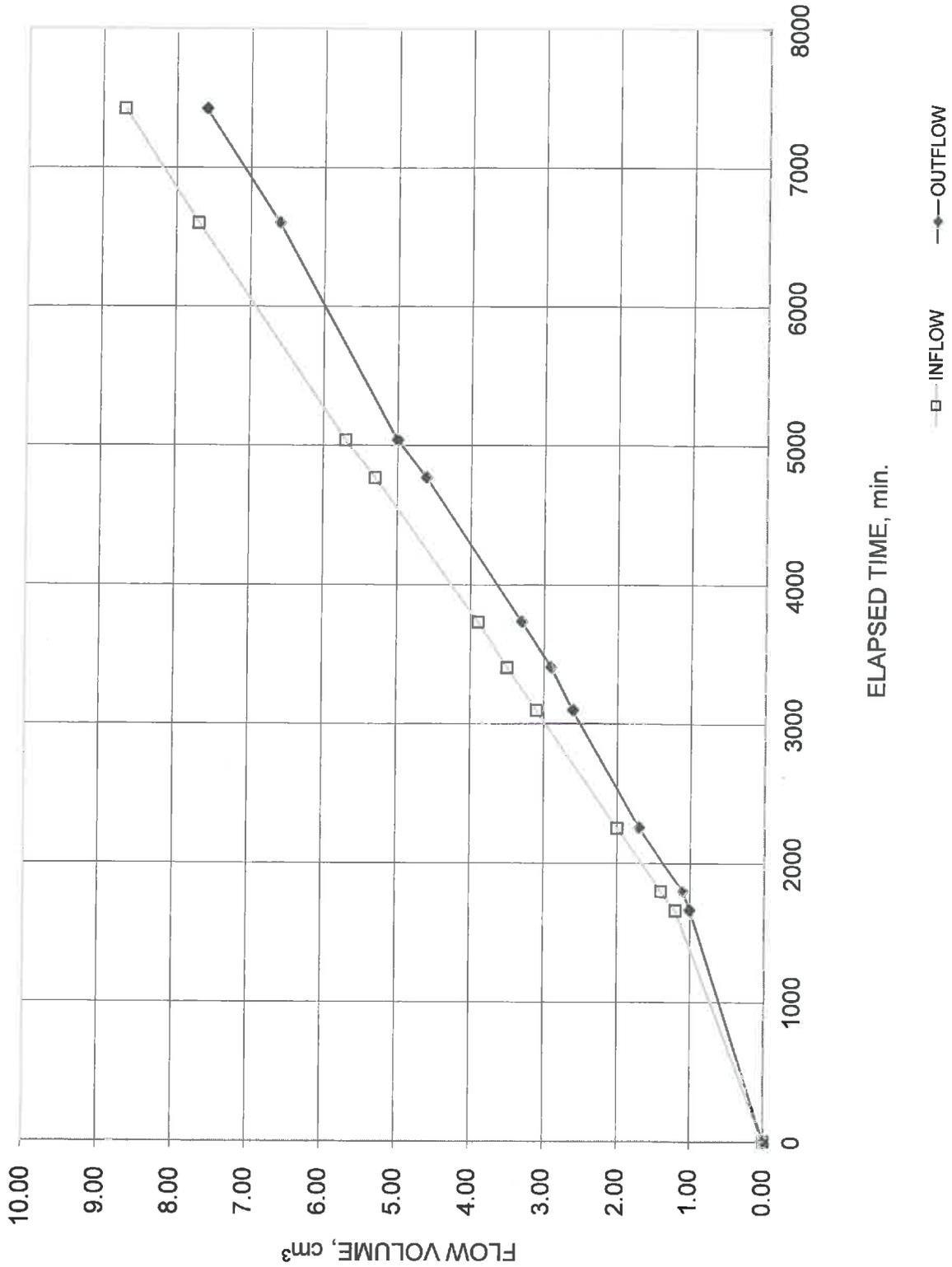
Sample Bag 1 (McGee Campbellford)





# HYDRAULIC CONDUCTIVITY TEST

Sample Bag 2 (Young Ome mnee)





# HYDRAULIC CONDUCTIVITY TEST

Sample Bag 3 (Westone, Onemea)

