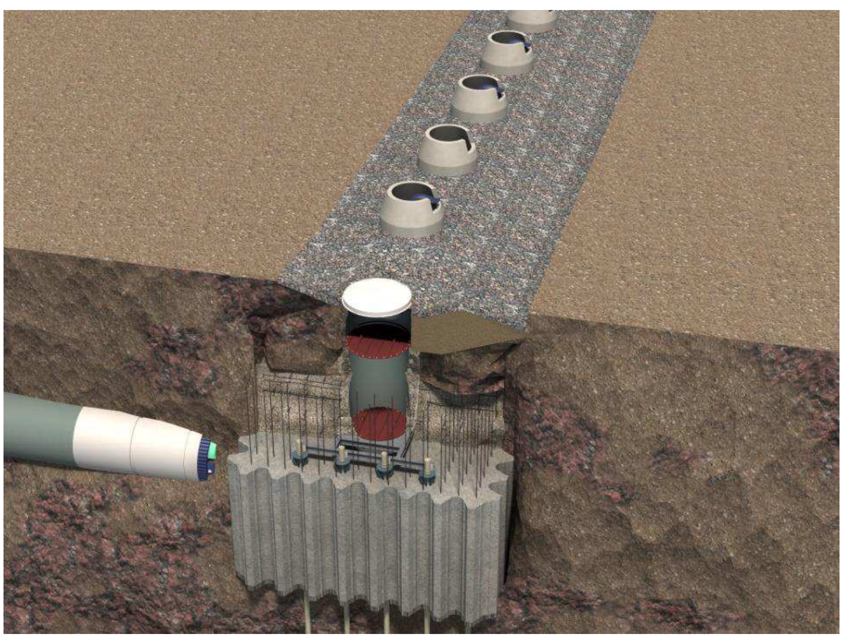
APPENDIX B
GEOTECHNICAL REPORTS

B.1: Geotechnical Data Report

Part H: Appendix F

Annacis Island WWTP New Outfall System

Vancouver Fraser Port Authority
Project and Environmental Review Application



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SERVICES AND SOLUTIONS FOR
A LIVABLE REGION

CDM Smith

Golder Associates

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APPENDIX F

Hydrogeological Testing Results

TECHNICAL MEMORANDUM

DATE 26 September 2017 **REFERENCE No.** 1525010-033-TM-Rev0

TO Viji Fernando

FROM Nathan Fretz, Don Chorley **EMAIL** nfretz@golder.com, dchorley@golder.com

ANNACIS ISLAND WASTE WATER TREATMENT PLANT TRANSIENT MITIGATION AND OUTFALL - HYDROGEOLOGICAL TESTING AND RESULTS

1.0 FIELD INVESTIGATIONS

The scope of work for the hydrogeological component of the field investigations at the Annacis Island Waste Water Treatment Plant (the Site) located in Delta, BC included the following main tasks:

- Water level monitoring at select wells and in the Fraser River to calculate hydraulic gradient in the vicinity of the proposed effluent shaft and outfall shaft along the Option 6 outfall alignment.
- Single-well response testing in monitoring wells screened within various hydrostratigraphic units to estimate hydraulic conductivity.
- Dissolved gas sampling in select monitoring wells to estimate dissolved hydrogen sulfide, carbon dioxide, and methane gas concentrations in groundwater at the proposed effluent shaft and outfall shaft along the Option 6 outfall alignment, as well as the potential future shaft location associated with the conveyance system from the Stage V expansion of the treatment plant to the proposed outfall.

This memo describes two separate hydrogeological field programs carried out at the Site. The first program was carried out in April and May of 2016 along the preferred western alignment corridor. The second program was carried out in December of 2016 along the Option 6 outfall alignment corridor. Data from both field programs have are included in this document.

1.1 Water Level Monitoring

Solinst Levelogger pressure transducers were installed in select monitoring wells and the Fraser River over two separate time intervals in order to monitor groundwater level fluctuations and response to tides.

