MEMORANDUM

DATE: October 15, 2018
TO: Chris Prucha, Bill McDonough and Jim Forney (WM)
FROM: Alija Bos, Madeleine Corriveau, Phil Tibble and Francois Richard (BluMetric)
PROJECT NO: 180150-06
SUBJECT: Preliminary Purge Well System Evaluation, WM Richmond Landfill
Town of Greater Napanee

OBJECTIVE

A purge well system may be required in the southeast portion of the Waste Management (WM) Richmond Landfill property. The objective of the purge well system is to hydraulically control contaminated groundwater in the intermediate bedrock flow zone, currently travelling off property while minimizing the volume of water requiring treatment or transport for disposal.

Preliminary design scenarios using aquifer properties derived from pumping test results, suggest hydraulic capture can be achieved for control of off-site migration. Details are provided below related to the field testing, including drilling test wells and conducting a pumping test, as well as results and interpretations aimed at establishing the feasibility and preliminary design scenarios for the system.

FIELD METHODOLOGY

DRILLING

A total of four boreholes were drilled south and southeast of the landfill footprint on August 16th 2018 (M212-PW through M215-PW). The test wells were installed along a roughly north-south axis 25 to 50 m west from the downgradient Waste Management property line (Figure 1). The intermediate bedrock groundwater flow zone potentiometric surface from May 2018[1] and approximate extent of the known impacted area[2] are also shown on Figure 1.

[1] Spring 2018 Semi-Annual Monitoring Report, Waste Management Richmond Landfill Site, prepared by BluMetric Environmental Inc., July 2018
[2] Site Conceptual Model Update and Contaminant Attenuation Zone Delineation, Waste Management Richmond Landfill Site, prepared by BluMetric Environmental Inc., July 2017

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BluMetric Environmental Inc.
The Tower, The Woolen Mill, 4 Cataraqui Street, Kingston, Ontario, Canada K7K 1Z7
www.blumetric.ca

The test wells were installed upgradient of the adjacent property to the east, where landfill derived impacts in the intermediate bedrock groundwater flow zone have been identified.

Drilling of boreholes M212-PW through M215-PW was completed by Chalk Well Drilling Ltd. of Napanee, ON using cable tool, air percussion techniques. After drilling through the overburden, steel casing was installed from ground surface and set into the upper portion of the bedrock. Borehole records are included in Appendix A.

Table 1: Summary of Borehole Construction Details

Borehole	Easting	Northing	Ground Surface Elevation (masl)	Bedrock Elevation (masl)	Bottom of Hole Elevation (masl)
M212-PW	335891	4902773	128.361	125.471	93.5
M213-PW	335857	4902784	127.976	125.236	93.2
M214-PW	335883	4902829	127.245	125.417	93.4
M215-PW	335822	4902889	127.636	126.426	94.4

Reported initial yields during drilling for the boreholes were low, about 1 U.S. gallons per minute (gpm) at M212-PW and less than 1 gpm at the other three holes. Chalk Well Drilling developed the wells with a cable tool and achieved improvements in potential yields, reporting potential yields and depths where water was found as listed in Table 2:

Table 2: Summary of Borehole Observations

Borehole	Potential Yield Lpm (USgpm)	Fractures Noted mbgs (masl)	Water Found mbgs (masl)
M212-PW	75.7 (20)	12.5 (115.9) 27.7 (100.6)	27.7 (100.6)
M213-PW	5.7 (1.5)	12.2 (115.8) 27.4 (100.5)	27.4 (100.5)
M214-PW	15.1 (4)	11.6 (115.7) 26.5 (100.7)	26.5 (100.7)
M215-PW	75.7 (20)	10.7 (117.0) 25.9 (101.7)	25.9 (101.7)

Pumping Test

Groundwater was pumped from M212-PW pumping well using a three inch Grundfos SQE pump. Groundwater was discharged through a four inch 'lay flat' hose to a temporary water storage tank which was routinely pumped out by Sutcliffe Sanitation Services Ltd. of Napanee, ON. Collected discharge water was disposed of at the Napanee Waste Water Treatment Plant. The flow rate was monitored by an inline Lake displacement gauge and flow rate was controlled by adjustment of a gate valve at the well head. Table 2 summarizes the flow rate and maximum observed drawdown in the pumping well for the test.

Table 2: Summary of Pumping Test Details

Pumping Test Duration (hrs)	Average Flow Rate (USgpm)	Maximum Drawdown (m)	Total Volume USgal
46	8.78	5.86	24,233 (~91,732 L)

Solinst Leveloggers (pressure transducers) were installed in test wells M213-PW, M214-PW, M215-PW as well as in nearby observation wells installed in the intermediate bedrock flow zone, and set to acquire groundwater level readings on five minute intervals. Figure 1 illustrates the location of the observation wells with respect to the pumping well. The Solinst Leveloggers were hung below the water level in the well using optical connection cables that allowed data to be checked and downloaded from the surface without removing the logger from the well. Loggers were installed at least 24 hours prior to the start of the long term constant discharge test to collect background data. Atmospheric pressure was also recorded during the testing period to allow for barometric compensation of the Solinst Levelogger data. In addition to the Solinst Levelogger data, manual water levels were collected using an electronic water level tape prior to and several times during the pumping and recovery phases of the test.

Inflatable packers were used to isolate vertical intervals in M215-PW and M212-PW boreholes for testing purposes. Water level measurements were recorded above and below the isolated zones in these boreholes.

On completion of the pumping and recovery components of the constant discharge test, the water level measurements collected by the data loggers were retrieved and the Solinst Leveloggers removed from the wells. Water level data from the Solinst Leveloggers was corrected for barometric pressure changes and then were normalized to a zero point coinciding with the start of the pumping phase of the constant discharge test to facilitate recognition of the extent of drawdown and recovery.

Observation well response curves to the pumping test conducted at M212-PW are presented in Appendix B.

DATA ANALYSIS

Response to pumping at M212-PW was observed in all monitoring wells indicating the pumping well and other new wells were intersecting the hydraulically active system in the area as identified by previous investigations.

Water level data from the pumping test described above was plotted on a composite plot, with an x-axis of t/r^2, where:

- *t*: elapsed time since the start of pumping; and,
- *r*: radial distance from the pumped well.

The Cooper-Jacob analysis can be applied to a composite plot as follows:

$$s = \frac{Q}{4\pi T} 2.303 log_{10} \left[2.2459 \frac{T}{S} \left(\frac{t}{r^2} \right) \right]$$

Where:

- *Q*: constant well discharge;
- *T*: transmissivity; and,
- *S*: storage coefficient.

