

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 2018¹ and approximate extent of the known impacted area² are also shown on Figure 1.

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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¹ Spring 2018 Semi-Annual Monitoring Report, Waste Management Richmond Landfill Site, prepared by BluMetric Environmental Inc., July 2018

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.

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

 Table 1:
 Summary of Borehole Construction Details

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:

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)			
M212-PW	75.7 (20)	27.7 (100.6)	27.7 (100.6)			
M213-PW	E 7 (1 E)	12.2 (115.8)	27.4 (100.5)			
M213-PW	5.7 (1.5)	27.4 (100.5)	27.4 (100.5)			
M214-PW	15 1 (4)	11.6 (115.7)	2(5 (100 7))			
M214-PW	15.1 (4)	26.5 (100.7)				
M215-PW	75.7 (20)	10.7 (117.0)	25.0 (101.7)			
101213-PW	75.7 (20)	25.9 (101.7)	25.9 (101.7)			

Table 2:Summary of Borehole Observations



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.

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

Table 2:Summary of Pumping Test Details

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:

$$T = 2.303 \frac{48 \frac{m^3}{day}}{4\pi} (1.5m)^{-1}$$

$$T = 5.8 m^2/day$$

$$T = 7E^{-5} m^2/s$$

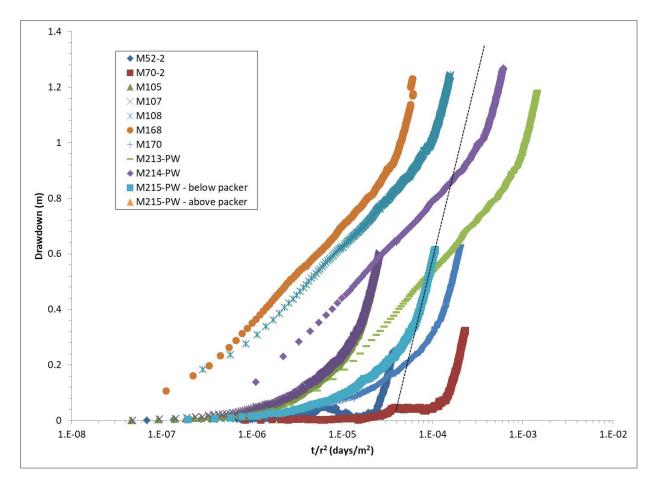


Figure 2: Composite plot of drawdown data



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 m²/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 x 10^{-5} m²/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:

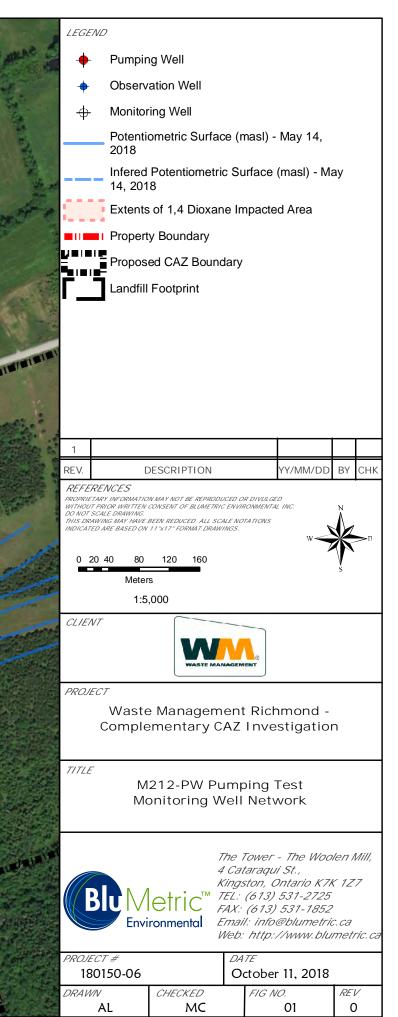
Figure 1: M212-PW Pumping Test Monitoring Well Network Appendix A: Borehole Records Appendix B: Observation Well Drawdown Curves Appendix C: Pumping Test Analysis Appendix D: Preliminary Purge Well Scenarios