Pressure transducers were installed in the following locations over the period of April 27 to May 6, 2016 to record water levels in support of the preferred western alignment corridor:

- SH16-01 (10m, 35m, and 55m piezometers)
- SH16-02 (10m, 45m, and 52m piezometers)
- SH16-03 (10m piezometer)
- SH16-04 (10m and 36.6m piezometer)

Pressure transducers were installed in the following locations over the period of December 23 to 29, 2016 to record water levels in support of the Option 6 alignment corridor:

- SH16-05 (10m and 33m piezometers)
- SH16-06 (10m and 33m piezometers)
- SH16-07 (10m and 31m piezometers)
- Fraser River (installed off the end of Turning Point Brewery's dock)

In addition to the locations listed above, a Solinst Barologger pressure transducer was installed at SH16-02 to monitor changes in atmospheric pressure during the monitoring periods. All transducers were synchronized and were set to collect data every 5 minutes.

1.2 Single-Well Response Tests

Single-well response tests (slug tests) were conducted at monitoring wells using either pneumatic slug or solid slug methods; a solid slug method was employed in cases where lower permeability dictated its use.

Pneumatic slug tests involve using air pressure to cause near-instantaneous changes in water level in wells. A Midwest GeoSciences Group Pneumatic "Hi-K" Slug™ Assembly (the "assembly") was installed on select wells to control the pressure in the well heads. Positive pressure was applied with the assembly to conduct rising head tests with water level displacements varying between 0.3 m and 0.8 m.

Solid slug tests involve lowering or raising an object of known mass into or out of the water column to cause a sudden change in water level in a well. Weighted sections of closed PVC pipe were used to conduct rising and falling head tests with water level displacements varying between 0.4 m to 1.0 m.

During testing, continuous water levels were recorded using a Solinst Levelogger pressure transducer and direct-read cable. Table 1 summarizes the testing methods performed at each monitoring well.

Table 1: Slug Tests

Monitoring Location	Depth(m)	Soil Classification (from borehole logs)	Slug Test Method
SH16-01	10	SILT to sandy SILT	Pneumatic Slug
SH16-01	35	SAND	Solid Slug
SH16-01	55	SILTto SILTY CLAY	Solid Slug
SH16-02	10	SAND	Solid Slug
SH16-02	45	SAND	Solid Slug
SH16-02	52	SILTY CLAY	Solid Slug
SH16-03	10	SAND	Pneumatic Slug
SH16-04	10	SAND	Pneumatic Slug
SH16-04	36.6	Sandy GRAVEL	Pneumatic Slug
SH16-05	10	SAND	Solid Slug
SH16-05	33	SILTY SAND to SAND	Solid Slug

Monitoring Location	Depth(m)	Soil Classification (from borehole logs)	Slug Test Method
SH16-05	55	SILTY CLAY	Solid Slug
SH16-06	10	SILTY SAND to SAND	Solid Slug
SH16-06	33	SAND to SILTY SAND	Solid Slug
SH16-07	10	SAND	Solid Slug
SH16-07	31	SAND	Solid Slug
SH16-07	48	SILTY CLAY to CLAYEY SILT	Solid Slug

When possible, multiple slug tests were conducted at individual monitoring wells to assess the sufficiency of well development and to assess the reproducibility of the slug tests. In the case of pneumatic slug tests, three tests were completed at approximately the same initial displacement and an additional two tests were conducted at greater and lesser displacements. In the case of solid slug tests, multiple tests were conducted with the same slug volume except when time constraints relating to long test-times in low K material prevented it.

1.3 Dissolved Gas Sampling

Select monitoring wells located in the vicinity of the proposed effluent shaft (SH16-01) and outfall shaft (SH16-05) along the Option 6 outfall alignment, as well as the potential future shaft location (SH16-07) were sampled for analysis of dissolved hydrogen sulfide, carbon dioxide, and methane gases. The following monitoring wells were sampled:

- SH16-01(10m)
- SH16-01(35m)
- SH16-05(10m)
- SH16-05(33m)
- SH16-07(10m)
- SH16-07(31m)

Dissolved gas samples were collected *in-situ* using Snap Samplers and were analyzed via laboratory single-stage flash analytical techniques.

A Snap Sampler (Britt et al, 2010) is a passive sampling system that consists of a series of individual samplers that each hold a Snap Sampler bottle. Each bottle has caps on either end that are connected together through the bottle with a Teflon-coated spring. The caps are set in an open position during deployment with a release-pin system, and are closed just prior to retrieval by pneumatically triggering the release-pin. Once the bottles are closed *in-situ*, the entire Snap Sampler system is retrieved and the bottles are prepared for laboratory submittal. Since sample bottles are closed downhole and delivered to a laboratory in said bottles, there is no exposure to the atmosphere due to sample-transfer to alternate bottles, which can result in volatilization of gases and changes to chemistry from exposure to oxygen.