The approximation in this form suggests that after some time has elapsed, the drawdown is a linear function of the logarithm of t/r^2. Solving for T:

$$T = 2.303 \frac{Q}{4\pi} (SLOPE)^{-1}$$

Where:

- *SLOPE* = drawdown per log cycle t/r^2

As shown in Figure 2, after some early-time curvature, the drawdown data from all observation wells approximate straight lines with a similar slope indicating that all wells are installed within the same hydrostratigraphic unit. Therefore it is appropriate to use this slope to estimate a representative bulk average transmissivity of the intermediate bedrock unit in this portion of the site as follows:

$$T = 2.303 \frac{48 \frac{m^3}{day}}{4\pi} (1.5m)^{-1}$$
$$T = 5.8\, m^2/day$$
$$T = 7E^{-5}\, m^2/s$$

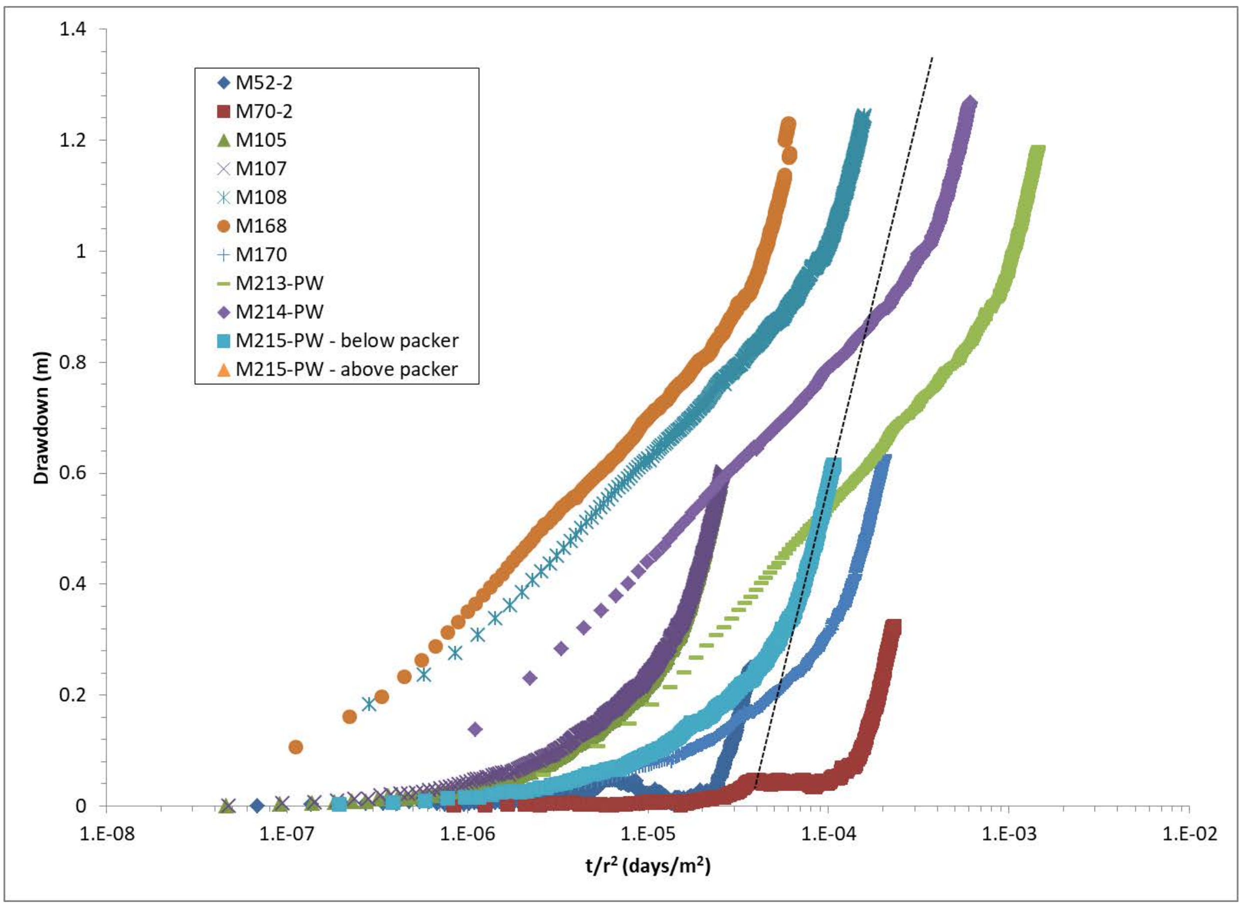


Figure 2: Composite plot of drawdown data

Pumping test data was also analyzed using aquifer test analysis software AquiferTest™ to estimate hydraulic parameters. The Theis solution provided an average transmissivity value of $8E^{-5}$ m^2/s for test wells M213-PW, M214-PW and M215-PW. Analysis data sheets are provided in Appendix C.

PRELIMINARY PURGE WELL DESIGN

The AquiferTest software was used to simulate different potential combinations of pumping wells and pumping rates to hydraulically control impacted groundwater near the southeastern corner of the landfill property.

Three scenarios were simulated, using 2, 3 and 4 pumping wells. Pumping rates in each pumping well were adjusted to achieve 1 m of drawdown throughout the north-south transect, approximately parallel to the property boundary. The target drawdown was selected arbitrarily, with objective of controlling the hydraulic gradient locally while keeping the total pumping rate relatively low.

Scenario 1: Two pumping wells

Pumping Well	Pumping Rate Q (USgmp)
M212-PW	4.2
M215-PW	4.2

Total estimated Q = 8.4 USgpm

Scenario 2: Three pumping wells

Pumping Well	Pumping Rate Q (USgmp)
M212-PW	2.2
M214-PW	2.3
M215-PW	2.2

Total Q = estimated 6.7 USgpm

Scenario 3: Four pumping wells

Pumping Well	Pumping Rate Q (USgmp)
M212-PW	1.4
M213-PW	0.7
M214-PW	2.4
M215-PW	2.0

Total Q = estimated 6.5 USgpm

DISCUSSION AND RECOMMENDATIONS

Water bearing fractures were noted at similar elevations amongst the new boreholes and at elevations consistent with existing groundwater monitoring wells in the area. By way of water level response in the new boreholes and in existing groundwater monitoring wells, the long-term (46 hr) constant discharge test confirmed that the newly installed boreholes are in hydraulically connection with the identified intermediate bedrock groundwater flow zone. The bulk transmissivity of this hydrostratigraphic unit in this portion of the landfill property was estimated through long term pumping test data at approximately 7.5×10^{-5} m^2/s.