FIGURES







APPENDIX A

Well Records



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Address c 1181	ofWellLocal Beech	tion (Street N wood R	umber/Name)		Township	. L			Lot	22020	Concess	on	the second second
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Boring	Reverse)	Driving			Test Hol	e 🖡	Monitoring		hrs + mi		5		5	
Air percu		C ci8ôn.ô	🗌 Ind	ustrial	Cooling	& Air Condit	ioning	Fina	al water level end of p	oumping (m/it)	10		10	
Other, sp		struction R	Same and Street Street	ner, specify				If fic	wing give rate (Vmin.	/ GPM)	15		15	
Inside	Open Hole	OR Material	Wall		n (<i>m/ft</i>)	Statu	s of Well	Ber	ommanded and a	11.16 . 101	20		20	
Diameter (cm/in)	(Galvanize Concrete, I	d, Fibreglass, Plastic, Steel)	Thickness (cm/in)	From	То	Repla	cement Well	Rec	commended pump de	epth (m/tt)	25	-	25	
6.25	Stee	1	.188	+2	20	E Test H	2-2-2-1 C	Rec	commended pump ra	te	30		30	
							tering Well vation and/or		C. S.		40		40	
			-				oring Hole	Wel	production (Vmin / G	PM)	50	-		
-		-		1		(Const	truction)	-	nfected?		101224	-	50	-
1999 Star	Con	struction R	ecord - Scr	200			cient Supply		Yes No		60		60	
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						C Other,	specify		1	Ma	13-	PW		East
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90 (m/	(ft) Gas	Other, spe	cify		Depth From	(<i>m/ft</i>) To	Diameter (cm/in)					ř-	7	Line
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(m/ Water found	at Depth	Other, spe Gind of Water	Cify	Untested	20	109	6"				54			
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Business Na	We	Il Contracto	r and Well	Technician				-	0			I	1	
Chalk	Well]	Drilli	ng Ltd.		Well		s Licence No.		Beechu	spod	Ra	÷.		
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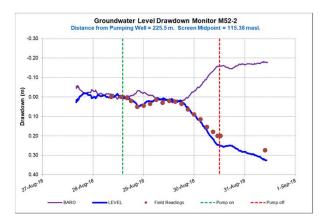
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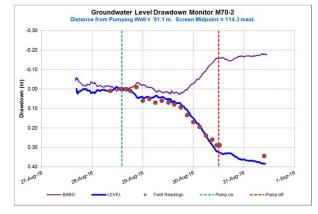
APPENDIX B