Snap Samplers capable of sampling with up to three 40 mL bottles at a time were employed. Laboratory sample volume requirements dictated that 15 bottles be collected per location. To facilitate this, the Snap Samplers were deployed and retrieved five times at each location. A peristaltic pump system was set a distance above the top of the well screens and pumped at a low flowrate to ensure that water level drawdown was minimal (a requirement of the low-flow sampling method). Stabilization of hydraulic conditions was allowed to occur for approximately 10 minutes before the Snap Samplers were closed and retrieved. Samples were sent to AGAT Laboratories (AGAT) in Calgary, AB under chain of custody protocols.

2.0 RESULTS OF INVESTIGATION

2.1 Water Level Monitoring

2.1.1 Pre-processing of water levels

Barometric pressure fluctuations were removed from the Solinst Levelogger pressure data using Solinst data management software together with barometric data collected from the Solinst Barologger. Pressure readings were then converted to hydraulic heads with the elevation datum set to m geodetic. To convert from m geodetic to CGVD28-GVRD, add 100 m.

2.1.2 Water Levels

Figure 1a-c and 2a-b present continuous hydraulic head data at the monitoring wells over the periods of April 27 to May 6, 2016 and December 23 to 29, 2016, respectively. Seventy-two hour moving average hydraulic heads were calculated for each well using an averaging method described in Serfes (1991) and are presented as dashed lines in Figures 1a-c and 2a-b.

2.1.3 Hydraulic Gradients

Instantaneous and seventy-two hour moving average hydraulic gradients were conservatively calculated from the continuous hydraulic head data, using available well-pairs. Figures 3 and 4 present hydraulic gradients between well pairs at various depths over the periods of April 27 to May 6, 2016 and December 23 to 29, 2016, respectively. Positive gradients (i.e., greater than zero) designate groundwater flow towards the Fraser River and negative gradients designate groundwater flow inland away from the river.

Over the period of April 27 to May 6, 2016 the largest hydraulic gradients were calculated between SH16-02(10m) and SH16-03(10m) and between SH16-01(35m) and SH16-04(36.6m). The maximum instantaneous hydraulic gradients at 10 m and 35 m depth was approximately 0.0027 m/m and 0.0018 m/m, respectively and the average hydraulic gradients at 10 m and 35 m depth was approximately 0.0010 m/m and 0.0004 m/m, respectively.

Over the period of December 23 to 29, 2016 the largest hydraulic gradients were between SH16-05(10m) and SH16-06(10m) and between SH16-05(33m) and SH16-06(33m). The maximum instantaneous hydraulic gradients at 10 m and 33 m depth was approximately 0.0033 m/m and 0.0037 m/m, respectively and the average hydraulic gradients at 10 m and 33 m depth was approximately 0.0004 m/m and 0.0005 m/m, respectively.

The calculated hydraulic gradients at well-pairs monitored along the preferred western alignment corridor and the Option 6 outfall alignment corridor indicate that net groundwater flow is directed towards the river, with some reversal of flow direction during a tidal cycle. The magnitude and direction of hydraulic gradients at the Site will vary with the timing and amplitude of the tide in the Fraser River, as well as with other environmental fluctuations. Therefore, the gradients presented above are representative of conditions that existed at the Site during the monitoring periods from April 27 to May 6, 2016 and December 23 to 29, 2016.

2.2 Results of Single-Well Response Testing

Hydrogeological responses observed during slug testing were analyzed using AQTESOLV, a commercially available software package for aquifer test analysis (Duffield, 2007). Test data were analyzed using the Bower and Rice (1976) semi-analytical method for fully or partially penetrating wells. Table 2 below summarizes the slug test results.