Preliminary design scenarios using aquifer properties derived from pumping test results with the new test wells as potential purge wells confirm the feasibility of an engineered system to prevent further off-site migration of impacted groundwater, by inducing groundwater capture through altering the groundwater flow pattern.

It is recommended to move forward with additional testing to confirm simulated results, and refine and optimize individual purge well pumping rates to create sufficient drawdown of hydraulic heads while minimizing total pumping rates. To accomplish this, complementary field testing will be required to confirm individual test well pumping rates, radius of influence and combined hydraulic head drawdown. The quality of the combined discharge from the potential purge well system will also need to be established through sampling and analysis of purge water during testing.

Additionally, a technical and economic evaluation of discharge options for groundwater collected from the proposed purge well system, including associated permitting requirements as needed, will also need to be considered. Options may include, for example, off site hauling and treatment at an approved waste water treatment plant, on-site treatment plant and/or discharge to surface water following on site passive treatment (e.g., constructed wetlands), collection pond(s) potentially linked to the existing pond system located in the front field of the landfill property to accommodate the additional requirements in terms of storage capacity and holding times.

Attachments:

Figure 1: M212-PW Pumping Test Monitoring Well Network
Appendix A: Borehole Records
Appendix B: Observation Well Drawdown Curves
Appendix C: Pumping Test Analysis
Appendix D: Preliminary Purge Well Scenarios

FIGURES

LEGEND

- Pumping Well
- Observation Well
- Monitoring Well
- Potentiometric Surface (masl) - May 14, 2018
- Infered Potentiometric Surface (masl) - May 14, 2018
- Extents of 1,4 Dioxane Impacted Area
- Property Boundary
- Proposed CAZ Boundary
- Landfill Footprint

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

PROPRIETARY INFORMATION MAY NOT BE REPRODUCED OR DIVULGED WITHOUT PRIOR WRITTEN CONSENT OF BLUMETRIC ENVIRONMENTAL INC.
DO NOT SCALE DRAWING.
THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

0 20 40 80 120 160
Meters
1:5,000

N W E S

CLIENT

WASTE MANAGEMENT

PROJECT

Waste Management Richmond - Complementary CAZ Investigation

TITLE

M212-PW Pumping Test Monitoring Well Network

BluMetric™ Environmental

The Tower - The Woolen Mill,
4 Cataraqui St.,
Kingston, Ontario K7K 1Z7
TEL: (613) 531-2725
FAX: (613) 531-1852
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
180150-06	October 11, 2018

DRAWN	CHECKED	FIG NO.	REV
AL	MC	01	0

APPENDIX A

Well Records

Well Record

Ontario — Ministry of the Environment and Climate Change

Well Tag#: A250917 — A250917 — M212-PW

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Measurements recorded in: ☐ Metric ☒ Imperial

Well Owner's Information

Field	Value
First Name / Last Name / Organization	WASTE MANAGEMENT CANADA CORP.
E-mail Address	UNK
Well Constructed by Well Owner	☐
Mailing Address (Street Number/Name)	1271 Beechwood Road
Municipality	Napanee
Province	Ontario
Postal Code	K7R 3L1
Telephone No. (inc. area code)	613 388-1057

Well Location

Field	Value
Address of Well Location (Street Number/Name)	1181 Beechwood Road
Township	Richmond
Lot	3
Concession	IV
County/District/Municipality	Lennox & Addington
City/Town/Village	Greater Napanee
Province	Ontario
Postal Code	K7R 3L1
Other	
UTM Coordinates Zone / Easting / Northing	NAD 83, Zone 18, Easting 335891, Northing 4902773
Municipal Plan and Sublot Number	

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
Brown	Clay		Packed	0	3
Brown	Clay Till		Packed	3	9.5
Grey	Limestone		Hard	9.5	114.5

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
20	0	Bentonite	7.0

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify ____

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ____ hrs + ____ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Method of Construction

☒ Cable Tool ☐ Rotary (Conventional) ☐ Rotary (Reverse) ☐ Boring ☒ Air percussion ☐ Other, specify ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging

Well Use

☐ Public ☐ Domestic ☐ Livestock ☐ Irrigation ☐ Industrial ☐ Other, specify ☐ Commercial ☐ Municipal ☐ Test Hole ☐ Cooling & Air Conditioning ☐ Not used ☐ Dewatering ☒ Monitoring

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
6.25	Steel	.188	+2	20

Status of Well

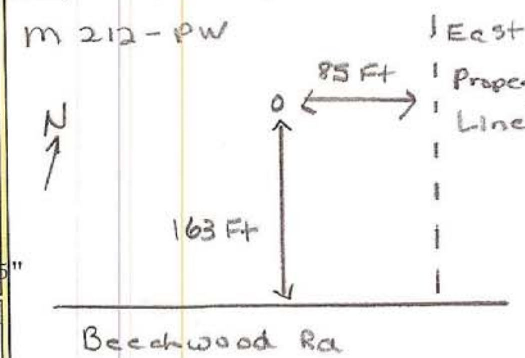
☐ Water Supply ☐ Replacement Well ☐ Test Hole ☐ Recharge Well ☐ Dewatering Well ☒ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☐ Abandoned, other, specify ☐ Other, specify

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To

Map of Well Location

Please provide a map below following instructions on the back.



Water Details

Water found at Depth 91 (m/ft) Kind of Water: ☐ Fresh ☒ Untested ☐ Gas ☐ Other, specify

Water found at Depth ____ (m/ft) Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, specify

Water found at Depth ____ (m/ft) Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, specify

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	20	10"
20	109.5	6"
109.5	114.5	5.75"

Well Contractor and Well Technician Information

Field	Value
Business Name of Well Contractor	Chalk Well Drilling Ltd.
Well Contractor's Licence No.	1507
Business Address (Street Number/Name)	31 Johson's Side Road
Municipality	Napanee
Province	Ontario
Postal Code	K7R 3L1
Business E-mail Address	chalkwel kos.net
Bus. Telephone No. (inc. area code)	613 388-2809
Name of Well Technician (Last Name, First Name)	Chalk, Kevin
Well Technician's Licence No.	0627
Signature of Technician and/or Contractor	Kevin Chalk
Date Submitted	2018 08 16

Comments: Fractures at 41 Ft. & 91 Ft.

