GeoHydroCycle, Inc.

Hazardous Waste
Water Supply

Assessment
Remediation
Analyses
Permitting
Modeling
Software

October 27, 2019

Mr. Ted O'Harte
136 Seekonk Street
Norfolk, MA 02056

re: Lakeland Hills
Norfolk, MA
Groundwater Evaluation
GHC #17020

Dear Mr. O'Harte:

GeoHydroCycle, Inc. (GHC) is pleased to present you with the results of our evaluation of groundwater conditions at the proposed Lakeland Hills project at 144 Seekonk Street in Norfolk, MA. GHC's analysis included: the installation of six groundwater monitoring wells, performance of single well slug tests in two of the wells, analysis of groundwater flow based on groundwater levels recorded in three wells, and the simulation of groundwater mounding conditions.

Using data from the newly installed groundwater monitoring wells, GHC has prepared the following for the area around the proposed leach field:

1. Groundwater contour plan.
2. Seasonal high groundwater contour plan.
3. Groundwater mound height using 25,000 gallon per day discharge.
4. Groundwater elevation contours under mounding and seasonal high groundwater conditions.

1.0 Introduction

Lakeland Hills is a proposed residential development off Seekonk Street in Norfolk, MA (the Site), see Figure 1 in Enclosure 1. Based on Tile 5, Lakeland Hills will discharge as much as 25,000 gallons per day to groundwater under the Massachusetts Groundwater Discharge Permit program. Treated wastewater discharge is proposed to be into a 17,500 square foot leach field located in the southern portion of the property, as shown in Figure 2.

2.0 Well Installation and Testing

From October 14 to October 16, 2019, a GHC representative observed the installation of six groundwater monitoring wells at the Site. Drilling was accomplished by Drilex Environmental using a hollow stem auger mounted on an All-Terrain Vehicle. Wells were located around the proposed leach field, as shown in Figure 2.

Well Drilling

Drilling depths ranged between 12 and 19 feet and soil samples were obtained at 5-foot intervals. Visual inspection of the soil samples showed primarily Sands and Gravels with varying

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amounts of silt. Following the drilling 2-inch PVC wells were installed in the six borings. Well screens were set at or near the deepest extent of drilling. At the end of the drilling groundwater was found in three of the new monitoring wells, MW-1, MW-3 and MW-5. Each of these wells was developed by Drilex after installation. Enclosure 2 presents well logs summarizing the soils encountered and the construction of the wells.

Well Testing

On October 18, 2019 GHC was at the Site to measure groundwater and conduct aquifer slug tests in the monitoring wells that had been developed by Drilex after the installations. Following groundwater measurement, GHC conducted two sets of falling and rising head tests in wells that contained sufficient water (MW-1 and MW-3). The combined falling head and rising head slug test protocol involved: 1) measuring the depths to groundwater in each well; 2) installing a pressure transducer (INW) in the well to be tested; 3) connecting the transducer cable to a laptop computer; 4) recording the static depth of the transducer; 5) inserting a solid slug into the well and recording a falling head test; 6) allowing the water level to recover to 95 percent of pretest level; 7) beginning the rising head test by removing the solid slug from the well and recording the data. Each test was performed using a slug capable of displacing water in the 2-inch diameter well approximately 0.80 feet. This testing method produced four test results for each well.

To analyze the slug test data GHC used two methods, Bouwer & Rice[1] and Hvorslev[2] (Basic Time Lag and Variable Head). These two methods provided three solutions for each slug test, and for the two tested wells resulted in a total of 24 hydraulic conductivity estimates. Plots of these analyses are presented in Enclosure 3, which also presents a summary of a statistical analyses method developed by the Connecticut DEP[3]. The method was developed to provide a basis for selecting hydraulic conductivities for the design of large wastewater systems.

The resulting hydraulic conductivity is 87.1 feet per day, which is consistent with hydraulic conductivities for similar soils. This value of hydraulic conductivity was used for the groundwater mounding model.

3.0 Groundwater Contour Plan

GHC personnel were at the Site on October 18, 2019 to take groundwater depth measurements in the six new monitoring wells. Using the surveyed top of well (TOC) elevations provided by Andrews Survey & Engineering, GHC converted the depth measurements to water table elevations, see Table 3.0.1.

[1] Bouwer, H. and R. C. Rice. *A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells.* Water Resources Research, Vol. 12, pp. 423-428, 1976.
Bouwer, H. *The Bouwer and Rice Slug Test - An Update*. Ground Water, pp. 304-309, Vol. 27, No.3, 1989.

[2] Hvorslev, M.J. 1951. *Time Lag and Soil Permeability in Groundwater Observations.* U.S. Army Corps Engrs. Waterways Exp. Sta. Bull. 36, Vicksburg, Miss.

[3] Connecticut DEP. 2006. Guidance for the Design of Large Scale On-Site Wastewater Renovation Systems, Appendix C - Selecting Hydraulic Conductivity Values for Design.

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Table 3.0.1. Groundwater Measurements, October 18, 2019.

Well	Top of Well Casing (Elev)	Depth to Groundwater (ft)	Groundwater Elevation (Elev)
MW-1	187.92	15.46	172.46
MW-2	182.16	dry	
MW-3	199.46	16.47	182.99
MW-4	192.14	dry	
MW-5	181.57	21.68	159.89
MW-6	170.31	dry	

Based on the groundwater elevation data presented in Table 3.0.1, GHC prepared a groundwater contour map, see Figure 3. As the figure illustrates, groundwater beneath proposed leach field flows south toward an unnamed tributary of the Stop River which is located to the east of the property.

4.0 Groundwater Mounding

Prior to calculating groundwater mounding, as required by state guidelines[4], it is necessary to estimate a base seasonal high groundwater condition. For this report GHC used the Frimpter Method[5] to calculate seasonal high groundwater for the Site. The Frimpter Method calculates an adjustment which is commonly added to the measured groundwater values. The following Table 5.01 presents the Frimpter calculations.

Table 4.0.1. Frimpter Method.

Parameter	Depths (feet)	Notes
Measured Depth to Groundwater (Sc)	16.47	MW-3, 10/18/19
Range in GW levels in similar topography (Sr)	3.98	Valley - 10%
Measured depth to GW at similar time (OWc)	6.53	USGS Norfolk Well 10/18/19
Measured depth of max GW level (OWmax)	3.48	
Maximum GW range (OWr)	3.56	
Predicted depth to SHGW (Sh)	13.06	
Difference between measured and predicted	3.41	Frimpter Adjustment

The Frimpter analysis resulted in a 3.41 foot adjustment to the 10/18/19 groundwater measurements, essentially raising the measured groundwater up 3.41 feet.

Table 4.0.2. Seasonal High Groundwater.

Well	Measured Groundwater Elevation (Elev)	Frimpter Adjustment (ft)	Seasonal High Groundwater Elevation (Elev)
MW-1	172.46	3.41	175.87
MW-3	182.99	3.41	186.40
MW-5	159.89	3.41	163.30

As shown in Figure 4, using the groundwater elevations from Table 4.0.1, GHC added 3.41 feet to calculate seasonal high groundwater. Based on the groundwater contours shown in Figure 4, seasonal

[4] Massachusetts DEP. November 2014. *Guidelines for the Design, Construction, Operation, and Maintenance of Small Wastewater Treatment Facilities with Land Disposal.*

[5] Frimpter, M.H., 1981. Probable High Groundwater Levels in Massachusetts. *USGS, WRI 80-1205*.

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high groundwater flows south toward an unnamed tributary of the Stop River which is located to the east of the property.

GHC used the seasonal high groundwater elevations and the bottom elevations of the three wells MW-1, MW-3 and MW-5 to calculate a saturated thickness of 5.8 feet for the groundwater mounding model.

5.0 Groundwater Model Development and Simulation

GHC accomplished the groundwater mounding analyses for the Site with the widely used and accepted groundwater model, MODFLOW. Input parameters to the model were obtained from GHC's environmental drilling logs, field observations and testing data.

Information concerning the design of the SAS was obtained from Andrews Survey & Engineering and included: 1) the wastewater application rate of 25,000 gallons per day, and 2) the location and layout of the square foot leach field.

5.1 Conceptual Model

In developing the groundwater model to predict the mounding height beneath the proposed leach field, GHC prepared a conceptual model of the aquifer. Features of the conceptual model include:

1. The predictive simulation can be achieved by modeling the proposed aquifer stress on a flat water table with the resulting changes in the water table superimposed onto a measured groundwater surface;
2. The aquifer beneath the Site can be modeled as a single, unconfined layer with the water table as the upper surface;
3. Seasonal high groundwater can be estimated by adding a single value, calculated using the Frimpter method or measured mottling, to the contours of measured groundwater elevations;
4. Elevations of the aquifer lower surface can be estimated using refusal observations made during the drilling of Site borings;
5. An average saturated thickness can be calculated using the elevation difference between seasonal high groundwater and refusal in Site wells;
6. Aquifer hydraulic conductivity can be estimated using single well slug tests; and
7. An average hydraulic conductivity based on single well test results can be used in the model to be representative of the entire modeled aquifer.

5.2 MODFLOW Setup

The following paragraphs describe the MODFLOW model input parameters. Figures 8a and 8b shows the MODFLOW features

5.2.1 Model Parameters

The MODFLOW model was designed to represent a single layer, unconfined aquifer as described above using a 2,048 foot by 2,048 foot grid. In plan view, the aquifer was gridded using a variable node spacing consisting of 64 foot by 64 foot at the edges of the model and telescoping to a 16 by 16 foot in the area of the leach field. The smaller grid spacing was used in the area around the leach field where discharge to groundwater causes steeper gradients. Higher resolution from the smaller grid spacing allows for a more accurate model prediction of groundwater elevations around SAS areas, see Figure 5A.

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5.2.2 Wastewater Recharge

To simulate the application of 25,000 gallons per day of treated wastewater into the 17,500 square foot bottom of the SAS areas, GHC designated 67 nodes in the model to simulate the wastewater recharge. This results in a leach field area in the model of 17,152 square feet which is smaller than the actual disposal area. To account for the difference in areas, values of the simulated recharge to these nodes were increased by the ratio of the actual area divided by the modeled area. The result was that the proposed actual application rate of 25,000 gallons per day was accurately simulated, see Figure 5B.

5.3 MODFLOW Simulation

To predict the groundwater mounding beneath the proposed soil absorption system, GHC ran a transient MODFLOW simulation. Table 10.3.1 summarizes the parameters used in the model.

Table 5.3.1. MODFLOW Model Input Parameters.

Parameter	Value	Unit
Disposal Rate:	25,000	gallons per day
Model Soil Absorption Area :	17,152	square feet
Model Recharge Rate:	0.194860	cubic feet per day per square foot
Hydraulic Conductivity:	87.1	feet per day
Saturated Thickness:	5.8	feet
Mounding Time	90	days

6.0 MODFLOW Mounding Results

Results of the MODFLOW groundwater mounding simulation indicated that the increase in groundwater due to the application of treated wastewater into the soil absorption system would be 2.6 feet, see Figure 6. Superimposing the mounding on the Seasonal High Groundwater elevations yields simulated groundwater elevations under the proposed leach field, see Figure 7. This figure demonstrates that the maximum predicted mounded groundwater elevation at the Site beneath the leach field will be approximately elevation 191 feet.

If you have any questions, please call me.

Sincerely,
GeoHydroCycle, Inc.

Stephen W. Smith, P.E., P.HGW.

Enclosures: 1 - Figures
2 - Well Drilling Logs
3 - Slug Test Results

cc: Mr. Christopher Agostino, Ruberto, Israel & Weiner
Mr. Travis Brown, Andrews Survey & Engineering, Inc.
Mr. Carlos Quintal, CAQ Engineering Associates
Mr. Sean Reardon, Tetra Tech

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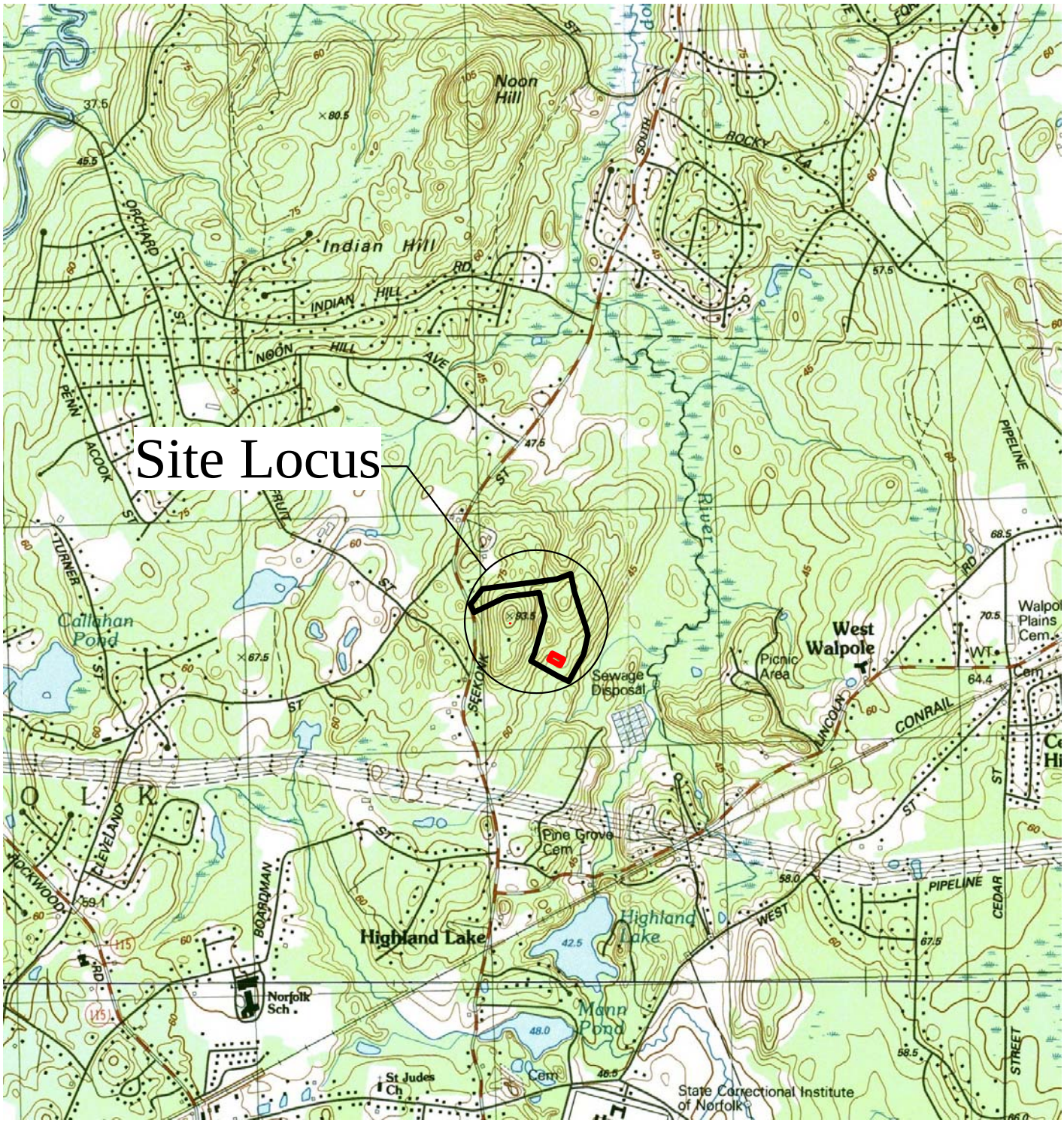
Enclosure 1 - Figures



0 2,000

Scale in feet

Base Map: MassGIS Quads.

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Figure 1. Site Locus.