Table 2: Hydraulic Conductivity Calculated from Slug Test Data

Monitoring Location	Depth (m)	Soil Classification (from borehole logs)	Hydraulic Conductivity (Geometric Mean) (m/s)
SH16-01	10	SILT to sandy SILT	$1x10^{-5}$
SH16-01	35	SAND	$2x10^{-5}$
SH16-01	55	SILTto SILTY CLAY	$2x10^{-7}$
SH16-02	10	SAND	$5x10^{-5}$
SH16-02	45	SAND	$2x10^{-7}$(A)
SH16-02	52	SILTY CLAY	$7x10^{-8}$
SH16-03	10	SAND	$4x10^{-5}$
SH16-04	10	SAND	$1x10^{-5}$
SH16-04	36.6	Sandy GRAVEL	$2x10^{-4}$
SH16-05	10	SAND	$2x10^{-6}$
SH16-05	33	SILTY SAND to SAND	$8x10^{-6}$
SH16-05	55	SILTY CLAY	---(B)
SH16-06	10	SILTY SAND to SAND	$2x10^{-5}$
SH16-06	33	SAND to SILTY SAND	$3x10^{-5}$
SH16-07	10	SAND	$3x10^{-4}$
SH16-07	31	SAND	$5x10^{-5}$
SH16-07	48	SILTY CLAY to CLAYEY SILT	---(B)

(A) Likely not representative of the material logged in the borehole.
(B) Noise to signal ratio was too high to obtain a meaningful response from slug tests.

Attachment 1 provides the slug tests analysis outputs from AQTESOLV.

It should be noted that slug tests provide point-scale estimates of hydraulic conductivity and are generally representative of formation properties in the immediate vicinity of the well screens. It has been found that because of this, single-well response tests tend to underestimate the bulk hydraulic conductivity of a layer by a scaling factor of 2 to 5 times (Niemann and Rovey, 2009).

2.2.1 Interpretation of Gravel Layer Hydraulic Conductivity

The hydraulic conductivity of a gravel layer encountered in borehole SH16-04 and estimated from the single-well response test at SH16-04(36.6m), was lower than initially expected based on borehole log descriptions of predominantly gravel material, but falls within the range of typical values for unconsolidated sands and gravels (Domenico and Schwartz, 1990). Therefore, hydraulic conductivity was also estimated from grain-size analyses as an additional check.

Hydraulic conductivity was estimated using HydrogeoSieveXL, an excel-based tool for calculating hydraulic conductivity from grain-size distribution curves that includes 15 different analysis-methods (Devlin, 2015). Four grain-size analysis samples (#'s 22, 24, 26, and 28) from BH15-03 (Golder, 2015) were used in the analysis; BH15-03 was drilled in the vicinity of SH16-04. The grain-size samples were collected over a depth of 10 metres, between approximately 30 m and 40 m below ground surface. Based on the grain-size distributions of the samples, six analysis-methods were considered applicable to estimate hydraulic conductivity: Slichter (1898), Terzaghi (1925), Beyer (1964), Zamarin (1928), Barr (2001), and Alyamani and Sen (1993). Table 3 below summarizes the hydraulic conductivity estimates as well as the percent recovery of the soil core during drilling.

Table 3: Grain-size estimates of Hydraulic Conductivity – Unit 5

BH15-03 Sample Number	Average Hydraulic Conductivity From All Methods (m/s)	Percent Recovery During Drilling (%)
22	7×10^{-3}	54
24	7×10^{-5}	54
26	2×10^{-4}	58
28	2×10^{-4}	42

The geometric mean of hydraulic conductivity for the individual samples ranged from 7×10^{-3} m/s to 7×10^{-5} m/s, with a geometric mean for all four samples of 4×10^{-4} m/s. Attachment 2 provides the HydrogeoSieveXL output for the grain-size samples.

The estimate of hydraulic conductivity from grain-size analyses (geometric mean of 4×10^{-4} m/s) is similar to the slug test result at SH16-05(36.6m) (2×10^{-4} m/s). The average percent recovery during drilling was about 50 percent and it is understood that the finer-grained fraction of the material was more likely to be lost than the coarser-grained gravels. As a result, it is likely that the grain-size analyses provide an overestimate of the hydraulic conductivity.

2.3 Dissolved Gas Sampling

Table 4 presents gas analysis results from groundwater samples collected via Snap Sampler and processed by AGAT, using single-stage flash analytical techniques, for hydrogen sulfide (H_2S), carbon dioxide (CO_2), and methane (CH_4) gases. Lab certificates for the gas analyses are provided in Attachment 3.