Well owner's information package delivered ☐ Yes ☐ No

Date Package Delivered: Y Y Y Y M M D D

Date Work Completed: 2018 08 16

Ministry Use Only

Audit No. Z291286

Received

0506E (2014/11) — Ministry's Copy

Ontario — Ministry of the Environment and Climate Change

Measurements recorded in: ☐ Metric ☒ Imperial

Well Tag No. (Place Sticker and/or Print Below) Tag#: A250918
A 250918 M213-PW

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
WASTE MANAGEMENT	CANADA CORP.	UNK	

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
1271 Beechwood Road	Napanee	Ontario	K7R 3L1	613 388-1057

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
1181 Beechwood Road	Richmond	3	IV

County/District/Municipality	City/Town/Village	Province	Postal Code
Lennox & Addington	Greater Napanee	Ontario	K7R 3L1

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	335857	4902784		

Overburden and Bedrock Materials/Abandonment Sealing Record (see instructions on the back of this form)

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
Brown	Clay		Packed	0	2
Brown	Clay Till		Packed	2	6
Brown	Clay/Gravel	Silt	Loose	6	9
Grey	Limestone		Hard	9	114

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
20	0	Bentonite	11.2

Method of Construction

☒ Cable Tool ☐ Rotary (Conventional) ☐ Rotary (Reverse) ☐ Boring ☒ Air percussion ☐ Other, specify ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging

Well Use

☐ Public ☐ Domestic ☐ Livestock ☐ Irrigation ☐ Industrial ☐ Other, specify ☐ Commercial ☐ Municipal ☐ Test Hole ☐ Cooling & Air Conditioning ☐ Not used ☐ Dewatering ☒ Monitoring

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
6.25	Steel	.188	+2	20

Status of Well

☐ Water Supply ☐ Replacement Well ☐ Test Hole ☐ Recharge Well ☐ Dewatering Well ☒ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☐ Abandoned, other, specify ☐ Other, specify

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To

Water Details

Water found at Depth 90 (m/ft) Kind of Water: ☐ Fresh ☒ Untested ☐ Gas ☐ Other, specify

Water found at Depth (m/ft) Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, specify

Water found at Depth (m/ft) Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, specify

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	20	10"
20	109	6"
109	114	5.75

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ___ hrs + ___ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

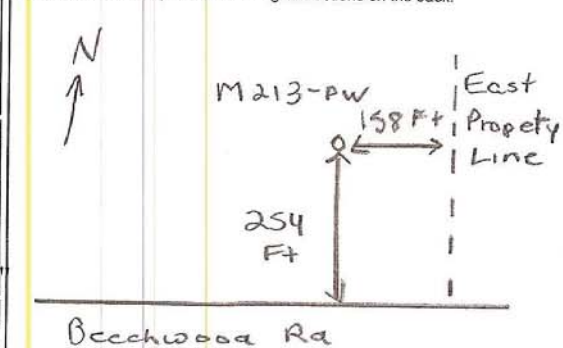
Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Chalk Well Drilling Ltd.	1507

Business Address (Street Number/Name)	Municipality
31 Johnson's Side Road	Napanee

Province	Postal Code	Business E-mail Address
Ontario	K7R 3L1	chalkwel.kos.net

Bus.Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
613 388-2809	Chalk, Kevin

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
0627	Kevin Chalk	2018 08 16

Comments: Fractures at 40 ft. and 90 ft.

Well owner's information package delivered ☐ Yes ☐ No

Date Package Delivered Y Y Y Y M M D D

Date Work Completed 2018 08 16

Ministry Use Only — Audit No. Z291283 — Received

0506E (2014/11)

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Well Tag No. (Place Sticker and/or Print Below)
Tag#: A250919
A250919 M214-PW

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Measurements recorded in: ☐ Metric ☒ Imperial

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
WASTE MANAGEMENT	CANADA CORP.	UNK	

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
1271 Beechwood Road	Napanee	Ontario	K7R 3L1	613 388-1057

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
1181 Beechwood Road	Richmond	3	IV

County/District/Municipality	City/Town/Village	Province	Postal Code
Lennox & Addington	Greater Napanee	Ontario	K7R 3L1

UTM Coordinates Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83 18	335883	4902829		

Overburden and Bedrock Materials/Abandonment Sealing Record (see instructions on the back of this form)

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
Brown	Clay		Packed	0	2
Brown	Clay Till		Packed	2	6
Grey	Limestone		Hard	6	111

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
20	0	Bentonite	7.0

Method of Construction

☒ Cable Tool ☐ Rotary (Conventional) ☐ Rotary (Reverse) ☐ Boring ☒ Air percussion ☐ Other, specify ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging

Well Use

☐ Public ☐ Domestic ☐ Livestock ☐ Irrigation ☐ Industrial ☐ Other, specify ☐ Commercial ☐ Municipal ☐ Test Hole ☐ Cooling & Air Conditioning ☐ Not used ☐ Dewatering ☒ Monitoring

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
6.25	Steel	.188	+2	20

Status of Well

☐ Water Supply ☐ Replacement Well ☐ Test Hole ☐ Recharge Well ☐ Dewatering Well ☒ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☐ Abandoned, other, specify ☐ Other, specify

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To

Water Details

Water found at Depth 87 (m/ft) ☐ Gas | Kind of Water: ☐ Fresh ☒ Untested ☐ Other, specify

Water found at Depth (m/ft) ☐ Gas | Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify

Water found at Depth (m/ft) ☐ Gas | Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	20	10"
20	105	6"
106	111	5.75"

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ___ hrs + ___ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

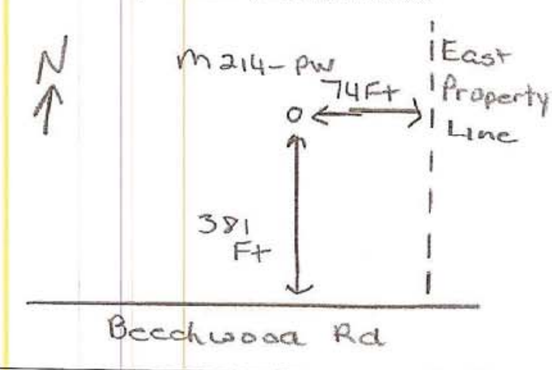
Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Chalk Well Drilling Ltd.	1507

Business Address (Street Number/Name)	Municipality
31 Johnson's Side Road	Napanee

Province	Postal Code	Business E-mail Address
Ontrio	K7R 3L1	chalkwel kos.net

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
613 388-2809	Chalk, Kevin

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
0627	Kevin Chalk	2018 08 16

Comments: Fractures at 38 Ft & 87 Ft.