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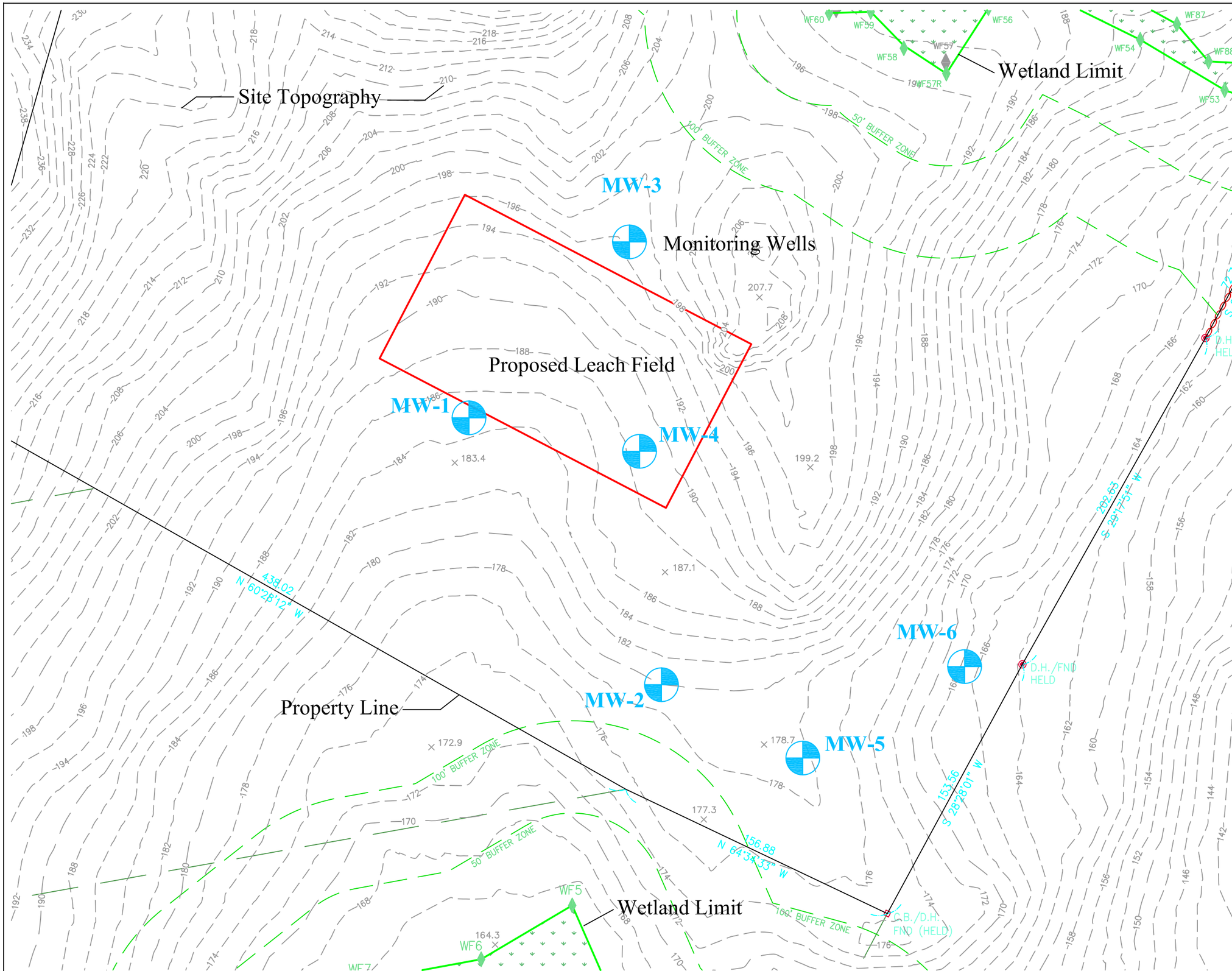

Figure 2. Site Features.

0 50

Scale in feet

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Date 10/23/19 Rev 10/27/19
Base Map: CAD file from
Andrew Survey & Engineering.

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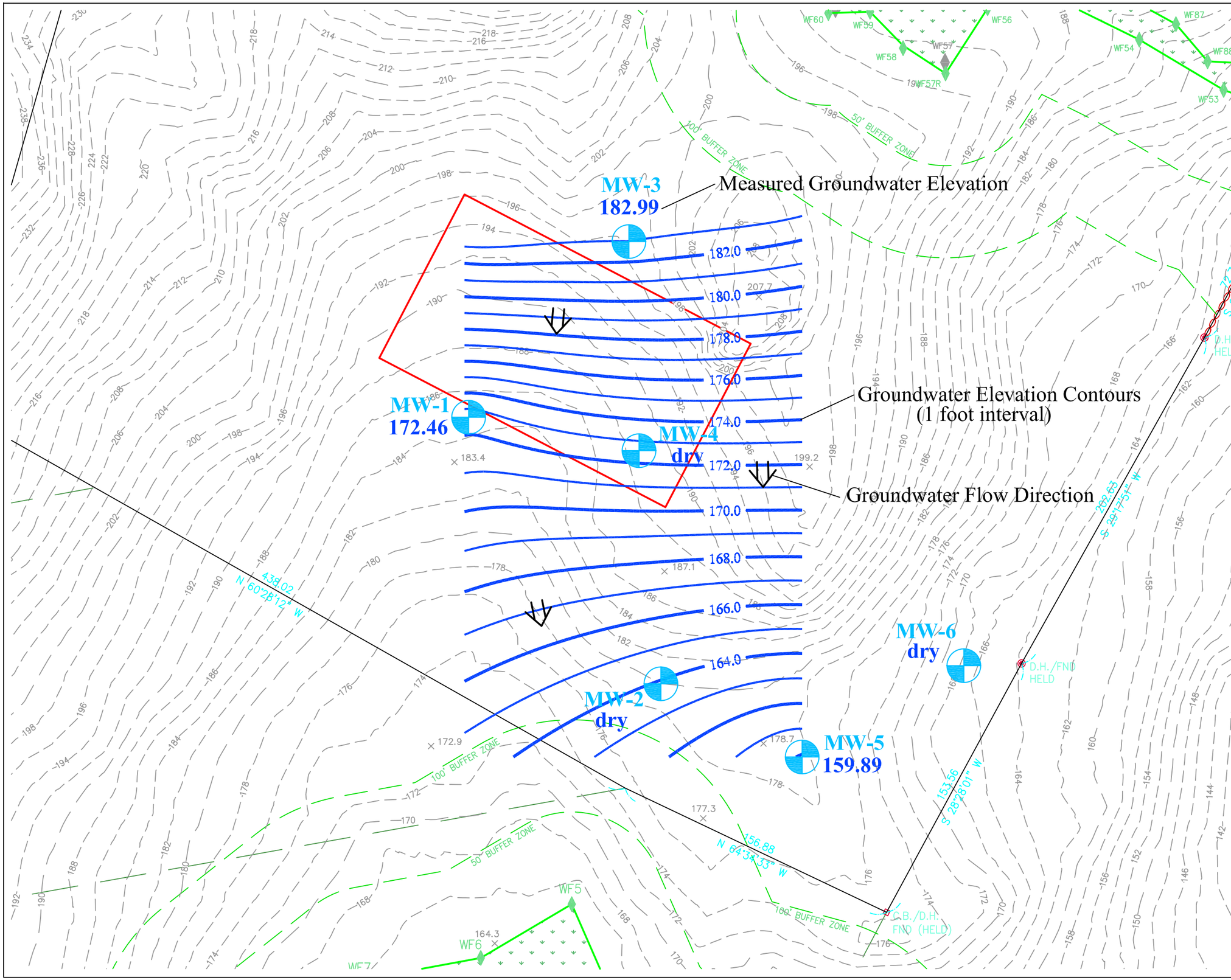

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Figure 3. Groundwater Elevation Contours, Measured 10/18/19.

0 50

Scale in feet

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Base Map: CAD file from
Andrew Survey & Engineering.

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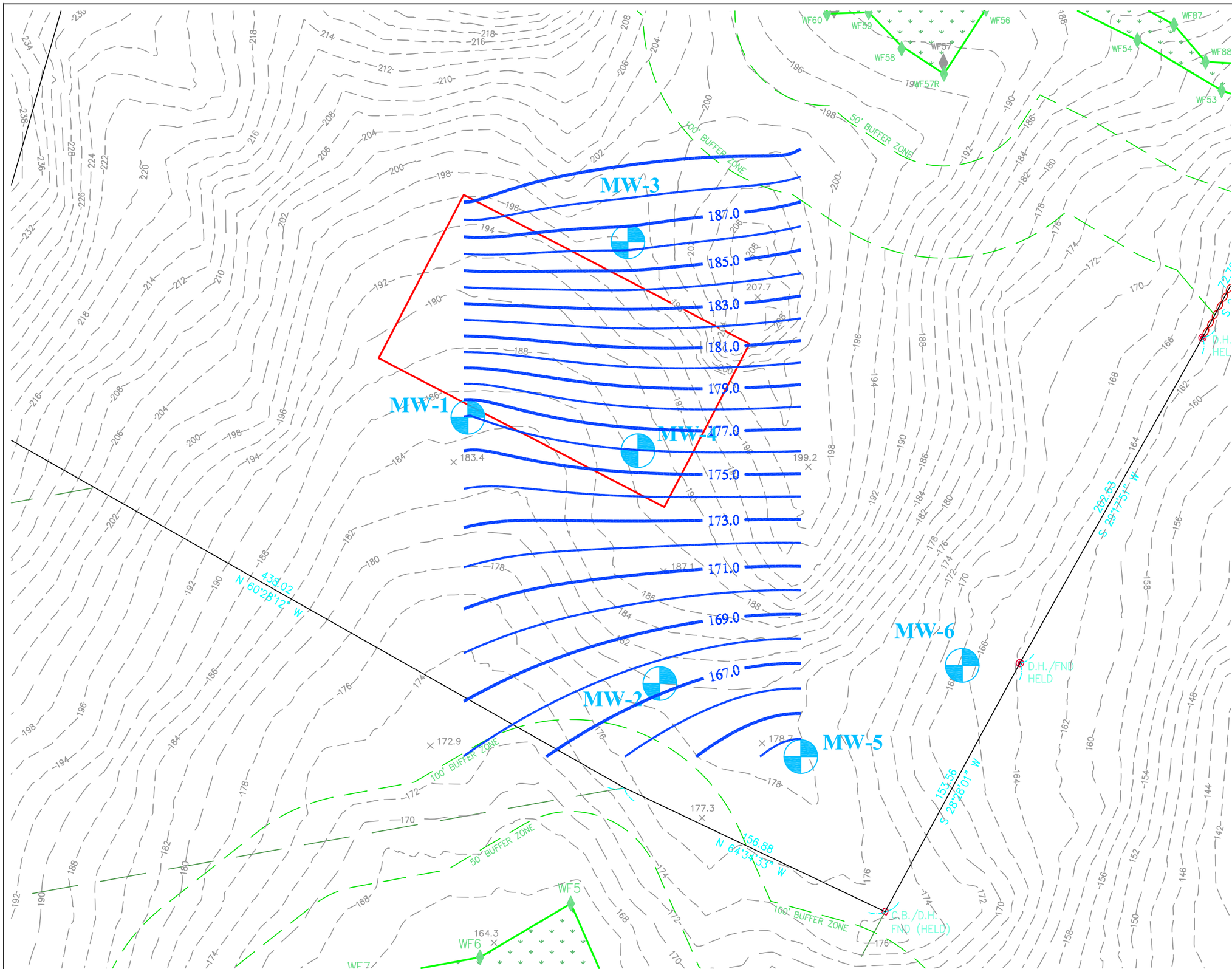

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Figure 4. Seasonal High Groundwater Elevation Contours.

0 50

Scale in feet

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Base Map: CAD file from
Andrew Survey & Engineering.

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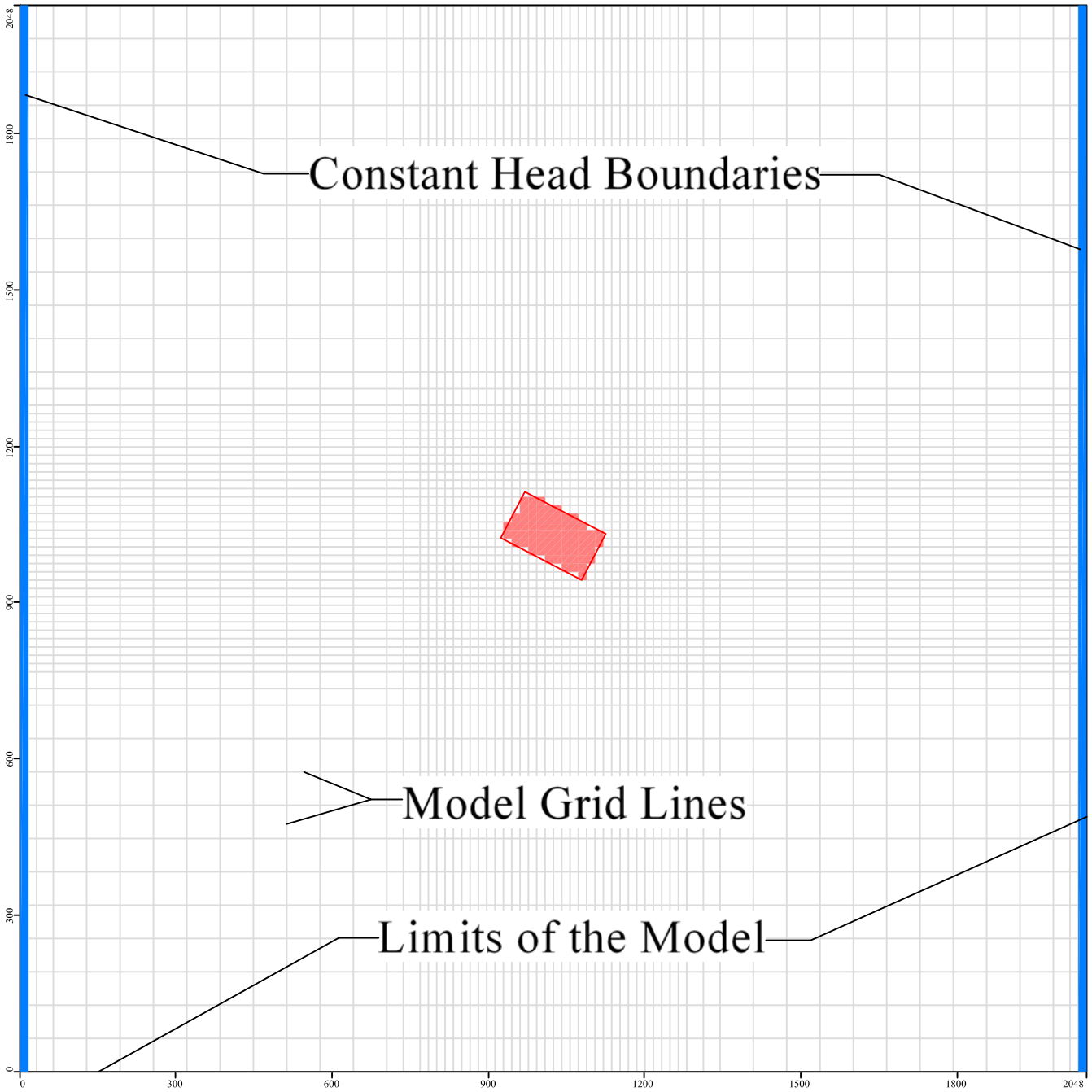

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Figure 5A. MODFLOW Layout.

0 300
Scale in feet

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Date 10/24/19 Rev
Base Map: MODFLOW.

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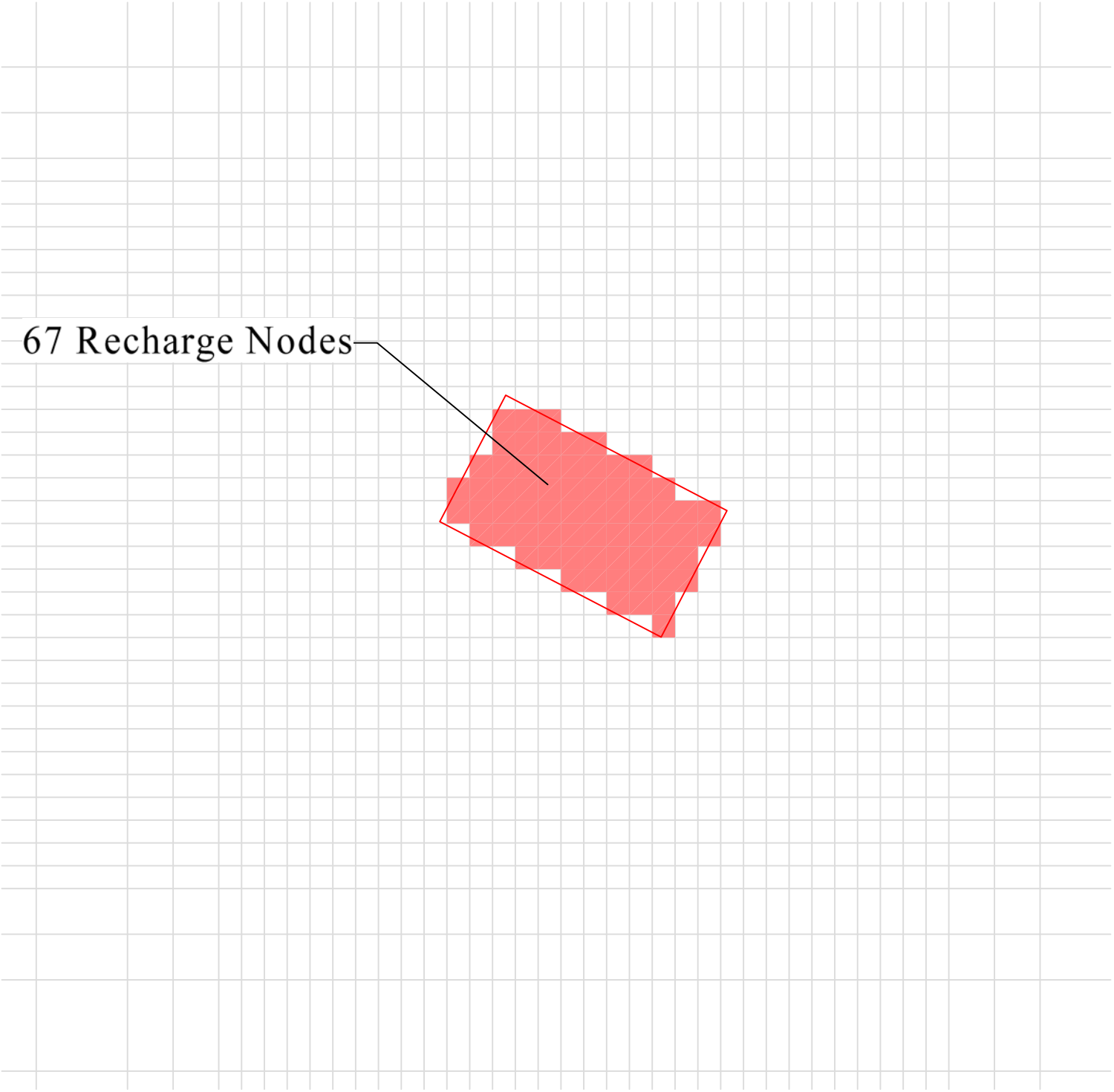

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Figure 5B. MODFLOW Recharge.