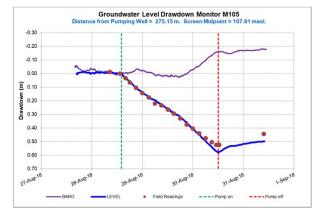
Observation Well Drawdown Curves

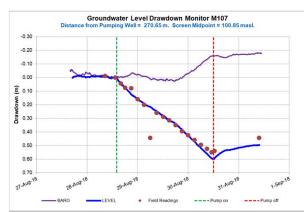


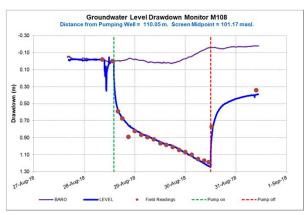
Observation Well Drawdown Charts

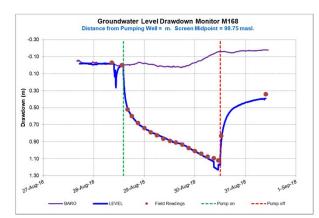


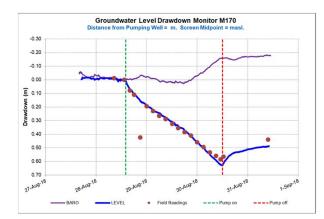




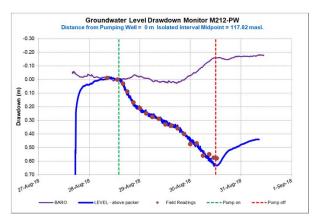


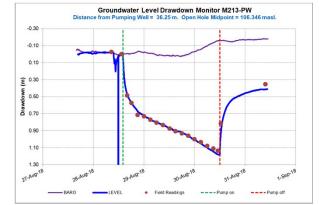


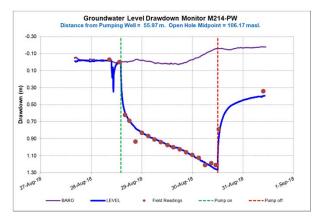


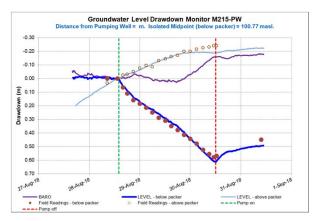


Observation Well Drawdown Charts





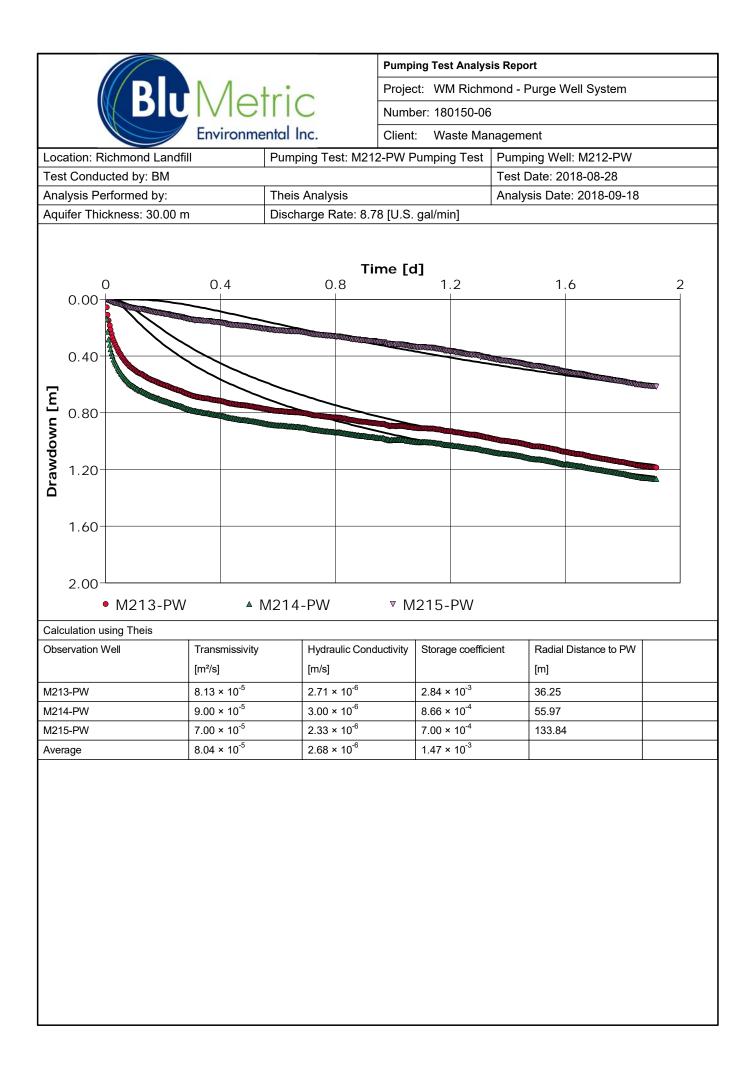


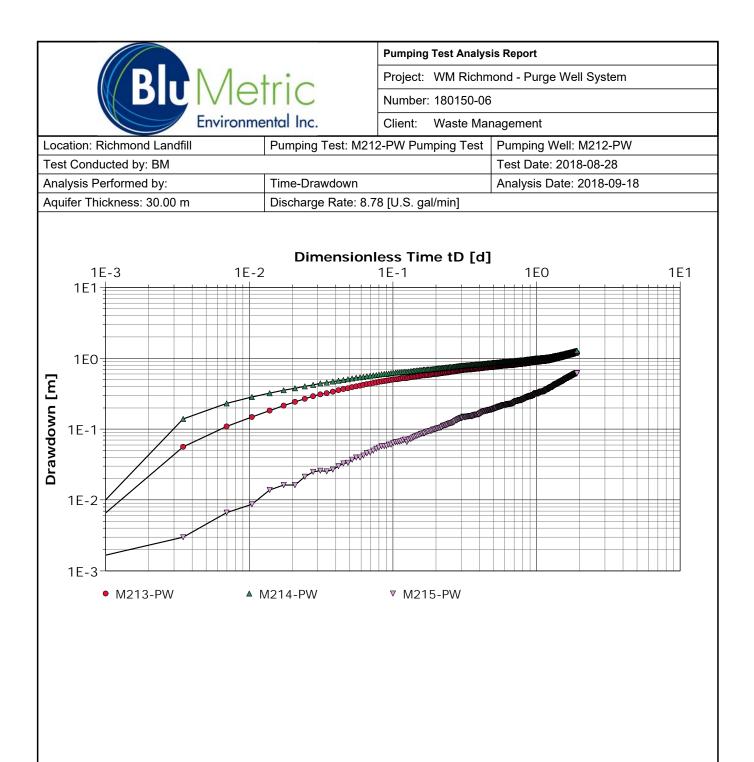


APPENDIX C

Pumping Test Analysis



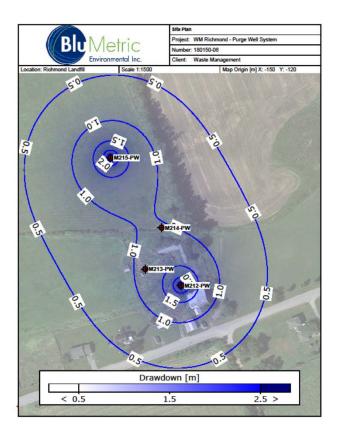


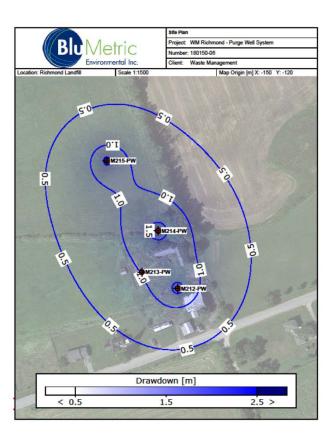


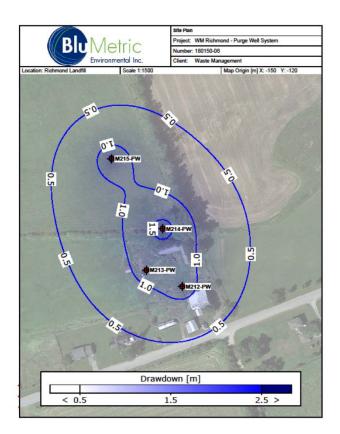
APPENDIX D

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