Well owner's information package delivered ☐ Yes ☐ No

Date Package Delivered: YYYY MM DD

Date Work Completed: 2018 08 16

Ministry Use Only
Audit No. Z291287
Received

0506E (2014/11)

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Ontario Ministry of the Environment and Climate Change

Well Tag No. *(Place Sticker and/or Print Below)* Tag#: A250920

A250920 M215-PW

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Measurements recorded in: ☐ Metric ☒ Imperial

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	Well Constructed by Well Owner
	WASTE MANAGEMENT CANADA CORP.	UNK	☐

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
1271 Beechwood Road	Napanee	Ontario	K7R 3L1	613 388-1057

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
1681 Beechwood Road	Richmond	3	IV

County/District/Municipality	City/Town/Village	Province	Postal Code
Lennox & Addington	Greater Napanee	Ontario	K7R 3L1

UTM Coordinates Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83 18	335822	4902889		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
Brown	Clay		Packed	0	3
Brown	Clay Till		Packed	3	4
Grey	Limestone		Hard	4	109

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
20	0	Bentonite	7.0

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ___ hrs + ___ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Method of Construction

☒ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☒ Air percussion ☐ Other, specify

Well Use

☐ Public ☐ Domestic ☐ Livestock ☐ Irrigation ☐ Industrial ☐ Other, specify ☐ Commercial ☐ Municipal ☐ Test Hole ☐ Cooling & Air Conditioning ☐ Not used ☐ Dewatering ☒ Monitoring

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
6.25	Steel	.188	+2	20

Status of Well

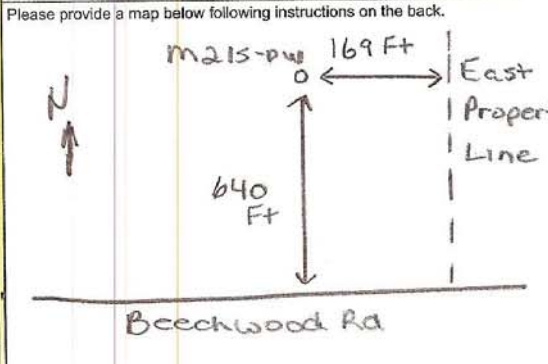
☐ Water Supply ☐ Replacement Well ☐ Test Hole ☐ Recharge Well ☐ Dewatering Well ☒ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☐ Abandoned, other, specify ☐ Other, specify

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To

Map of Well Location

Please provide a map below following instructions on the back.



Water Details

Water found at Depth 85 (m/ft) ☐ Gas Kind of Water: ☐ Fresh ☒ Untested ☐ Other, specify

Water found at Depth ___ (m/ft) ☐ Gas Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify

Water found at Depth ___ (m/ft) ☐ Gas Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	20	10"
20	104	6"
104	109	5.75"

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Chalk Well Drilling Ltd.	1507

Business Address (Street Number/Name)	Municipality
31 Johnson's Side Road	Napanee

Province	Postal Code	Business E-mail Address
Ontario	K7R 3L1	chalkwel kos.net

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
613 388-2809	Chalk, Kevin

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
0627	Kevin Chalk	2018 08 16

Comments: Fractures at 35 Ft. & 85 Ft.

Well owner's information package delivered ☐ Yes ☐ No

Date Package Delivered: Y Y Y Y M M D D

Date Work Completed: 2018 08 16

Ministry Use Only Audit No. Z291285

Received

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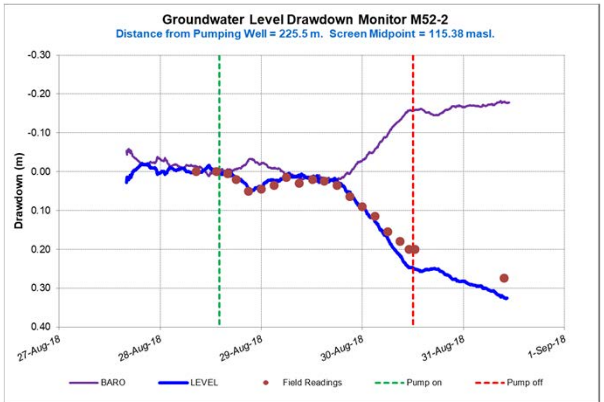
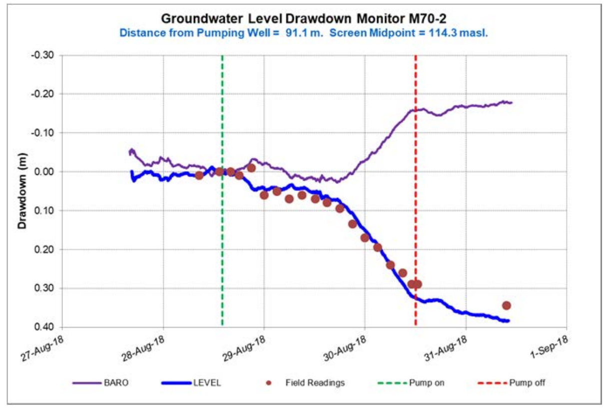
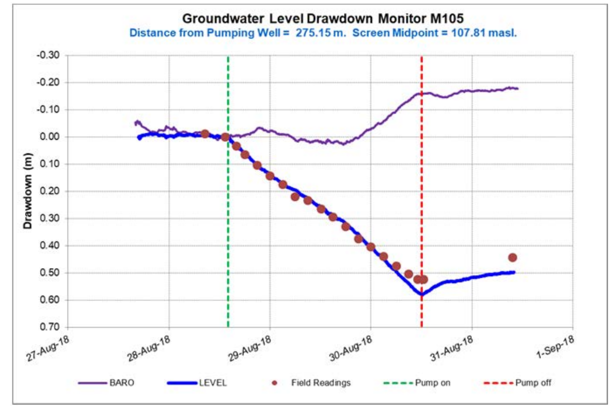
APPENDIX B