0 100
Scale in feet

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Base Map: MODFLOW.

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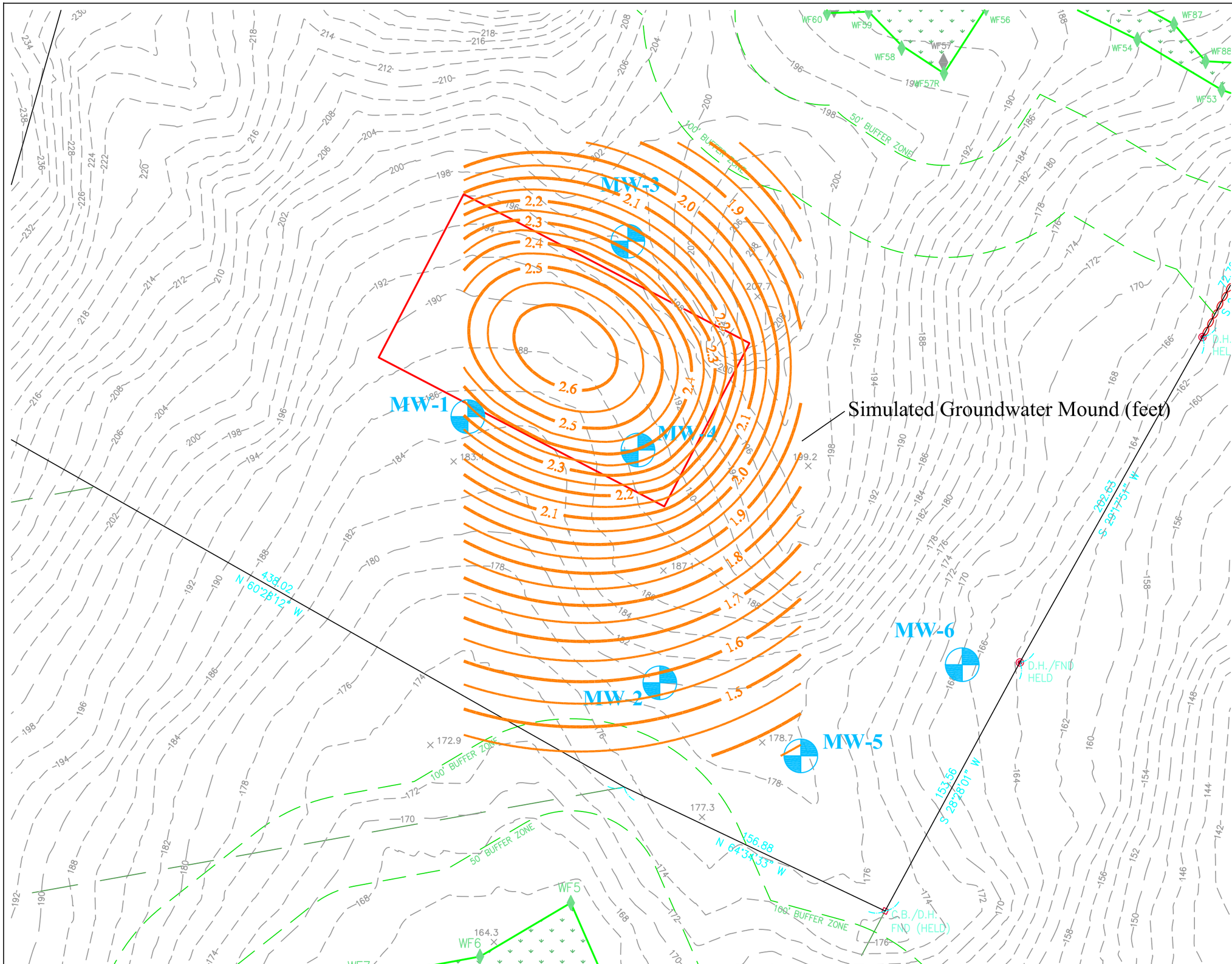

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Figure 6. Groundwater Mound Height, Discharge 25,000 Gallons per Day.

0 50

Scale in feet

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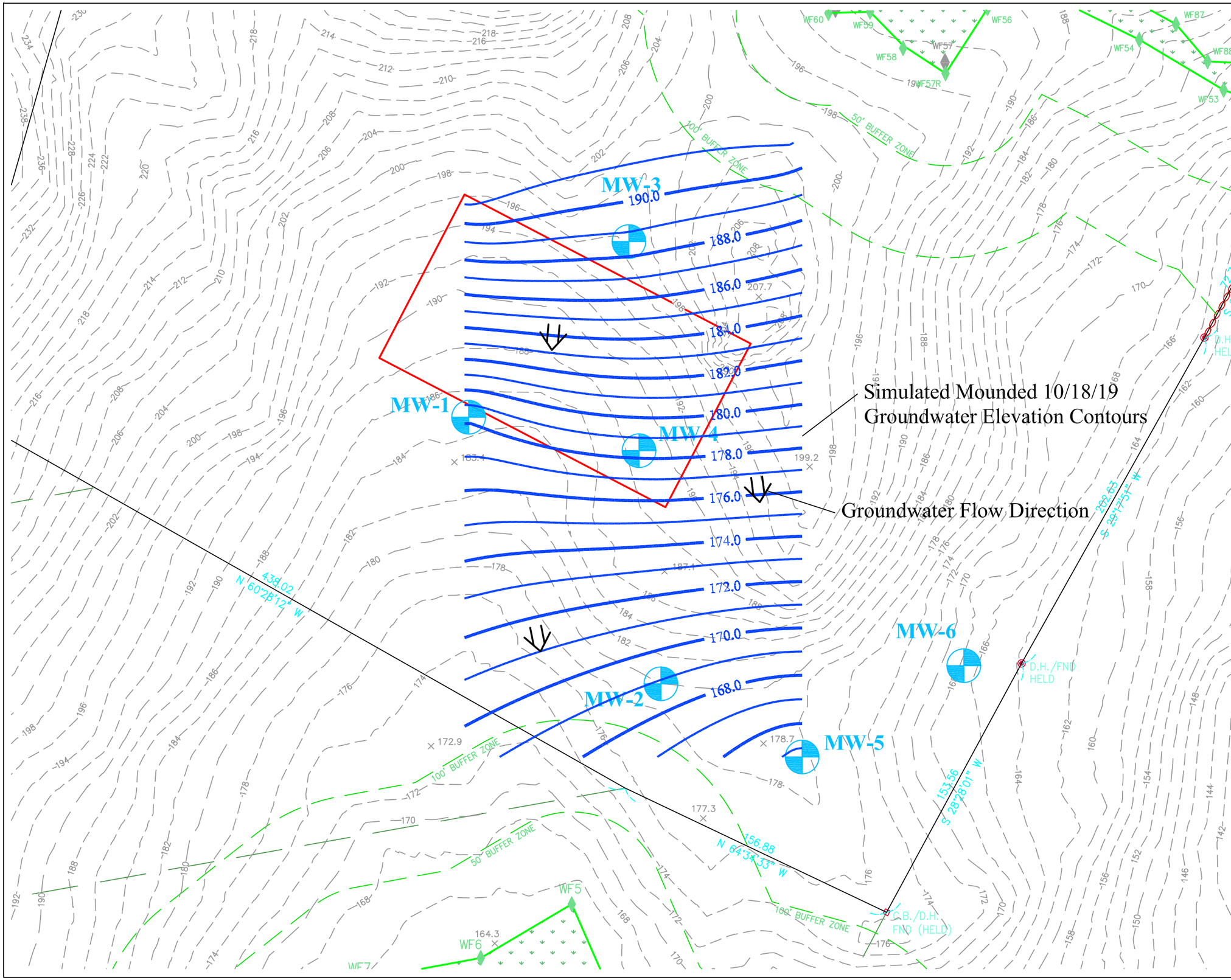
Drafted SWS Checked
Date 10/23/19 Rev 10/27/19
Base Map: CAD file from
Andrew Survey & Engineering.

GeoHydroCycle, Inc.



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144 Seekonk Street
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Figure 7. Mounded Seasonal High Groundwater Elevations, Discharge 25,000 Gallons per Day.

Project No. GHC#17020
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Date 10/23/19 Rev 10/27/19
Base Map: CAD file from
Andrew Survey & Engineering.

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Enclosure 2 - Well Drilling Logs

Log of Borehole: MW-1

Project: Lakeland Hills LLC

Client: Lakeland Hills LLC

Location: Norfolk, MA

Geologist/Engineer: Jim O'Brien

SUBSURFACE PROFILE				SAMPLE			Standard Penetration Test	Well Data	Remarks
Depth (ft / m)	Symbol	Description	Elev.	Number	N value	Recovery	blows (25, 50, 75)		
0 / 0		Ground Surface	0						
		Overburden Note-No soil samples collected from 0 to 5 feet Monitoring well relocated 3 times due to cobble and boulder shallow refusals	-5				1, 10		Standpipe 3.03 ft stick-up; Concrete 0-2 feet; Bentonite 2-3 feet; Silica sand 3-14 feet
		Glacial Deposits Very dense gray medium to fine GRAVEL, little coarse to fine sand, trace silt Numerous cobbles and boulders-auger advancement difficult	-10	S-1	75		65, 60		Well screen 4-14 feet
		Glacial Deposits Very dense dark gray coarse to fine SAND, trace fine gravel, trace silt Numerous cobbles and boulders-auger refusal at 14 feet	-14	S-2	71		20, 32, 39, 60		DrilEx developed well with Whale pump-good recharge; Groundwater @ 12.20 feet below GS
		End of Borehole							

Drill Method: Hollow Stem Augers

Drill Date: 14 October 2019

Borehole Size: 4.25 inch ID

O'Brien And O'Brien Associates

Datum: NA

Driller: DrilEx

Sheet: 1 of 1

Log of Borehole: MW-2

Project: Lakland Hills LLC

Client: Lakeland Hills LLC

Location: Norfolk, MA

Geologist/Engineer: Jim O'Brien

SUBSURFACE PROFILE				SAMPLE			Standard Penetration Test	Well Data	Remarks
Depth (ft / m)	Symbol	Description	Elev.	Number	N value	Recovery	blows (25, 50, 75)		
0		Ground Surface	0						
		Overburden Note-No soil samples collected from 0 to 5 feet. Monitoring well was relocated 4 times due to cobble and boulder shallow refusals	-5						Standpipe 3.16 ft stick-up; Concrete 0-2 feet; Bentonite 2-3 feet; Silica sand 3-10 feet
		Glacial Deposits Dense gray medium to fine SAND, trace medium to fine gravel, trace silt. Numerous cobbles and boulders-auger advancement difficult	-7	S-1	32		12, 14, 18, 20		Well screen 5-10 feet
		Glaciaol Deposits Very dense gray medium to fine GRAVEL, little coarse to fine sand, trace silt Numerous cobbles and boulders-auger refusal at 12 feet	-12	S-2	105		28, 48, 57, 59		No groundwater following installation
		End of Borehole							

Drill Method: Hollow Stem Auger

Drill Date: 15 October 2019

Borehole Size: 4.25 inch ID

O'Brien And O'Brien Associates

Datum: NA

Driller: DrilEx

Sheet: 1 of 1

Log of Borehole: MW-3

Project: Lakeland Hills LLC

Client: Lakeland Hills LLC

Location: Norfolk, MA

Geologist/Engineer: Jim O'Brien

SUBSURFACE PROFILE				SAMPLE			Standard Penetration Test	Well Data	Remarks
Depth (ft / m)	Symbol	Description	Elev.	Number	N value	Recovery	blows (25, 50, 75)		
0		Ground Surface	0						
		Overburded Note-No soil samples collected from 0 to 5 feet. Monitoring well relocated once due to cobble and boulder shallow refusals	-5						Standpipe 3.00 ft stick-up; Concrete 0-2 feet; Natural soils backfill 2-7 feet
		Glacial Deposits Very dense gray medium to fine GRAVEL, trace coarse to fine sand, trace silt Numerous cobbles and boulders-auger advancement difficult	-8.5	S-1	84		33, 51, 50		Bentonite 7-7.5 feet
		Glacial Deposits Very dense gray medium to fine SAND, little medium to fine gravel, trace silt w/ lenses of medium gravel Numerous cobbles and boulders-auger advancement difficult	-15	S-2	59		20, 28, 31, 43, 27		Silica sand 7.5 to 18.5 feet; Well screen 8.5 to 18.5 feet; Groundwater @ 13.37 feet below GS

Drill Method: Hollow Stem Augers

Drill Date: 15 October 2019

Borehole Size: 4.25 inch ID

O'Brien And O'Brien Associates

Datum: NA

Driller: DrilEx

Sheet: 1 of 2

Log of Borehole: MW-3

Project: Lakeland Hills LLC

Client: Lakeland Hills LLC

Location: Norfolk, MA

Geologist/Engineer: Jim O'Brien

SUBSURFACE PROFILE				SAMPLE			Standard Penetration Test		Remarks
Depth	Symbol	Description	Elev.	Number	N value	Recovery	blows (25, 50, 75)	Well Data	
16, 17, 18		***Glacial Deposits*** Very dense gray medium to fine SAND, trace silt Numerous cobbles and boulders-auger refusal at 18.5 feet	-18.5	S-3	55		26, 29, 46		DrilEx developed well with Whale pump-good recovery
19		End of Borehole							

Depth scale: 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30; 5, 6, 7, 8, 9

Drill Method: Hollow Stem Augers

Drill Date: 15 October 2019

Borehole Size: 4.25 inch ID

O'Brien And O'Brien Associates

Datum: NA

Driller: DrilEx

Sheet: 2 of 2

Log of Borehole: MW-4

Project: Lakeland Hills LLC

Client: Lakeland Hills LLC

Location: Norfolk, MA

Geologist/Engineer: Jim O'Brien

SUBSURFACE PROFILE				SAMPLE			Standard Penetration Test	Well Data	Remarks
Depth (ft / m)	Symbol	Description	Elev.	Number	N value	Recovery	blows (25, 50, 75)		
0		Ground Surface	0						
		Overburden Note-No soil samples collected from 0 to 10 feet Boring advanced within TP-2041							Standpipe 3.06 ft stick-up; Concrete 0-2 feet; Natural soil backfill 2-5 feet; Bentonite 5-5.5 feet; Silica sand 5.5 to 17 feet
10			-10				16, 25, 37, 73		Well screen 7-17 feet
				S-1	62				
		Glacial Deposits Very dense gray medium to fine GRAVEL, trace coarse to fine sand, trace silt Numerouis cobbles and boulders-auger advancement difficult					21		No groundwater following installation

Drill Method: Hollow Stem Augers

Drill Date: 15 October 2019

Borehole Size: 4.25 inch ID

O'Brien And O'Brien Associates

Datum: NA

Driller: DrilEx

Sheet: 1 of 2

Log of Borehole: MW-4

Project: Lakeland Hills LLC

Client: Lakeland Hills LLC

Location: Norfolk, MA

Geologist/Engineer: Jim O'Brien

SUBSURFACE PROFILE				SAMPLE			Standard Penetration Test	Well Data	Remarks
Depth	Symbol	Description	Elev.	Number	N value	Recovery	blows (25, 50, 75)		
16				S-2	89		42, 47, 60		
5			-16.6						
17		***Glacial Deposits*** Very dense dark gray coarse to fine SAND, trace silt Numerous cobbles and boulders-auger refusal at 17 feet	-17						
18									
19		End of Borehole							
6									
20									
21									
22									
23									
7									
24									
25									
26									
8									
27									
28									
29									
9									
30									