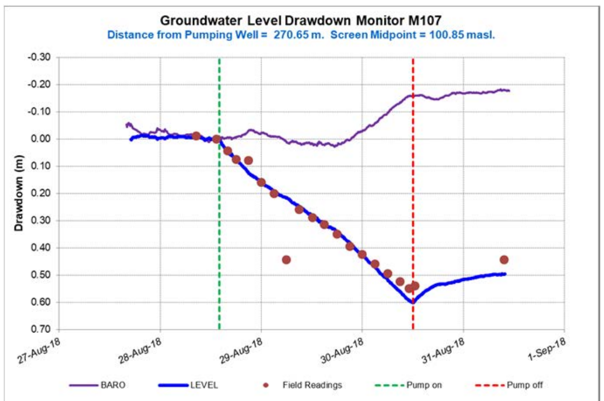
Observation Well Drawdown Curves

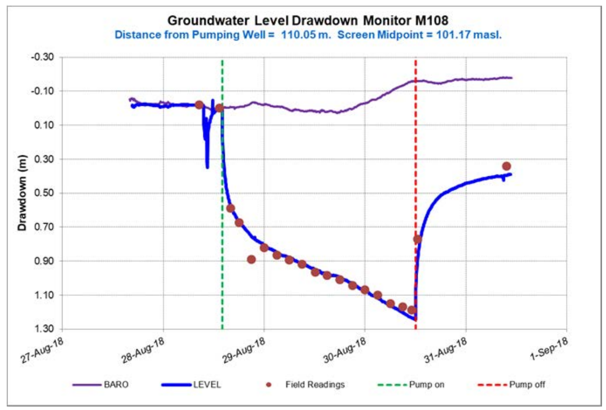
Observation Well Drawdown Charts

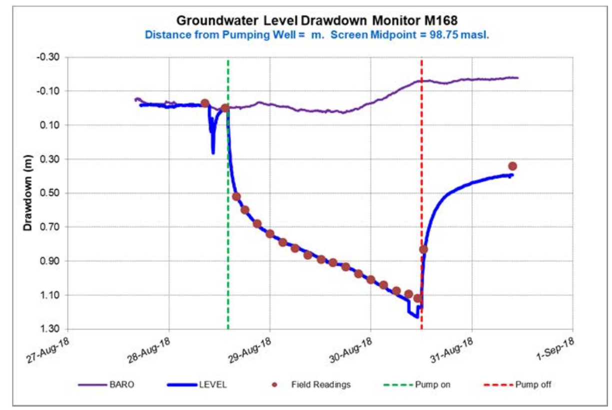


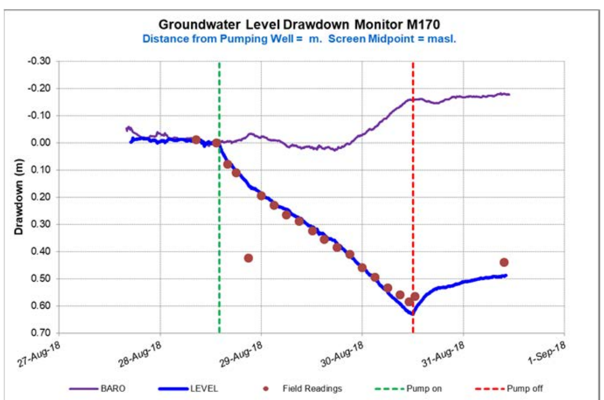




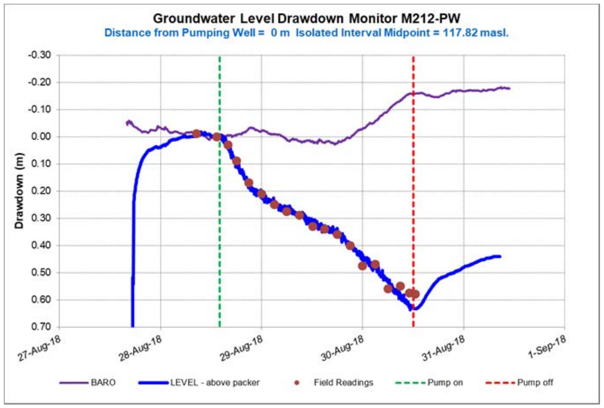


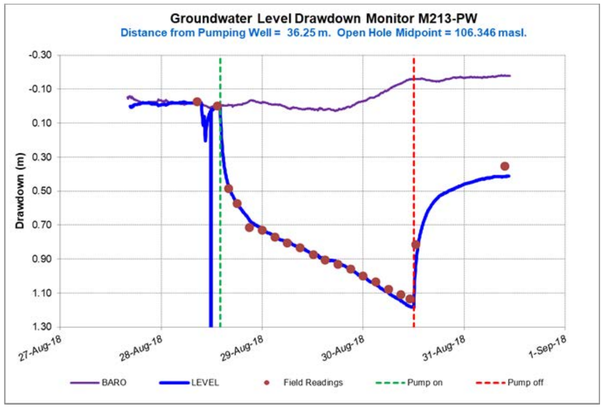


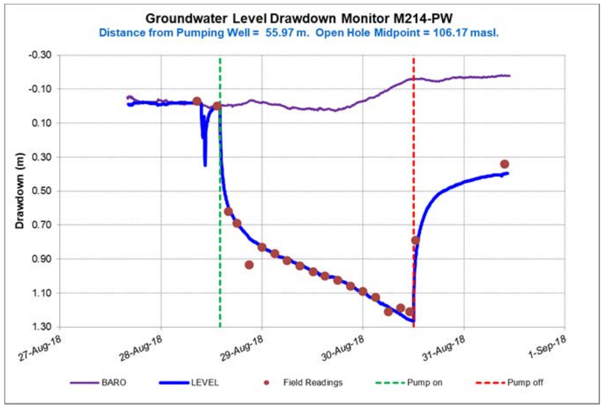


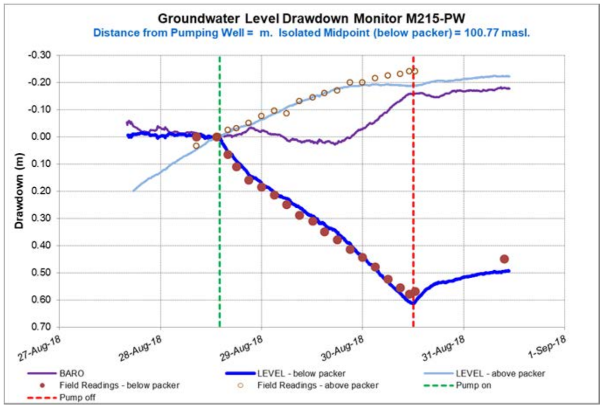


Observation Well Drawdown Charts







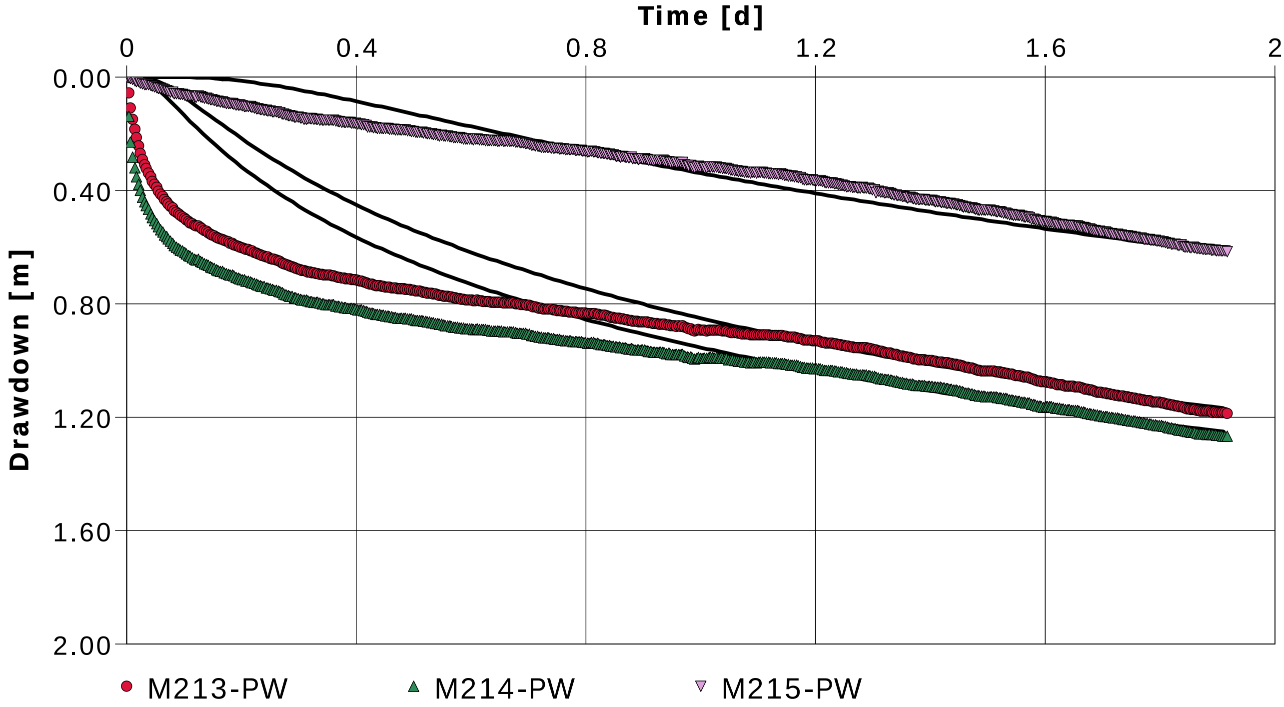


APPENDIX C

Pumping Test Analysis

Pumping Test Analysis Report
Project: WM Richmond - Purge Well System
Number: 180150-06
Client: Waste Management