Drill Method: Hollow Stem Augers

Drill Date: 15 October 2019

Borehole Size: 4.25 inch ID

O'Brien And O'Brien Associates

Datum: NA

Driller: DrilEx

Sheet: 2 of 2

Log of Borehole: MW-5

Project: Lakeland Hills LLC

Client: Lakeland Hills LLC

Location: Norfolk, MA

Geologist/Engineer: Jim O'Brien

SUBSURFACE PROFILE				SAMPLE			Standard Penetration Test	Well Data	Remarks
Depth (ft / m)	Symbol	Description	Elev.	Number	N value	Recovery	blows (25, 50, 75)		
0 / 0		Ground Surface	0						Standpipe 3.5 ft stick-up
1, 2, 3, 4 / 1		***Overburden*** Note-No soil samples collected from 0 to 5 feet Monitoring well relocated twice due to cobbble and boulder shallow refusals	-5						Concrete 0-2 feet; bentonite 2-3 feet
5, 6, 7 / 2		***Glacial Deposits*** Medium dense gray medium to fine SAND, trace fine gravel, trace silt	-8.5	S-1	15		6, 5, 10, 10		Silica sand 3-19 feet
9, 10, 11, 12 / 3		***Glacial Deposits*** Medium dense to stiff finely interbedded SILT, little fine sand w/fine sand partings and lenses	-13	S-2	12		6, 6, 6, 9		Well screen 4 to 19 feet
13, 14, 15 / 4							5		No groundwater following installation

Drill Method: Hollow Stem Augers

Drill Date: 16 October 2019

Borehole Size: 4,25 inch ID

O'Brien And O'Brien Associates

Datum: NA

Driller: DrilEx

Sheet: 1 of 2

Log of Borehole: MW-5

Project: Lakeland Hills LLC

Client: Lakeland Hills LLC

Location: Norfolk, MA

Geologist/Engineer: Jim O'Brien

SUBSURFACE PROFILE				SAMPLE			Standard Penetration Test	Well Data	Remarks
Depth	Symbol	Description	Elev.	Number	N value	Recovery	blows (25, 50, 75)		
16		***Glacial Deposits*** Vert dense gray medium to fine GRAVEL, little coarse to fine sand, trace silt Numerous cobbles and boulders-auger refusal at 19 feet		S-3	62		16, 46, 41		
17									
18									
19			-19						
		End of Borehole							
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

Drill Method: Hollow Stem Augers

Drill Date: 16 October 2019

Borehole Size: 4,25 inch ID

O'Brien And O'Brien Associates

Datum: NA

Driller: DrilEx

Sheet: 2 of 2

Log of Borehole: MW-6

Project: Lakeland Hills LLC

Client: Lakeland Hills LLC

Location: Norfolk, MA

Geologist/Engineer: Jim O'Brien

SUBSURFACE PROFILE				SAMPLE			Standard Penetration Test (blows)	Well Data	Remarks
Depth (ft / m)	Symbol	Description	Elev.	Number	N value	Recovery	25 50 75		
0 / 0		Ground Surface	0						
1, 2, 3 / 1		***Overburden*** Note-No soil samples collected from 0-5 feet Monitoring well relocated 4 times due to cobble and boulder shallow refusals	-5						Standpipe 3.14 ft stick-up; Concrete 0-2 feet; Natural soil backfill 2-4 feet; Bentonite 4 to 5 feet
5, 6 / 2		***Glacial Deposits*** Dense gray coarse to fine SAND, little silt, trace medium gravel Numerous cobbles and boulders-auger refusal at 12.75 feet		S-1	46		13, 33, 60		Silica sand 5 to 12.75 feet
7, 8, 9, 10 / 3				S-2	60		60		Well Screen 7.75 to 12.75 feet
11, 12, 13 / 4		End of Borehole	-12.8						No groundwater following installation
14, 15									

Drill Method: Hollow Stem Augers

Drill Date: 16 October 2019

Borehole Size: 4,25 inch ID

O'Brien And O'Brien Associates

Datum: NA

Driller: DrilEx

Sheet: 1 of 1

Enclosure 3 - Slug Test Results

Statistics for Hydrauic Conductvity Values

K (ft/day)	Ln K
57.2	4.04655
117	4.76217
63.8	4.15575
98.1	4.58599
74.3	4.30811
27.3	3.30689
88.7	4.48526
29.0	3.36730
124	4.82028
150	5.01064
116	4.75359
267	5.58725
158	5.06260
67.6	4.21361
283	5.64545
60.6	4.10429
80.4	4.38701
165	5.10595
89.7	4.49647
113	4.72739
84.9	4.44147
37.0	3.61092
95.1	4.55493
39.3	3.67122

4.46713	Average	Mean of LNs = Geomean	87.1
4.49087	Median	Median of LNs	89.2
0.60828	Stnd Deviation	Std Dev of Geomean = s	1.8
24	Count	Number of K Values	
4.14289	1st quartile		63.0
4.49087	2nd quartile		89.2
4.77670	3rd quartile		118.7

Confidence Interval for Geomean

24	Count
4.90	Sq Root of Count

2.069	Student's t for 95% Confidence and N-1 Degrees of Freedom
87.1	Mid value of interval, which is Geometric Mean
112.6	High end of the 95% interval
67.4	Low end of the 95% interval

Does the Geometric Mean lie between the Low and High intervals?

Low: **Yes**

High: **Yes**

Check for Outliers

5.64545	Max of LNs
0.57003	LN of T statistic for Highest K value
1.77	T statistic for the Highest K value
3.30689	Min of LNs
0.55196	LN of T statistic for Lowest K value
1.74	T statistic for the Lowest K value
2.62	From Figure 2 for N-1 DoF

283	ft/day	**OK, not an outlier**
27.3	ft/day	**OK, not an outlier**

Calculate 95% Percentile Value of K

5.51505	LN of 95% Percentile Value of K
248.4	95% Percentile Value of K

Calculate Coefficient of Variation C_v

-3.85884	LN of Cv
0.02	Coefficeint of Variation Cv

BOUWER AND RICE INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-1-2
GeoHydroCycle, Inc.

Results

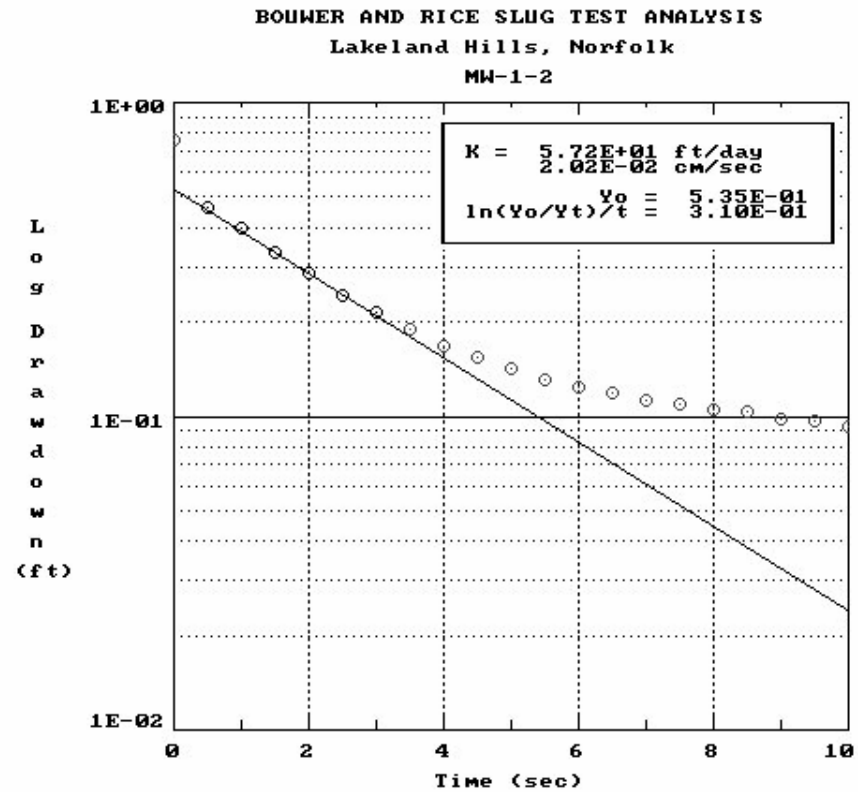
Hydraulic Conductivity: 5.72E+01 ft/day
2.02E-02 cm/sec
Y-Intercept (Yo): 5.35E-01 ft
Well Screen Ratio (Le/rw): 5.9
Dimensionless Parameter C: 0.95
Slope of Line [ln(Yo/Yt)/t]: 3.102E-01 1/sec
Well Parameters (Rc^2 / 2*Le): 1.660E-03 ft
Dimensionless Ratio [ln(Re/rw)]: 1.285
Effective Radius [Re]: 1.28 ft
Volume Tested [rw<Vol<Re]: 9.98E+00 ft^3

Well/Aquifer Parameters

Depth of well: 2.10 ft
Length of well screen: 2.10 ft
Saturated thickness: 2.10 ft
Diameter of the well casing: 0.167 ft
Diameter of the well filter: 0.708 ft

Time vs Drawdown Data

No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)
1	0.0000	0.757	2	0.5000	0.460	3	1.0000	0.397
4	1.5000	0.332	5	2.0000	0.285	6	2.5000	0.243
7	3.0000	0.215	8	3.5000	0.189	9	4.0000	0.168
10	4.5000	0.154	11	5.0000	0.142	12	5.5000	0.131
13	6.0000	0.124	14	6.5000	0.119	15	7.0000	0.112
16	7.5000	0.110	17	8.0000	0.105	18	8.5000	0.103
19	9.0000	0.098	20	9.5000	0.096	21	10.0000	0.093



HVORSLEV INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-1-2
GeoHydroCycle, Inc.

Results

Basic Time Lag-
Hydraulic Conductivity (Kh): 1.24E+02 ft/day
4.38E-02 cm/sec
Basic Time Lag: 2.09 s
2.3 Times Basic Time Lag: 4.80 s
(Equalization Ratio ÷ 0.90)

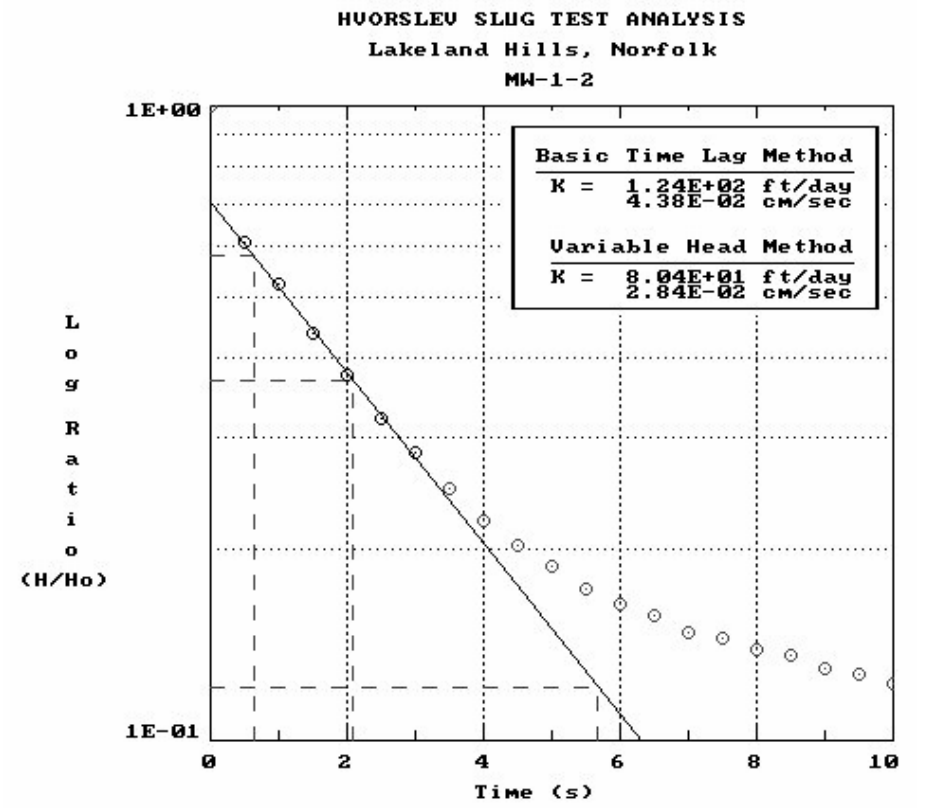
Variable Head-
Hydraulic Conductivity (Kh): 8.04E+01 ft/day
2.84E-02 cm/sec
Time Coordinate T1: 0.6 s
Time Coordinate T2: 5.7 s
Head Ratio Coordinate H1: 58.12E-02
Head Ratio Coordinate H2: 12.16E-02

Well/Aquifer Parameters

Length of well screen: 2.10 ft
Diameter of the well casing: 0.167 ft
Diameter of the well bore: 0.708 ft
Kh/Kv ratio: 1.0

Time vs Drawdown Ratio Data

No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)
1	0.0000	1.000	2	0.5000	0.608	3	1.0000	0.524
4	1.5000	0.439	5	2.0000	0.376	6	2.5000	0.321
7	3.0000	0.284	8	3.5000	0.250	9	4.0000	0.222
10	4.5000	0.203	11	5.0000	0.188	12	5.5000	0.173
13	6.0000	0.164	14	6.5000	0.157	15	7.0000	0.148
16	7.5000	0.145	17	8.0000	0.139	18	8.5000	0.136
19	9.0000	0.129	20	9.5000	0.127	21	10.0000	0.123



BOUWER AND RICE INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-1-3
GeoHydroCycle, Inc.

Results

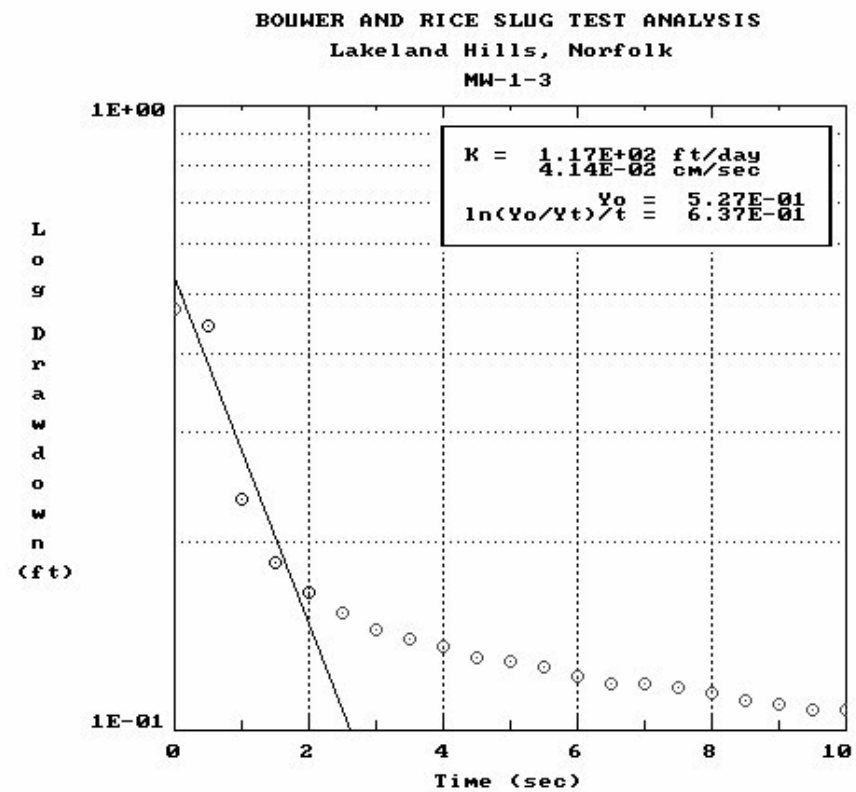
Hydraulic Conductivity: 1.17E+02 ft/day
4.14E-02 cm/sec
Y-Intercept (Yo): 5.27E-01 ft
Well Screen Ratio (Le/rw): 5.9
Dimensionless Parameter C: 0.95
Slope of Line [ln(Yo/Yt)/t]: 6.373E-01 1/sec
Well Parameters (Rc^2 / 2*Le): 1.660E-03 ft
Dimensionless Ratio [ln(Re/rw)]: 1.285
Effective Radius [Re]: 1.28 ft
Volume Tested [rw<Vol<Re]: 9.98E+00 ft^3

Well/Aquifer Parameters

Depth of well: 2.10 ft
Length of well screen: 2.10 ft
Saturated thickness: 2.10 ft
Diameter of the well casing: 0.167 ft
Diameter of the well filter: 0.708 ft

Time vs Drawdown Data

No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)
1	0.0000	0.472	2	0.5000	0.444	3	1.0000	0.234
4	1.5000	0.185	5	2.0000	0.166	6	2.5000	0.154
7	3.0000	0.145	8	3.5000	0.140	9	4.0000	0.136
10	4.5000	0.131	11	5.0000	0.129	12	5.5000	0.126
13	6.0000	0.122	14	6.5000	0.119	15	7.0000	0.119
16	7.5000	0.117	17	8.0000	0.115	18	8.5000	0.112
19	9.0000	0.110	20	9.5000	0.108	21	10.0000	0.108



HVORSLEV INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-1-3
GeoHydroCycle, Inc.

Results

Basic Time Lag-
Hydraulic Conductivity (Kh): 1.50E+02 ft/day
5.28E-02 cm/sec
Basic Time Lag: 1.73 s
2.3 Times Basic Time Lag: 3.99 s
(Equalization Ratio ÷ 0.90)

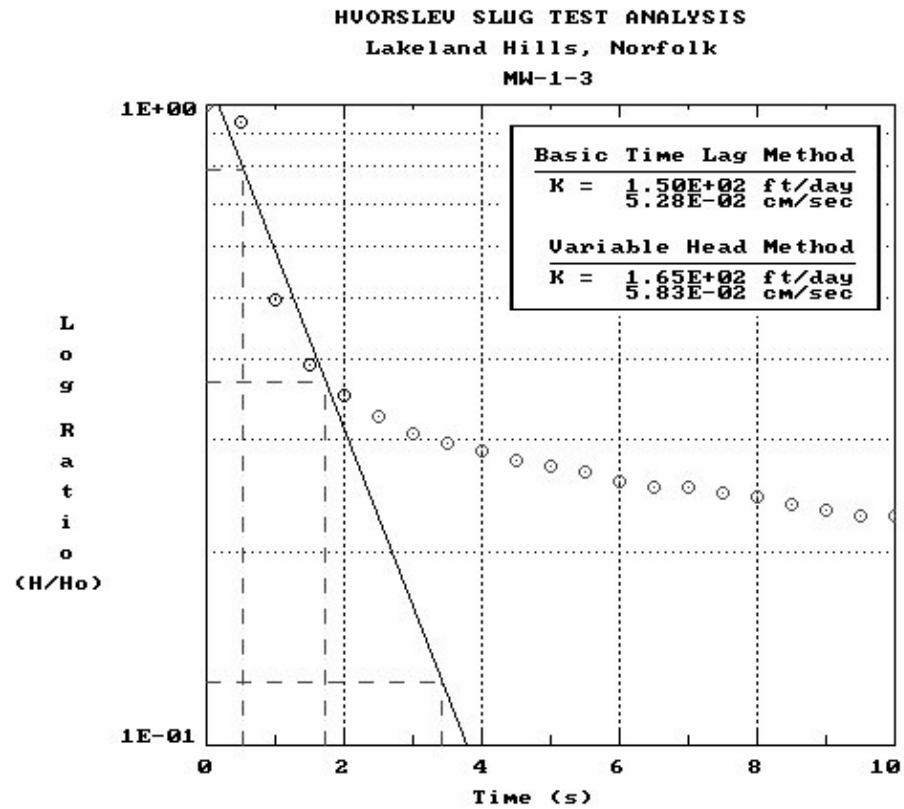
Variable Head-
Hydraulic Conductivity (Kh): 1.65E+02 ft/day
5.83E-02 cm/sec
Time Coordinate T1: 0.5 s
Time Coordinate T2: 3.4 s
Head Ratio Coordinate H1: 79.43E-02
Head Ratio Coordinate H2: 12.59E-02

Well/Aquifer Parameters

Length of well screen: 2.10 ft
Diameter of the well casing: 0.167 ft
Diameter of the well bore: 0.708 ft
Kh/Kv ratio: 1.0

Time vs Drawdown Ratio Data

No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)
1	0.0000	1.000	2	0.5000	0.941	3	1.0000	0.496
4	1.5000	0.392	5	2.0000	0.352	6	2.5000	0.326
7	3.0000	0.307	8	3.5000	0.297	9	4.0000	0.288
10	4.5000	0.278	11	5.0000	0.273	12	5.5000	0.267
13	6.0000	0.258	14	6.5000	0.252	15	7.0000	0.252
16	7.5000	0.248	17	8.0000	0.244	18	8.5000	0.237
19	9.0000	0.233	20	9.5000	0.229	21	10.0000	0.229



BOUWER AND RICE INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-1-4
GeoHydroCycle, Inc.

Results

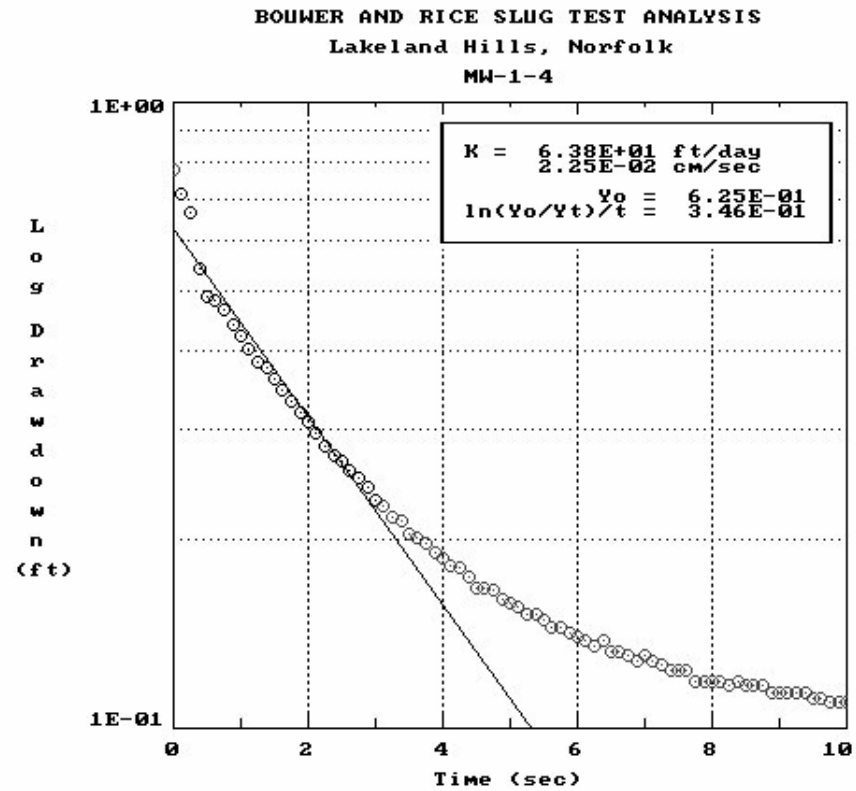
Hydraulic Conductivity: 6.38E+01 ft/day
2.25E-02 cm/sec
Y-Intercept (Yo): 6.25E-01 ft
Well Screen Ratio (Le/rw): 5.9
Dimensionless Parameter C: 0.95
Slope of Line [ln(Yo/Yt)/t]: 3.461E-01 1/sec
Well Parameters (Rc^2 / 2*Le): 1.660E-03 ft
Dimensionless Ratio [ln(Re/rw)]: 1.285
Effective Radius [Re]: 1.28 ft
Volume Tested [rw<Vol<Re]: 9.98E+00 ft^3

Well/Aquifer Parameters

Depth of well: 2.10 ft
Length of well screen: 2.10 ft
Saturated thickness: 2.10 ft
Diameter of the well casing: 0.167 ft
Diameter of the well filter: 0.708 ft

Time vs Drawdown Data

No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)
1	0.0000	0.780	2	0.1250	0.712	3	0.2500	0.666
4	0.3750	0.542	5	0.5000	0.490	6	0.6250	0.481
7	0.7500	0.465	8	0.8750	0.441	9	1.0000	0.423
10	1.1250	0.404	11	1.2500	0.385	12	1.3750	0.378
13	1.5000	0.362	14	1.6250	0.348	15	1.7500	0.334
16	1.8750	0.320	17	2.0000	0.308	18	2.1250	0.296
19	2.2500	0.282	20	2.3750	0.273	21	2.5000	0.268
22	2.6250	0.259	23	2.7500	0.252	24	2.8750	0.243
25	3.0000	0.231	26	3.1250	0.226	27	3.2500	0.217
28	3.3750	0.215	29	3.5000	0.205	30	3.6250	0.201
31	3.7500	0.198	32	3.8750	0.191	33	4.0000	0.187
34	4.1250	0.182	35	4.2500	0.180	36	4.3750	0.175
37	4.5000	0.168	38	4.6250	0.168	39	4.7500	0.166
40	4.8750	0.161	41	5.0000	0.159	42	5.1250	0.156
43	5.2500	0.152	44	5.3750	0.152	45	5.5000	0.149
46	5.6250	0.145	47	5.7500	0.145	48	5.8750	0.142
49	6.0000	0.140	50	6.1250	0.138	51	6.2500	0.135
52	6.3750	0.138	53	6.5000	0.133	54	6.6250	0.133
55	6.7500	0.131	56	6.8750	0.128	57	7.0000	0.131
58	7.1250	0.128	59	7.2500	0.126	60	7.3750	0.124
61	7.5000	0.124	62	7.6250	0.124	63	7.7500	0.119
64	7.8750	0.119	65	8.0000	0.119	66	8.1250	0.119
67	8.2500	0.117	68	8.3750	0.119	69	8.5000	0.117
70	8.6250	0.117	71	8.7500	0.117	72	8.8750	0.114
73	9.0000	0.114	74	9.1250	0.114	75	9.2500	0.114
76	9.3750	0.114	77	9.5000	0.112	78	9.6250	0.112
79	9.7500	0.110	80	9.8750	0.110	81	10.0000	0.110



HVORSLEV INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-1-4
GeoHydroCycle, Inc.

Results

Basic Time Lag-
Hydraulic Conductivity (Kh): 1.16E+02 ft/day
4.10E-02 cm/sec
Basic Time Lag: 2.23 s
2.3 Times Basic Time Lag: 5.13 s
(Equalization Ratio ÷ 0.90)

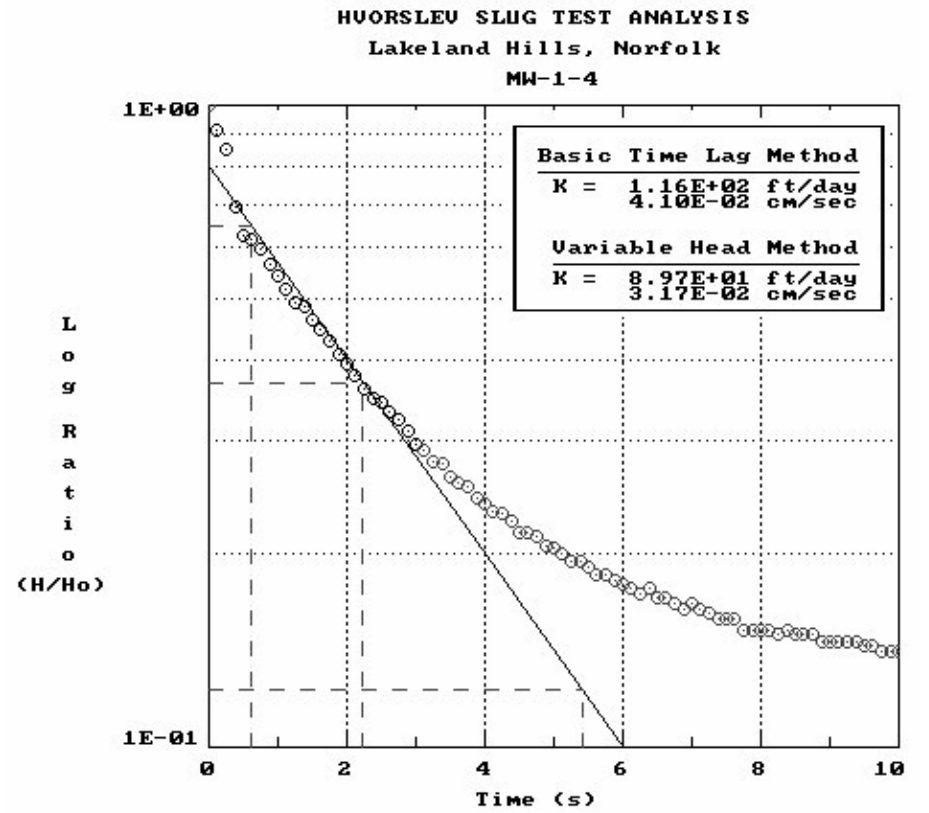
Variable Head-
Hydraulic Conductivity (Kh): 8.97E+01 ft/day
3.17E-02 cm/sec
Time Coordinate T1: 0.6 s
Time Coordinate T2: 5.4 s
Head Ratio Coordinate H1: 65.04E-02
Head Ratio Coordinate H2: 12.31E-02

Well/Aquifer Parameters

Length of well screen: 2.10 ft
Diameter of the well casing: 0.167 ft
Diameter of the well bore: 0.708 ft
Kh/Kv ratio: 1.0

Time vs Drawdown Ratio Data

No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)
1	0.0000	1.000	2	0.1250	0.913	3	0.2500	0.854
4	0.3750	0.695	5	0.5000	0.628	6	0.6250	0.617
7	0.7500	0.596	8	0.8750	0.565	9	1.0000	0.542
10	1.1250	0.518	11	1.2500	0.494	12	1.3750	0.485
13	1.5000	0.464	14	1.6250	0.446	15	1.7500	0.428
16	1.8750	0.410	17	2.0000	0.395	18	2.1250	0.379
19	2.2500	0.362	20	2.3750	0.350	21	2.5000	0.344
22	2.6250	0.332	23	2.7500	0.323	24	2.8750	0.312
25	3.0000	0.296	26	3.1250	0.290	27	3.2500	0.278
28	3.3750	0.276	29	3.5000	0.263	30	3.6250	0.258
31	3.7500	0.254	32	3.8750	0.245	33	4.0000	0.240
34	4.1250	0.233	35	4.2500	0.231	36	4.3750	0.224
37	4.5000	0.215	38	4.6250	0.215	39	4.7500	0.213
40	4.8750	0.206	41	5.0000	0.204	42	5.1250	0.200
43	5.2500	0.195	44	5.3750	0.195	45	5.5000	0.191
46	5.6250	0.186	47	5.7500	0.186	48	5.8750	0.182
49	6.0000	0.179	50	6.1250	0.177	51	6.2500	0.173
52	6.3750	0.177	53	6.5000	0.171	54	6.6250	0.171
55	6.7500	0.168	56	6.8750	0.164	57	7.0000	0.168
58	7.1250	0.164	59	7.2500	0.162	60	7.3750	0.159
61	7.5000	0.159	62	7.6250	0.159	63	7.7500	0.153
64	7.8750	0.153	65	8.0000	0.153	66	8.1250	0.153
67	8.2500	0.150	68	8.3750	0.153	69	8.5000	0.150
70	8.6250	0.150	71	8.7500	0.150	72	8.8750	0.146
73	9.0000	0.146	74	9.1250	0.146	75	9.2500	0.146
76	9.3750	0.146	77	9.5000	0.144	78	9.6250	0.144
79	9.7500	0.141	80	9.8750	0.141	81	10.0000	0.141



BOUWER AND RICE INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-1-5
GeoHydroCycle, Inc.

Results

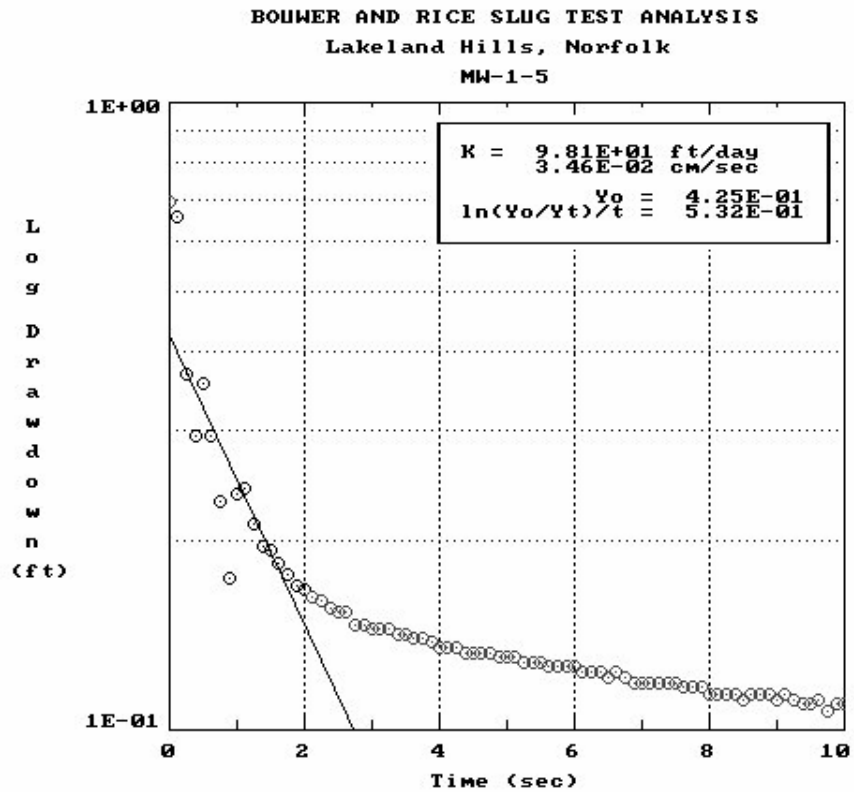
Hydraulic Conductivity: 9.81E+01 ft/day
3.46E-02 cm/sec
Y-Intercept (Yo): 4.25E-01 ft
Well Screen Ratio (Le/rw): 5.9
Dimensionless Parameter C: 0.95
Slope of Line [ln(Yo/Yt)/t]: 5.323E-01 1/sec
Well Parameters (Rc^2 / 2*Le): 1.660E-03 ft
Dimensionless Ratio [ln(Re/rw)]: 1.285
Effective Radius [Re]: 1.28 ft
Volume Tested [rw<Vol<Re]: 9.98E+00 ft^3

Well/Aquifer Parameters

Depth of well: 2.10 ft
Length of well screen: 2.10 ft
Saturated thickness: 2.10 ft
Diameter of the well casing: 0.167 ft
Diameter of the well filter: 0.708 ft

Time vs Drawdown Data

No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)
1	0.0000	0.696	2	0.1250	0.659	3	0.2500	0.369
4	0.3750	0.294	5	0.5000	0.357	6	0.6250	0.294
7	0.7500	0.231	8	0.8750	0.175	9	1.0000	0.238
10	1.1250	0.243	11	1.2500	0.213	12	1.3750	0.196
13	1.5000	0.194	14	1.6250	0.184	15	1.7500	0.177
16	1.8750	0.170	17	2.0000	0.168	18	2.1250	0.163
19	2.2500	0.161	20	2.3750	0.156	21	2.5000	0.154
22	2.6250	0.154	23	2.7500	0.147	24	2.8750	0.147
25	3.0000	0.145	26	3.1250	0.145	27	3.2500	0.145
28	3.3750	0.142	29	3.5000	0.142	30	3.6250	0.140
31	3.7500	0.140	32	3.8750	0.138	33	4.0000	0.135
34	4.1250	0.135	35	4.2500	0.135	36	4.3750	0.133
37	4.5000	0.133	38	4.6250	0.133	39	4.7500	0.133
40	4.8750	0.131	41	5.0000	0.131	42	5.1250	0.131
43	5.2500	0.128	44	5.3750	0.128	45	5.5000	0.128
46	5.6250	0.126	47	5.7500	0.126	48	5.8750	0.126
49	6.0000	0.126	50	6.1250	0.124	51	6.2500	0.124
52	6.3750	0.124	53	6.5000	0.121	54	6.6250	0.124
55	6.7500	0.121	56	6.8750	0.119	57	7.0000	0.119
58	7.1250	0.119	59	7.2500	0.119	60	7.3750	0.119
61	7.5000	0.119	62	7.6250	0.117	63	7.7500	0.117
64	7.8750	0.117	65	8.0000	0.114	66	8.1250	0.114
67	8.2500	0.114	68	8.3750	0.114	69	8.5000	0.112
70	8.6250	0.114	71	8.7500	0.114	72	8.8750	0.114
73	9.0000	0.112	74	9.1250	0.114	75	9.2500	0.112
76	9.3750	0.110	77	9.5000	0.110	78	9.6250	0.112
79	9.7500	0.107	80	9.8750	0.110	81	10.0000	0.110



HVORSLEV INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-1-5
GeoHydroCycle, Inc.