Location: Richmond Landfill	Pumping Test: M212-PW Pumping Test	Pumping Well: M212-PW
Test Conducted by: BM		Test Date: 2018-08-28
Analysis Performed by:	Theis Analysis	Analysis Date: 2018-09-18
Aquifer Thickness: 30.00 m	Discharge Rate: 8.78 [U.S. gal/min]	

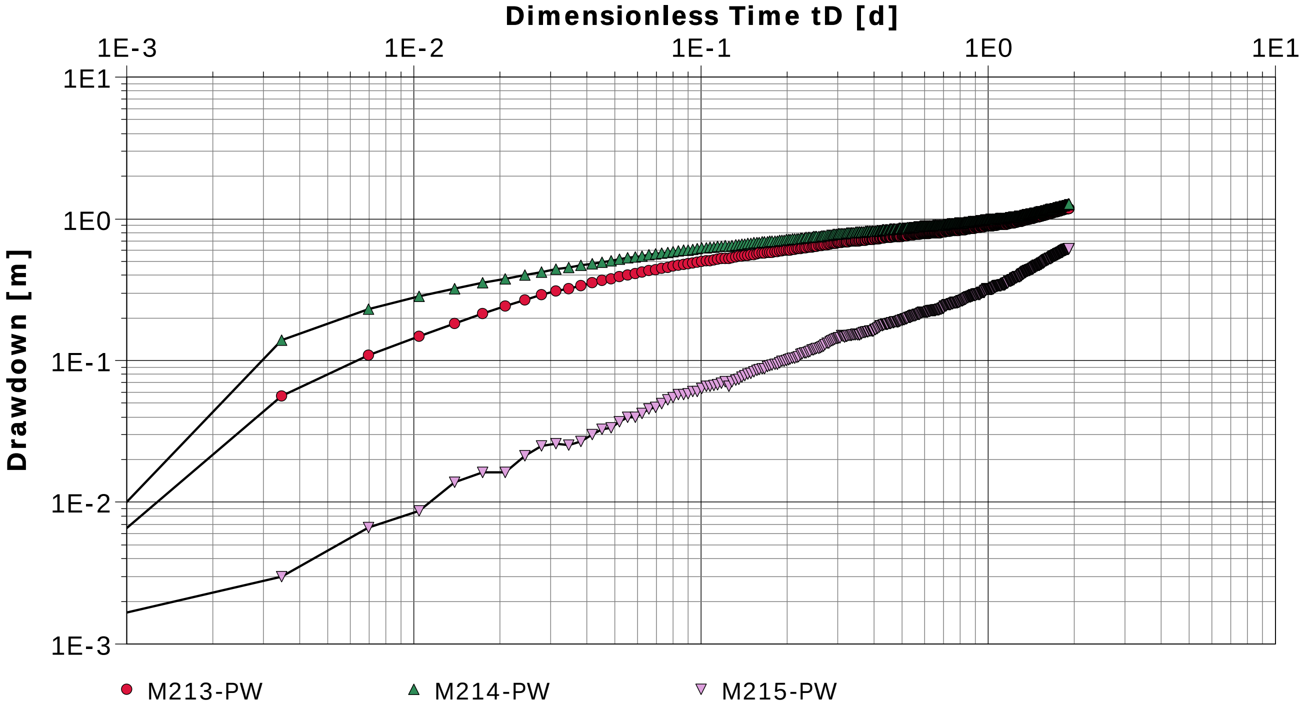


Calculation using Theis

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Storage coefficient	Radial Distance to PW [m]	
M213-PW	8.13×10^{-5}	2.71×10^{-6}	2.84×10^{-3}	36.25	
M214-PW	9.00×10^{-5}	3.00×10^{-6}	8.66×10^{-4}	55.97	
M215-PW	7.00×10^{-5}	2.33×10^{-6}	7.00×10^{-4}	133.84	
Average	8.04×10^{-5}	2.68×10^{-6}	1.47×10^{-3}		