Results

Basic Time Lag-
Hydraulic Conductivity (Kh): 2.67E+02 ft/day
9.43E-02 cm/sec
Basic Time Lag: 0.97 s
2.3 Times Basic Time Lag: 2.23 s
(Equalization Ratio ÷ 0.90)

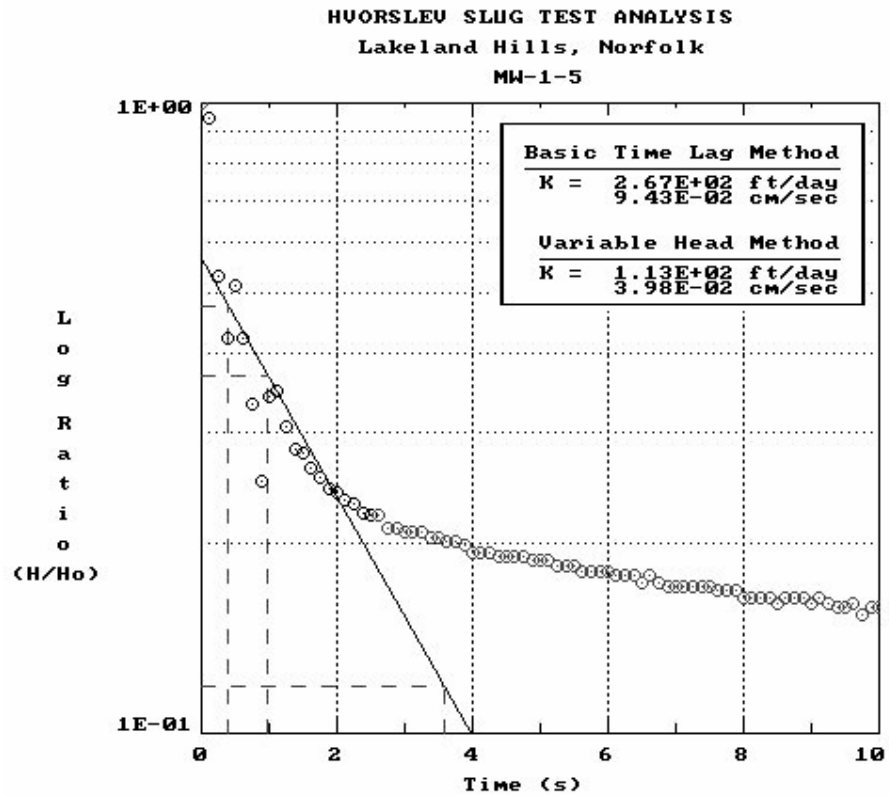
Variable Head-
Hydraulic Conductivity (Kh): 1.13E+02 ft/day
3.98E-02 cm/sec
Time Coordinate T1: 0.4 s
Time Coordinate T2: 3.6 s
Head Ratio Coordinate H1: 47.47E-02
Head Ratio Coordinate H2: 11.89E-02

Well/Aquifer Parameters

Length of well screen: 2.10 ft
Diameter of the well casing: 0.167 ft
Diameter of the well bore: 0.708 ft
Kh/Kv ratio: 1.0

Time vs Drawdown Ratio Data

No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)
1	0.0000	1.000	2	0.1250	0.947	3	0.2500	0.530
4	0.3750	0.422	5	0.5000	0.513	6	0.6250	0.422
7	0.7500	0.332	8	0.8750	0.251	9	1.0000	0.342
10	1.1250	0.349	11	1.2500	0.306	12	1.3750	0.282
13	1.5000	0.279	14	1.6250	0.264	15	1.7500	0.254
16	1.8750	0.244	17	2.0000	0.241	18	2.1250	0.234
19	2.2500	0.231	20	2.3750	0.224	21	2.5000	0.221
22	2.6250	0.221	23	2.7500	0.211	24	2.8750	0.211
25	3.0000	0.208	26	3.1250	0.208	27	3.2500	0.208
28	3.3750	0.204	29	3.5000	0.204	30	3.6250	0.201
31	3.7500	0.201	32	3.8750	0.198	33	4.0000	0.194
34	4.1250	0.194	35	4.2500	0.194	36	4.3750	0.191
37	4.5000	0.191	38	4.6250	0.191	39	4.7500	0.191
40	4.8750	0.188	41	5.0000	0.188	42	5.1250	0.188
43	5.2500	0.184	44	5.3750	0.184	45	5.5000	0.184
46	5.6250	0.181	47	5.7500	0.181	48	5.8750	0.181
49	6.0000	0.181	50	6.1250	0.178	51	6.2500	0.178
52	6.3750	0.178	53	6.5000	0.174	54	6.6250	0.178
55	6.7500	0.174	56	6.8750	0.171	57	7.0000	0.171
58	7.1250	0.171	59	7.2500	0.171	60	7.3750	0.171
61	7.5000	0.171	62	7.6250	0.168	63	7.7500	0.168
64	7.8750	0.168	65	8.0000	0.164	66	8.1250	0.164
67	8.2500	0.164	68	8.3750	0.164	69	8.5000	0.161
70	8.6250	0.164	71	8.7500	0.164	72	8.8750	0.164
73	9.0000	0.161	74	9.1250	0.164	75	9.2500	0.161
76	9.3750	0.158	77	9.5000	0.158	78	9.6250	0.161
79	9.7500	0.154	80	9.8750	0.158	81	10.0000	0.158



BOUWER AND RICE INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-3-1
GeoHydroCycle, Inc.

Results

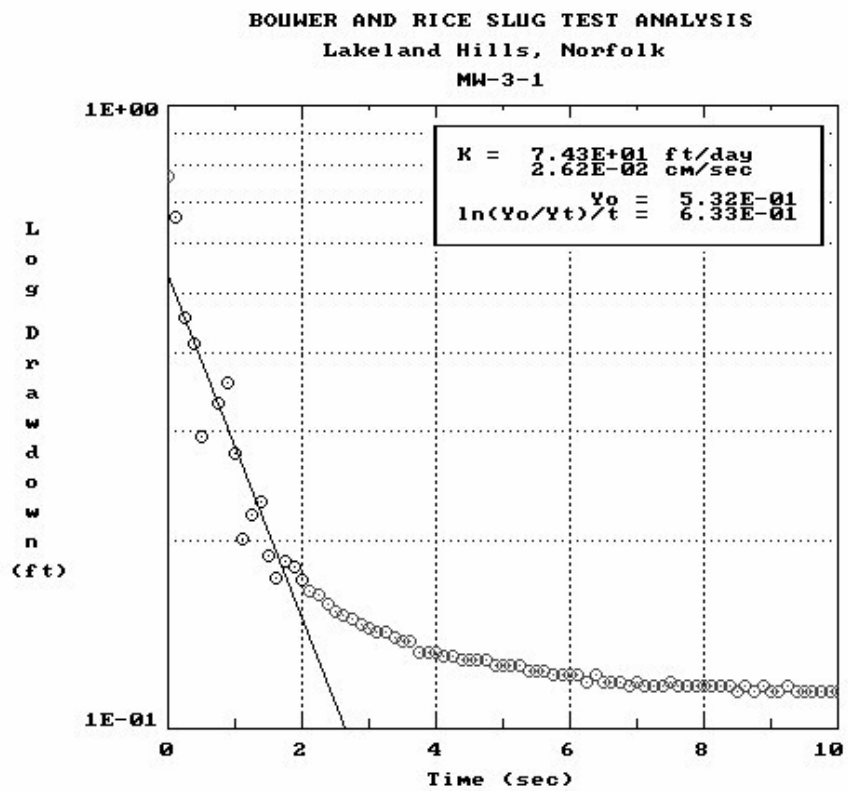
Hydraulic Conductivity: 7.43E+01 ft/day
2.62E-02 cm/sec
Y-Intercept (Yo): 5.32E-01 ft
Well Screen Ratio (Le/rw): 13.8
Dimensionless Parameter C: 1.45
Slope of Line [ln(Yo/Yt)/t]: 6.331E-01 1/sec
Well Parameters (Rc^2 / 2*Le): 7.115E-04 ft
Dimensionless Ratio [ln(Re/rw)]: 1.910
Effective Radius [Re]: 2.39 ft
Volume Tested [rw<Vol<Re]: 8.61E+01 ft^3

Well/Aquifer Parameters

Depth of well: 4.90 ft
Length of well screen: 4.90 ft
Saturated thickness: 4.90 ft
Diameter of the well casing: 0.167 ft
Diameter of the well filter: 0.708 ft

Time vs Drawdown Data

No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)
1	0.0000	0.769	2	0.1250	0.664	3	0.2500	0.458
4	0.3750	0.414	5	0.5000	0.295	6	0.7500	0.332
7	0.8750	0.360	8	1.0000	0.276	9	1.1250	0.201
10	1.2500	0.220	11	1.3750	0.231	12	1.5000	0.189
13	1.6250	0.175	14	1.7500	0.185	15	1.8750	0.182
16	2.0000	0.173	17	2.1250	0.166	18	2.2500	0.164
19	2.3750	0.159	20	2.5000	0.154	21	2.6250	0.152
22	2.7500	0.150	23	2.8750	0.147	24	3.0000	0.145
25	3.1250	0.143	26	3.2500	0.143	27	3.3750	0.140
28	3.5000	0.138	29	3.6250	0.138	30	3.7500	0.133
31	3.8750	0.133	32	4.0000	0.133	33	4.1250	0.131
34	4.2500	0.131	35	4.3750	0.129	36	4.5000	0.129
37	4.6250	0.129	38	4.7500	0.129	39	4.8750	0.126
40	5.0000	0.126	41	5.1250	0.126	42	5.2500	0.126
43	5.3750	0.124	44	5.5000	0.124	45	5.6250	0.124
46	5.7500	0.122	47	5.8750	0.122	48	6.0000	0.122
49	6.1250	0.122	50	6.2500	0.119	51	6.3750	0.122
52	6.5000	0.119	53	6.6250	0.119	54	6.7500	0.119
55	6.8750	0.117	56	7.0000	0.119	57	7.1250	0.117
58	7.2500	0.117	59	7.3750	0.117	60	7.5000	0.119
61	7.6250	0.117	62	7.7500	0.117	63	7.8750	0.117
64	8.0000	0.117	65	8.1250	0.117	66	8.2500	0.117
67	8.3750	0.117	68	8.5000	0.115	69	8.6250	0.117
70	8.7500	0.115	71	8.8750	0.117	72	9.0000	0.115
73	9.1250	0.115	74	9.2500	0.117	75	9.3750	0.115
76	9.5000	0.115	77	9.6250	0.115	78	9.7500	0.115
79	9.8750	0.115	80	10.0000	0.115	81	10.0000	0.110



HVORSLEV INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-3-1
GeoHydroCycle, Inc.

Results

Basic Time Lag-
Hydraulic Conductivity (Kh): 1.58E+02 ft/day
5.58E-02 cm/sec
Basic Time Lag: 1.02 s
2.3 Times Basic Time Lag: 2.35 s
(Equalization Ratio ÷ 0.90)

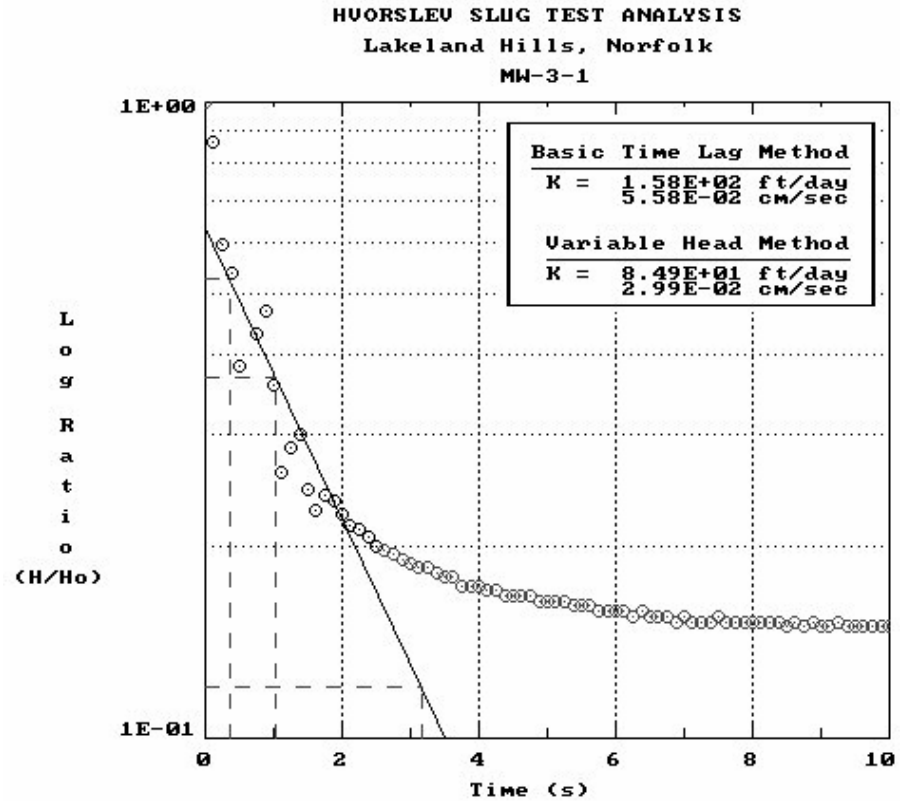
Variable Head-
Hydraulic Conductivity (Kh): 8.49E+01 ft/day
2.99E-02 cm/sec
Time Coordinate T1: 0.4 s
Time Coordinate T2: 3.2 s
Head Ratio Coordinate H1: 52.60E-02
Head Ratio Coordinate H2: 12.03E-02

Well/Aquifer Parameters

Length of well screen: 4.90 ft
Diameter of the well casing: 0.167 ft
Diameter of the well bore: 0.708 ft
Kh/Kv ratio: 1.0

Time vs Drawdown Ratio Data

No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)
1	0.0000	1.000	2	0.1250	0.863	3	0.2500	0.596
4	0.3750	0.538	5	0.5000	0.384	6	0.7500	0.432
7	0.8750	0.468	8	1.0000	0.359	9	1.1250	0.261
10	1.2500	0.286	11	1.3750	0.300	12	1.5000	0.246
13	1.6250	0.228	14	1.7500	0.241	15	1.8750	0.237
16	2.0000	0.225	17	2.1250	0.216	18	2.2500	0.213
19	2.3750	0.207	20	2.5000	0.200	21	2.6250	0.198
22	2.7500	0.195	23	2.8750	0.191	24	3.0000	0.189
25	3.1250	0.186	26	3.2500	0.186	27	3.3750	0.182
28	3.5000	0.179	29	3.6250	0.179	30	3.7500	0.173
31	3.8750	0.173	32	4.0000	0.173	33	4.1250	0.170
34	4.2500	0.170	35	4.3750	0.168	36	4.5000	0.168
37	4.6250	0.168	38	4.7500	0.168	39	4.8750	0.164
40	5.0000	0.164	41	5.1250	0.164	42	5.2500	0.164
43	5.3750	0.161	44	5.5000	0.161	45	5.6250	0.161
46	5.7500	0.159	47	5.8750	0.159	48	6.0000	0.159
49	6.1250	0.159	50	6.2500	0.155	51	6.3750	0.159
52	6.5000	0.155	53	6.6250	0.155	54	6.7500	0.155
55	6.8750	0.152	56	7.0000	0.155	57	7.1250	0.152
58	7.2500	0.152	59	7.3750	0.152	60	7.5000	0.155
61	7.6250	0.152	62	7.7500	0.152	63	7.8750	0.152
64	8.0000	0.152	65	8.1250	0.152	66	8.2500	0.152
67	8.3750	0.152	68	8.5000	0.150	69	8.6250	0.152
70	8.7500	0.150	71	8.8750	0.152	72	9.0000	0.150
73	9.1250	0.150	74	9.2500	0.152	75	9.3750	0.150
76	9.5000	0.150	77	9.6250	0.150	78	9.7500	0.150
79	9.8750	0.150	80	10.0000	0.150	81	10.0000	0.158



BOUWER AND RICE INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-3-2
GeoHydroCycle, Inc.

Results

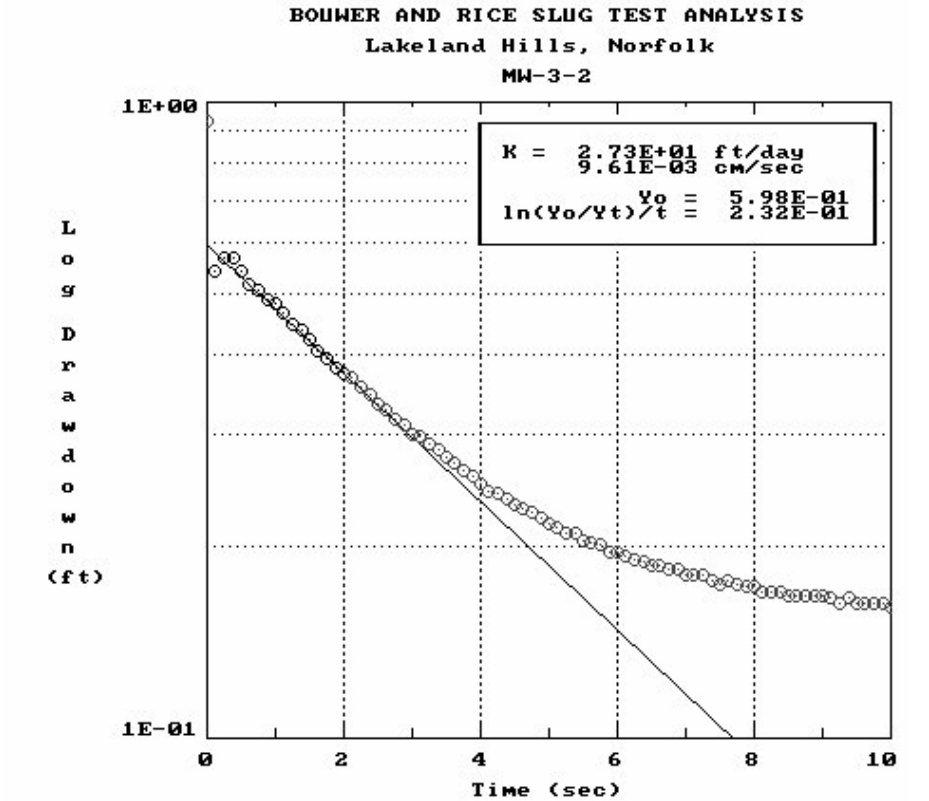
Hydraulic Conductivity: 2.73E+01 ft/day
9.61E-03 cm/sec
Y-Intercept (Yo): 5.98E-01 ft
Well Screen Ratio (Le/rw): 13.8
Dimensionless Parameter C: 1.45
Slope of Line [ln(Yo/Yt)/t]: 2.321E-01 1/sec
Well Parameters (Rc^2 / 2*Le): 7.115E-04 ft
Dimensionless Ratio [ln(Re/rw)]: 1.910
Effective Radius [Re]: 2.39 ft
Volume Tested [rw<Vol<Re]: 8.61E+01 ft^3

Well/Aquifer Parameters

Depth of well: 4.90 ft
Length of well screen: 4.90 ft
Saturated thickness: 4.90 ft
Diameter of the well casing: 0.167 ft
Diameter of the well filter: 0.708 ft

Time vs Drawdown Data

No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)
1	0.0000	0.932	2	0.1250	0.542	3	0.2500	0.568
4	0.3750	0.570	5	0.5000	0.542	6	0.6250	0.516
7	0.7500	0.505	8	0.8750	0.488	9	1.0000	0.481
10	1.1250	0.465	11	1.2500	0.448	12	1.3750	0.437
13	1.5000	0.423	14	1.6250	0.406	15	1.7500	0.395
16	1.8750	0.383	17	2.0000	0.374	18	2.1250	0.369
19	2.2500	0.357	20	2.3750	0.348	21	2.5000	0.336
22	2.6250	0.329	23	2.7500	0.318	24	2.8750	0.311
25	3.0000	0.301	26	3.1250	0.299	27	3.2500	0.290
28	3.3750	0.285	29	3.5000	0.276	30	3.6250	0.271
31	3.7500	0.264	32	3.8750	0.259	33	4.0000	0.252
34	4.1250	0.245	35	4.2500	0.243	36	4.3750	0.238
37	4.5000	0.233	38	4.6250	0.229	39	4.7500	0.226
40	4.8750	0.222	41	5.0000	0.217	42	5.1250	0.215
43	5.2500	0.210	44	5.3750	0.210	45	5.5000	0.205
46	5.6250	0.203	47	5.7500	0.201	48	5.8750	0.196
49	6.0000	0.196	50	6.1250	0.194	51	6.2500	0.191
52	6.3750	0.189	53	6.5000	0.187	54	6.6250	0.187
55	6.7500	0.184	56	6.8750	0.184	57	7.0000	0.180
58	7.1250	0.180	59	7.2500	0.180	60	7.3750	0.177
61	7.5000	0.175	62	7.6250	0.177	63	7.7500	0.175
64	7.8750	0.173	65	8.0000	0.173	66	8.1250	0.170
67	8.2500	0.170	68	8.3750	0.170	69	8.5000	0.168
70	8.6250	0.168	71	8.7500	0.168	72	8.8750	0.168
73	9.0000	0.168	74	9.1250	0.166	75	9.2500	0.163
76	9.3750	0.166	77	9.5000	0.163	78	9.6250	0.163
79	9.7500	0.163	80	9.8750	0.163	81	10.0000	0.161



HVORSLEV INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-3-2
GeoHydroCycle, Inc.

Results

Basic Time Lag-
Hydraulic Conductivity (Kh): 6.76E+01 ft/day
2.38E-02 cm/sec
Basic Time Lag: 2.39 s
2.3 Times Basic Time Lag: 5.50 s
(Equalization Ratio ÷ 0.90)

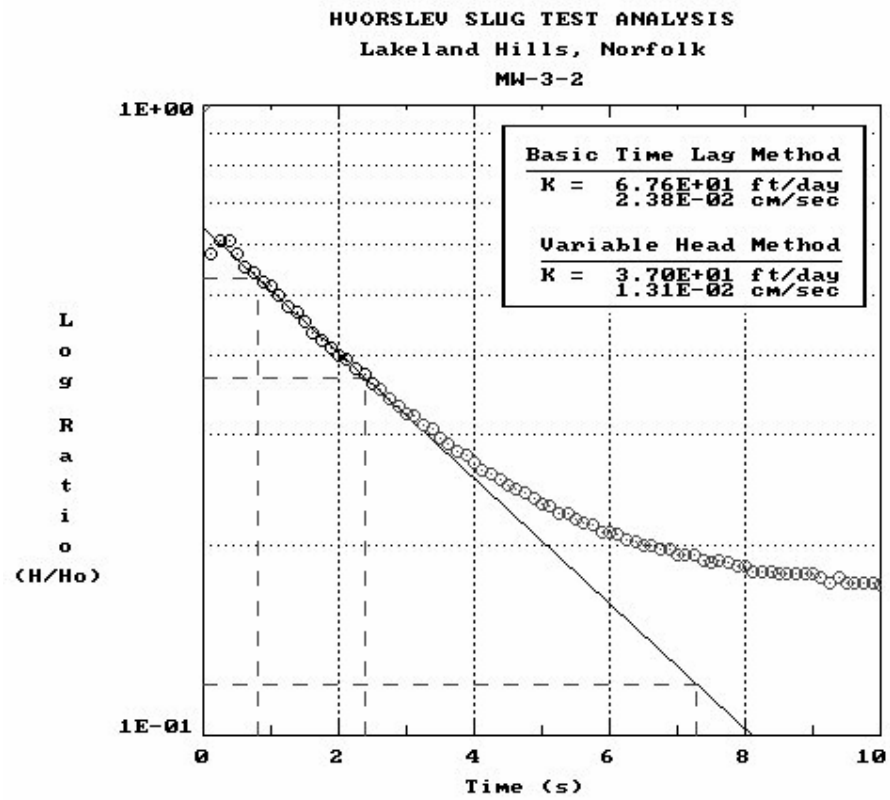
Variable Head-
Hydraulic Conductivity (Kh): 3.70E+01 ft/day
1.31E-02 cm/sec
Time Coordinate T1: 0.8 s
Time Coordinate T2: 7.3 s
Head Ratio Coordinate H1: 53.15E-02
Head Ratio Coordinate H2: 12.04E-02

Well/Aquifer Parameters

Length of well screen: 4.90 ft
Diameter of the well casing: 0.167 ft
Diameter of the well bore: 0.708 ft
Kh/Kv ratio: 1.0

Time vs Drawdown Ratio Data

No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)
1	0.0000	1.000	2	0.1250	0.582	3	0.2500	0.609
4	0.3750	0.612	5	0.5000	0.582	6	0.6250	0.554
7	0.7500	0.542	8	0.8750	0.524	9	1.0000	0.516
10	1.1250	0.499	11	1.2500	0.481	12	1.3750	0.469
13	1.5000	0.454	14	1.6250	0.436	15	1.7500	0.424
16	1.8750	0.411	17	2.0000	0.401	18	2.1250	0.396
19	2.2500	0.383	20	2.3750	0.373	21	2.5000	0.361
22	2.6250	0.353	23	2.7500	0.341	24	2.8750	0.334
25	3.0000	0.323	26	3.1250	0.321	27	3.2500	0.311
28	3.3750	0.306	29	3.5000	0.296	30	3.6250	0.291
31	3.7500	0.283	32	3.8750	0.278	33	4.0000	0.270
34	4.1250	0.263	35	4.2500	0.261	36	4.3750	0.255
37	4.5000	0.250	38	4.6250	0.246	39	4.7500	0.242
40	4.8750	0.238	41	5.0000	0.233	42	5.1250	0.231
43	5.2500	0.225	44	5.3750	0.225	45	5.5000	0.220
46	5.6250	0.218	47	5.7500	0.216	48	5.8750	0.210
49	6.0000	0.210	50	6.1250	0.208	51	6.2500	0.205
52	6.3750	0.203	53	6.5000	0.201	54	6.6250	0.201
55	6.7500	0.197	56	6.8750	0.197	57	7.0000	0.193
58	7.1250	0.193	59	7.2500	0.193	60	7.3750	0.190
61	7.5000	0.188	62	7.6250	0.190	63	7.7500	0.188
64	7.8750	0.186	65	8.0000	0.186	66	8.1250	0.182
67	8.2500	0.182	68	8.3750	0.182	69	8.5000	0.180
70	8.6250	0.180	71	8.7500	0.180	72	8.8750	0.180
73	9.0000	0.180	74	9.1250	0.178	75	9.2500	0.175
76	9.3750	0.178	77	9.5000	0.175	78	9.6250	0.175
79	9.7500	0.175	80	9.8750	0.175	81	10.0000	0.173



BOUWER AND RICE INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-3-3
GeoHydroCycle, Inc.

Results

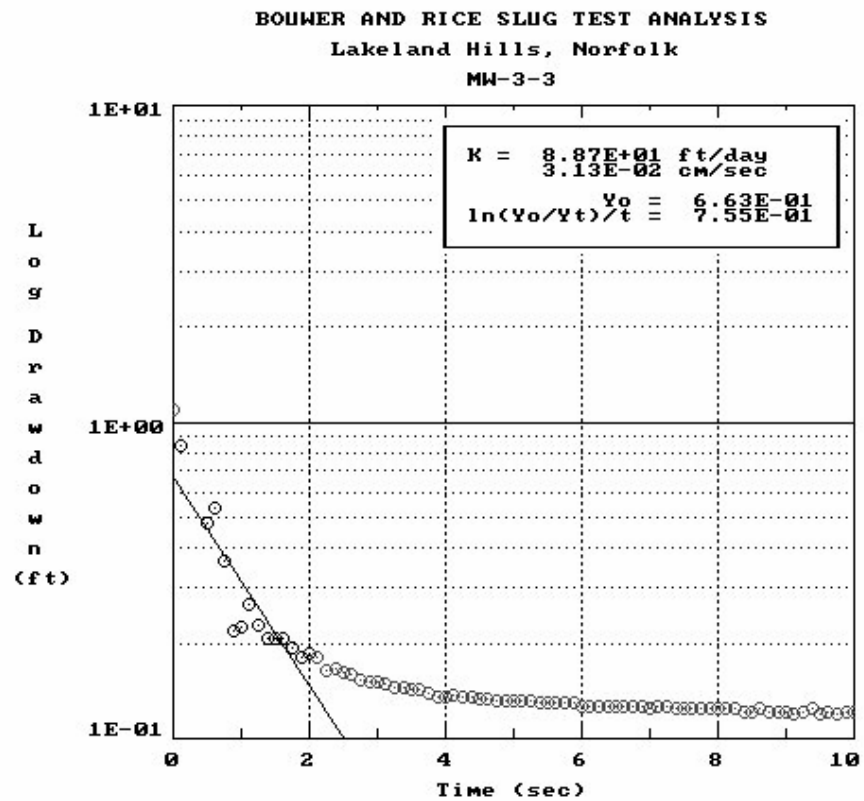
Hydraulic Conductivity: 8.87E+01 ft/day
3.13E-02 cm/sec
Y-Intercept (Yo): 6.63E-01 ft
Well Screen Ratio (Le/rw): 13.8
Dimensionless Parameter C: 1.45
Slope of Line [ln(Yo/Yt)/t]: 7.555E-01 1/sec
Well Parameters (Rc^2 / 2*Le): 7.115E-04 ft
Dimensionless Ratio [ln(Re/rw)]: 1.910
Effective Radius [Re]: 2.39 ft
Volume Tested [rw<Vol<Re]: 8.61E+01 ft^3

Well/Aquifer Parameters

Depth of well: 4.90 ft
Length of well screen: 4.90 ft
Saturated thickness: 4.90 ft
Diameter of the well casing: 0.167 ft
Diameter of the well filter: 0.708 ft

Time vs Drawdown Data

No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)
1	0.0000	1.096	2	0.1250	0.839	3	0.5000	0.477
4	0.6250	0.533	5	0.7500	0.365	6	0.8750	0.220
7	1.0000	0.224	8	1.1250	0.264	9	1.2500	0.229
10	1.3750	0.208	11	1.5000	0.206	12	1.6250	0.208
13	1.7500	0.194	14	1.8750	0.180	15	2.0000	0.185
16	2.1250	0.180	17	2.2500	0.164	18	2.3750	0.166
19	2.5000	0.161	20	2.6250	0.159	21	2.7500	0.154
22	2.8750	0.152	23	3.0000	0.152	24	3.1250	0.150
25	3.2500	0.145	26	3.3750	0.145	27	3.5000	0.143
28	3.6250	0.143	29	3.7500	0.140	30	3.8750	0.136
31	4.0000	0.136	32	4.1250	0.138	33	4.2500	0.136
34	4.3750	0.136	35	4.5000	0.133	36	4.6250	0.133
37	4.7500	0.131	38	4.8750	0.131	39	5.0000	0.131
40	5.1250	0.131	41	5.2500	0.131	42	5.3750	0.129
43	5.5000	0.129	44	5.6250	0.129	45	5.7500	0.129
46	5.8750	0.129	47	6.0000	0.126	48	6.1250	0.126
49	6.2500	0.126	50	6.3750	0.126	51	6.5000	0.126
52	6.6250	0.126	53	6.7500	0.126	54	6.8750	0.126
55	7.0000	0.124	56	7.1250	0.126	57	7.2500	0.126
58	7.3750	0.124	59	7.5000	0.124	60	7.6250	0.124
61	7.7500	0.124	62	7.8750	0.124	63	8.0000	0.124
64	8.1250	0.124	65	8.2500	0.124	66	8.3750	0.122
67	8.5000	0.122	68	8.6250	0.124	69	8.7500	0.122
70	8.8750	0.122	71	9.0000	0.122	72	9.1250	0.119
73	9.2500	0.122	74	9.3750	0.124	75	9.5000	0.119
76	9.6250	0.122	77	9.7500	0.119	78	9.8750	0.122
79	10.0000	0.122						



HVORSLEV INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-3-3
GeoHydroCycle, Inc.