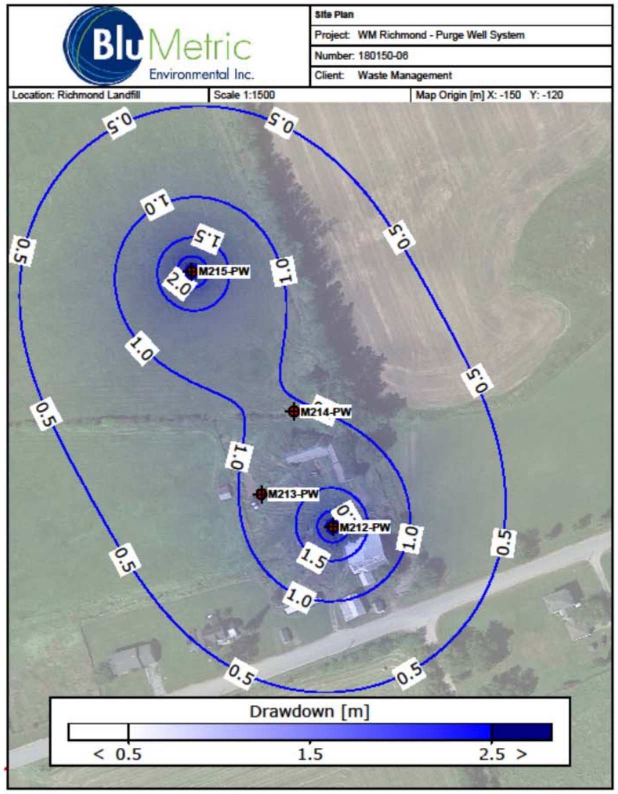
BluMetric Environmental Inc.	**Pumping Test Analysis Report**
	Project: WM Richmond - Purge Well System
	Number: 180150-06
	Client: Waste Management

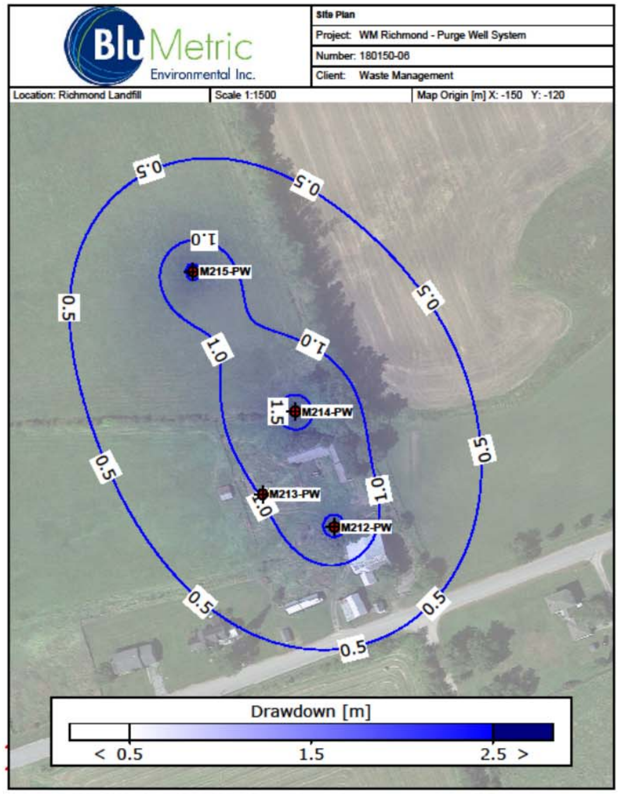
Location: Richmond Landfill	Pumping Test: M212-PW Pumping Test	Pumping Well: M212-PW
Test Conducted by: BM		Test Date: 2018-08-28
Analysis Performed by:	Time-Drawdown	Analysis Date: 2018-09-18
Aquifer Thickness: 30.00 m	Discharge Rate: 8.78 [U.S. gal/min]	

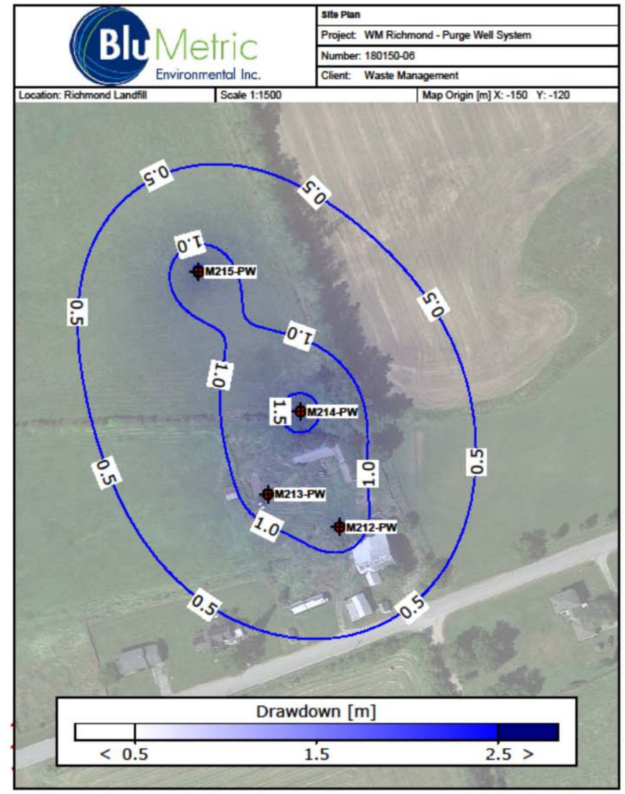


APPENDIX D

Preliminary Purge Well Scenarios







Scenario 1: Two pumping wells

Pumping Well	Rate (USgmp)
M212-PW	4.2
M215-PW	4.2

Total Q = 8.4 USgpm

Scenario 2: Three pumping wells

Pumping Well	Rate (USgmp)
M212-PW	2.2
M214-PW	2.3
M215-PW	2.2

Total Q = 6.7 USgpm

Scenario 3: Four pumping wells

Pumping Well	Rate (USgmp)
M212-PW	1.4
M213-PW	0.7
M214-PW	2.4
M215-PW	2.0

Total Q = 6.5 USgpm