Results

Basic Time Lag-
Hydraulic Conductivity (Kh): 2.83E+02 ft/day
9.98E-02 cm/sec
Basic Time Lag: 0.57 s
2.3 Times Basic Time Lag: 1.31 s
(Equalization Ratio ÷ 0.90)

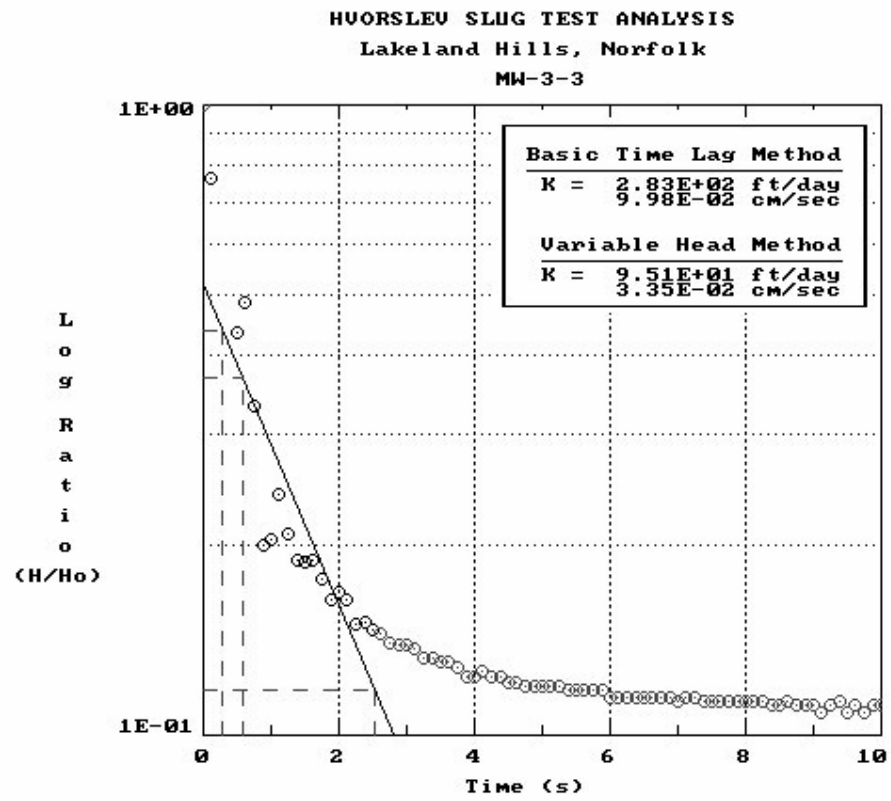
Variable Head-
Hydraulic Conductivity (Kh): 9.51E+01 ft/day
3.35E-02 cm/sec
Time Coordinate T1: 0.3 s
Time Coordinate T2: 2.5 s
Head Ratio Coordinate H1: 43.93E-02
Head Ratio Coordinate H2: 11.79E-02

Well/Aquifer Parameters

Length of well screen: 4.90 ft
Diameter of the well casing: 0.167 ft
Diameter of the well bore: 0.708 ft
Kh/Kv ratio: 1.0

Time vs Drawdown Ratio Data

No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)
1	0.0000	1.000	2	0.1250	0.766	3	0.5000	0.435
4	0.6250	0.486	5	0.7500	0.333	6	0.8750	0.201
7	1.0000	0.204	8	1.1250	0.241	9	1.2500	0.209
10	1.3750	0.190	11	1.5000	0.188	12	1.6250	0.190
13	1.7500	0.177	14	1.8750	0.164	15	2.0000	0.169
16	2.1250	0.164	17	2.2500	0.150	18	2.3750	0.151
19	2.5000	0.147	20	2.6250	0.145	21	2.7500	0.141
22	2.8750	0.139	23	3.0000	0.139	24	3.1250	0.137
25	3.2500	0.132	26	3.3750	0.132	27	3.5000	0.130
28	3.6250	0.130	29	3.7500	0.128	30	3.8750	0.124
31	4.0000	0.124	32	4.1250	0.126	33	4.2500	0.124
34	4.3750	0.124	35	4.5000	0.121	36	4.6250	0.121
37	4.7500	0.120	38	4.8750	0.120	39	5.0000	0.120
40	5.1250	0.120	41	5.2500	0.120	42	5.3750	0.118
43	5.5000	0.118	44	5.6250	0.118	45	5.7500	0.118
46	5.8750	0.118	47	6.0000	0.115	48	6.1250	0.115
49	6.2500	0.115	50	6.3750	0.115	51	6.5000	0.115
52	6.6250	0.115	53	6.7500	0.115	54	6.8750	0.115
55	7.0000	0.113	56	7.1250	0.115	57	7.2500	0.115
58	7.3750	0.113	59	7.5000	0.113	60	7.6250	0.113
61	7.7500	0.113	62	7.8750	0.113	63	8.0000	0.113
64	8.1250	0.113	65	8.2500	0.113	66	8.3750	0.111
67	8.5000	0.111	68	8.6250	0.113	69	8.7500	0.111
70	8.8750	0.111	71	9.0000	0.111	72	9.1250	0.109
73	9.2500	0.111	74	9.3750	0.113	75	9.5000	0.109
76	9.6250	0.111	77	9.7500	0.109	78	9.8750	0.111
79	10.0000	0.111						



BOUWER AND RICE INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-3-4
GeoHydroCycle, Inc.

Results

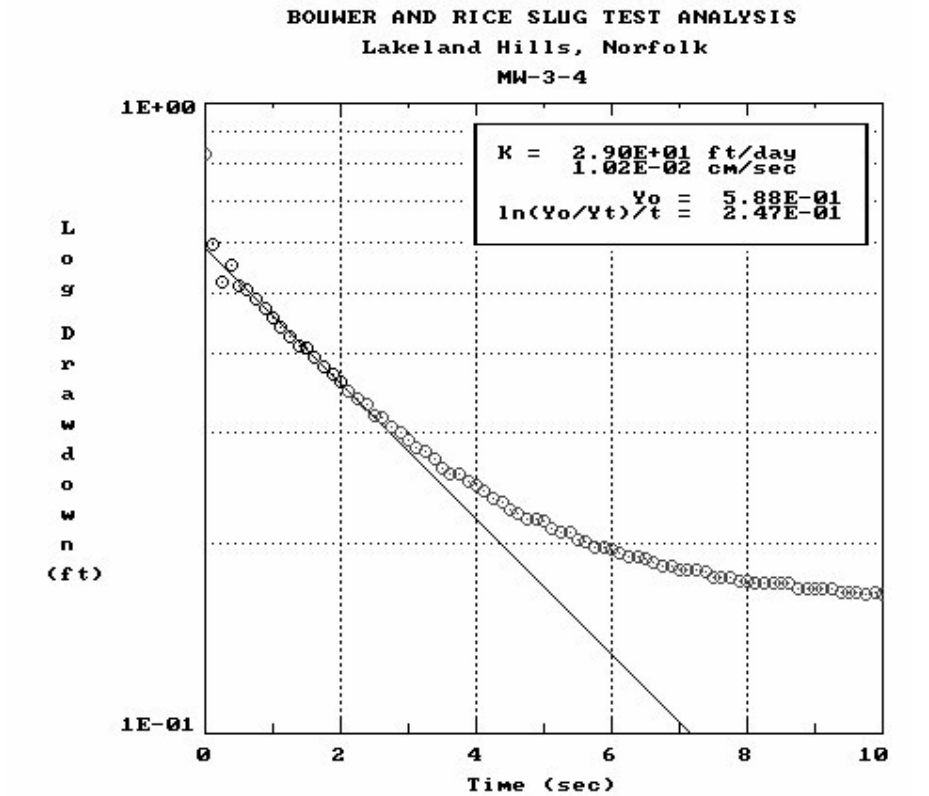
Hydraulic Conductivity: 2.90E+01 ft/day
1.02E-02 cm/sec
Y-Intercept (Yo): 5.88E-01 ft
Well Screen Ratio (Le/rw): 13.8
Dimensionless Parameter C: 1.45
Slope of Line [ln(Yo/Yt)/t]: 2.473E-01 1/sec
Well Parameters (Rc^2 / 2*Le): 7.115E-04 ft
Dimensionless Ratio [ln(Re/rw)]: 1.910
Effective Radius [Re]: 2.39 ft
Volume Tested [rw<Vol<Re]: 8.61E+01 ft^3

Well/Aquifer Parameters

Depth of well: 4.90 ft
Length of well screen: 4.90 ft
Saturated thickness: 4.90 ft
Diameter of the well casing: 0.167 ft
Diameter of the well filter: 0.708 ft

Time vs Drawdown Data

No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)	No.	Time (sec)	Drawdown (ft)
1	0.0000	0.829	2	0.1250	0.598	3	0.2500	0.521
4	0.3750	0.554	5	0.5000	0.514	6	0.6250	0.505
7	0.7500	0.488	8	0.8750	0.472	9	1.0000	0.458
10	1.1250	0.441	11	1.2500	0.427	12	1.3750	0.413
13	1.5000	0.409	14	1.6250	0.395	15	1.7500	0.383
16	1.8750	0.371	17	2.0000	0.362	18	2.1250	0.350
19	2.2500	0.341	20	2.3750	0.332	21	2.5000	0.320
22	2.6250	0.318	23	2.7500	0.306	24	2.8750	0.301
25	3.0000	0.292	26	3.1250	0.285	27	3.2500	0.280
28	3.3750	0.273	29	3.5000	0.264	30	3.6250	0.259
31	3.7500	0.259	32	3.8750	0.252	33	4.0000	0.247
34	4.1250	0.243	35	4.2500	0.236	36	4.3750	0.233
37	4.5000	0.226	38	4.6250	0.224	39	4.7500	0.219
40	4.8750	0.219	41	5.0000	0.217	42	5.1250	0.212
43	5.2500	0.208	44	5.3750	0.208	45	5.5000	0.203
46	5.6250	0.201	47	5.7500	0.198	48	5.8750	0.198
49	6.0000	0.196	50	6.1250	0.194	51	6.2500	0.191
52	6.3750	0.191	53	6.5000	0.189	54	6.6250	0.187
55	6.7500	0.184	56	6.8750	0.184	57	7.0000	0.182
58	7.1250	0.182	59	7.2500	0.182	60	7.3750	0.180
61	7.5000	0.177	62	7.6250	0.177	63	7.7500	0.177
64	7.8750	0.175	65	8.0000	0.175	66	8.1250	0.173
67	8.2500	0.173	68	8.3750	0.173	69	8.5000	0.173
70	8.6250	0.173	71	8.7500	0.170	72	8.8750	0.170
73	9.0000	0.170	74	9.1250	0.170	75	9.2500	0.170
76	9.3750	0.168	77	9.5000	0.168	78	9.6250	0.168
79	9.7500	0.166	80	9.8750	0.168	81	10.0000	0.166



HVORSLEV INTERACTIVE SLUG TEST ANALYSIS 10-18-2019

Lakeland Hills, Norfolk
MW-3-4
GeoHydroCycle, Inc.

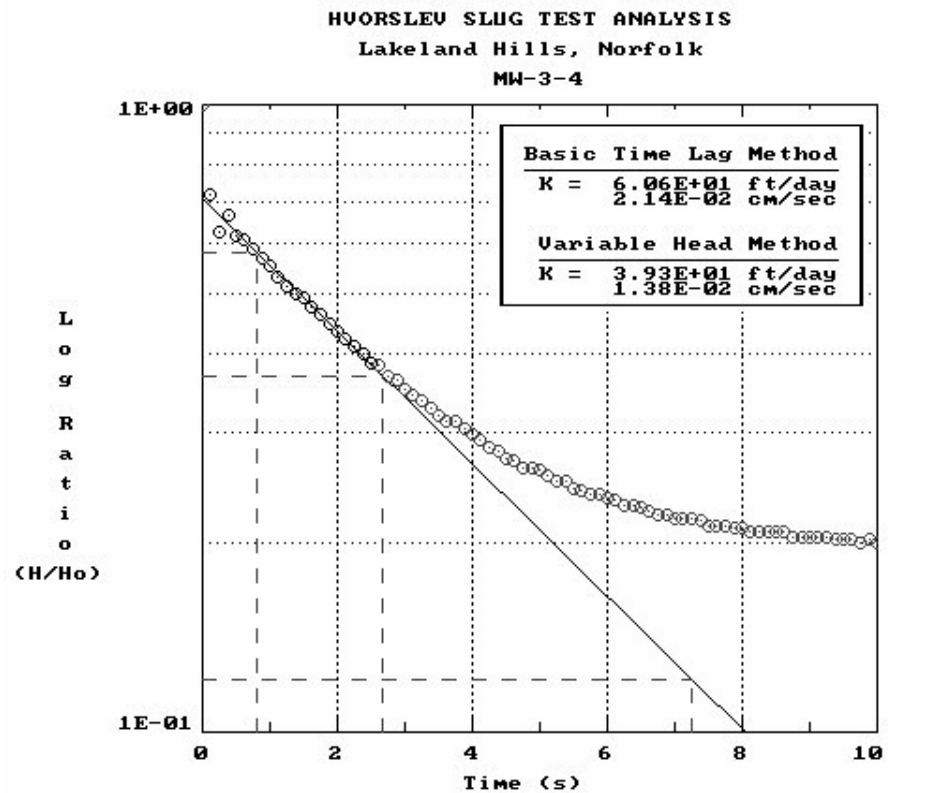
Results

Basic Time Lag-
Hydraulic Conductivity (Kh): 6.06E+01 ft/day
2.14E-02 cm/sec
Basic Time Lag: 2.66 s
2.3 Times Basic Time Lag: 6.13 s
(Equalization Ratio ÷ 0.90)

Variable Head-
Hydraulic Conductivity (Kh): 3.93E+01 ft/day
1.38E-02 cm/sec
Time Coordinate T1: 0.8 s
Time Coordinate T2: 7.2 s
Head Ratio Coordinate H1: 58.14E-02
Head Ratio Coordinate H2: 12.16E-02

Well/Aquifer Parameters

Length of well screen: 4.90 ft
Diameter of the well casing: 0.167 ft
Diameter of the well bore: 0.708 ft
Kh/Kv ratio: 1.0

Time vs Drawdown Ratio Data

No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)	No.	Time (s)	H/Hmax (ft)
1	0.0000	1.000	2	0.1250	0.721	3	0.2500	0.628
4	0.3750	0.668	5	0.5000	0.620	6	0.6250	0.609
7	0.7500	0.589	8	0.8750	0.569	9	1.0000	0.552
10	1.1250	0.532	11	1.2500	0.515	12	1.3750	0.498
13	1.5000	0.493	14	1.6250	0.476	15	1.7500	0.462
16	1.8750	0.448	17	2.0000	0.437	18	2.1250	0.422
19	2.2500	0.411	20	2.3750	0.400	21	2.5000	0.386
22	2.6250	0.384	23	2.7500	0.369	24	2.8750	0.363
25	3.0000	0.352	26	3.1250	0.344	27	3.2500	0.338
28	3.3750	0.329	29	3.5000	0.318	30	3.6250	0.312
31	3.7500	0.312	32	3.8750	0.304	33	4.0000	0.298
34	4.1250	0.293	35	4.2500	0.285	36	4.3750	0.281
37	4.5000	0.273	38	4.6250	0.270	39	4.7500	0.264
40	4.8750	0.264	41	5.0000	0.262	42	5.1250	0.256
43	5.2500	0.251	44	5.3750	0.251	45	5.5000	0.245
46	5.6250	0.242	47	5.7500	0.239	48	5.8750	0.239
49	6.0000	0.236	50	6.1250	0.234	51	6.2500	0.230
52	6.3750	0.230	53	6.5000	0.228	54	6.6250	0.226
55	6.7500	0.222	56	6.8750	0.222	57	7.0000	0.220
58	7.1250	0.220	59	7.2500	0.220	60	7.3750	0.217
61	7.5000	0.214	62	7.6250	0.214	63	7.7500	0.214
64	7.8750	0.211	65	8.0000	0.211	66	8.1250	0.209
67	8.2500	0.209	68	8.3750	0.209	69	8.5000	0.209
70	8.6250	0.209	71	8.7500	0.205	72	8.8750	0.205
73	9.0000	0.205	74	9.1250	0.205	75	9.2500	0.205
76	9.3750	0.203	77	9.5000	0.203	78	9.6250	0.203
79	9.7500	0.200	80	9.8750	0.203	81	10.0000	0.200