The results provided by AGAT (in ppm for H_2S and mole fraction for CH_4 and CO_2) represent the proportion of those components measured in the gas mixture extracted during the single-stage flash. These results were converted into the amount of a single component (mg) released per litre of groundwater using the gas in solution (m^3_{gas}/m^3_{sample}) extracted by AGAT from single-stage flash. The H_2S values were converted to mg of H_2S gas per litre of groundwater and expressed in parts per million (ppm). The CH_4 and CO_2 results were converted from mole fraction to mg/L_{water} using the following formula:

$$C_i\left(\frac{mg}{L_{water}}\right) = C_i\left(\frac{mol}{mol}\right) \cdot i \cdot \left(\frac{\rho_{gas}}{MW_{gas}}\right) \cdot MW_i \cdot 1000$$

where C_i is the concentration of the single gas, i is the gas-in-solution ratio, ρ_{gas} is the absolute density of the gas sample, MW_{gas} is the molecular weight of the gas sample and MW_i is the molecular weight of the single gas. CH_4 and CO_2 results were then converted to percent.

Table 4: Dissolved Gas Results

Location	Gas in Solution(A)	Absolute gas sample density(B)	Sample Molecular Weight(C)	CH_4(D)	CO_2(D)	H_2S(E)	CH_4(F)	CO_2(F)	H_2S(G)
	m^3/m^3	kg/m^3	g/mol	mol/mol		ppm	%		ppm
SH16-01(10m)	0.179	1.839	43.5	0.0493	0.7218	ND(H)	0.0006	0.024	ND(H)
SH16-01(35m)	0.183	1.834	43.4	0.0959	0.7641	ND(H)	0.0012	0.026	ND(H)
SH16-05(10m)	0.119	1.911	45.2	0.0107	0.8151	ND(H)	0.0001	0.018	ND(H)
SH16-05(33m)	0.148	2.002	47.3	0.0194	0.7737	0.2	0.0002	0.021	0.030
SH16-07(10m)	0.125	-	-	-	-	ND(H)	-	-	ND(H)
SH16-07(31m)	0.125	-	-	-	-	ND(H)	-	-	ND(H)

(A) Gas in solution extracted by lab from single-stage flash. Cubic metres of gas per cubic metres of water at standard conditions (101.325 kPa, 15.0 °C)
(B) Absolute sample density of the entire gas portion extracted from single-stage flash.
(C) Molecular weight of the total gas sample extracted from single-stage flash.
(D) Mole fraction of gas component, air free as received.
(E) ppm of H_2S gas in the gas sample extracted from single-stage flash.
(F) Milligrams of gas component per L of water (mg/L_{water}) expressed as a percent.
(G) Milligrams of H_2S gas per L of water (mg/L_{water}) expressed in ppm.
(H) ND (Non Detect) = Concentrations were below the laboratory detection limit of 0.1 ppm H_2S in the gas sample extracted from single-stage flash.

3.0 CLOSURE

We trust that this report provides you with the information you require at this time. Should you have any questions or require additional information, please feel free to contact us at your convenience.

GOLDER ASSOCIATES LTD.

Nathan Fretz, MSc, GIT
Hydrogeologist

Don Chorley, MSc, PGeo
Principal, Senior Hydrogeologist

NF/DC/asd

Attachments: Figures 1 to 4
Attachment 1 – Slug Test Reports
Attachment 2 – Grain Size Analysis Report
Attachment 3 – AGAT Laboratories Reports

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4.0 REFERENCES

Alyamani, M.S., Sen Z. 1993. Determination of hydraulic conductivity from complete grain-size distribution curves. Ground Water, v. 31, no. 4, 551-555.

Barr, D.W. 2001. Coefficient of permeability determined by measurable parameters. Ground Water, v. 39, no. 3, 356-361.

Beyer, W. 1964. "Zur Bestimmung der Wasserdurchlässigkeit von Kiesen und Sanden aus der Kornverteilungskurve." Wasserwirtschaft-Wassertechnik 14(6): 165-168.

Bouwer, H. and R.C. Rice, 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, vol. 12, no. 3, pp. 423-428.

Devlin, J.F., 2015. HydrogeoSieveXL: and Excel-based tool to estimate hydraulic conductivity from grain-size analysis. Hydrogeology Journal 23: 837-844.

Domenico, P.A. and F.W. Schwartz, 1990. *Physical and Chemical Hydrogeology*, John Wiley & Sons, New York, 824 p.

Duffield, G.M.., 2007. *AQTESOLV for Windows v4.5., User's Guide*. HydroSolve Inc., Reston, VA.

Niemann, W.L. and C.W. Rovey. 2009. A systematic field-based testing program of hydraulic conductivity and dispersivity over a range in scale. Hydrogeology Journal, v 17, p 307-320.

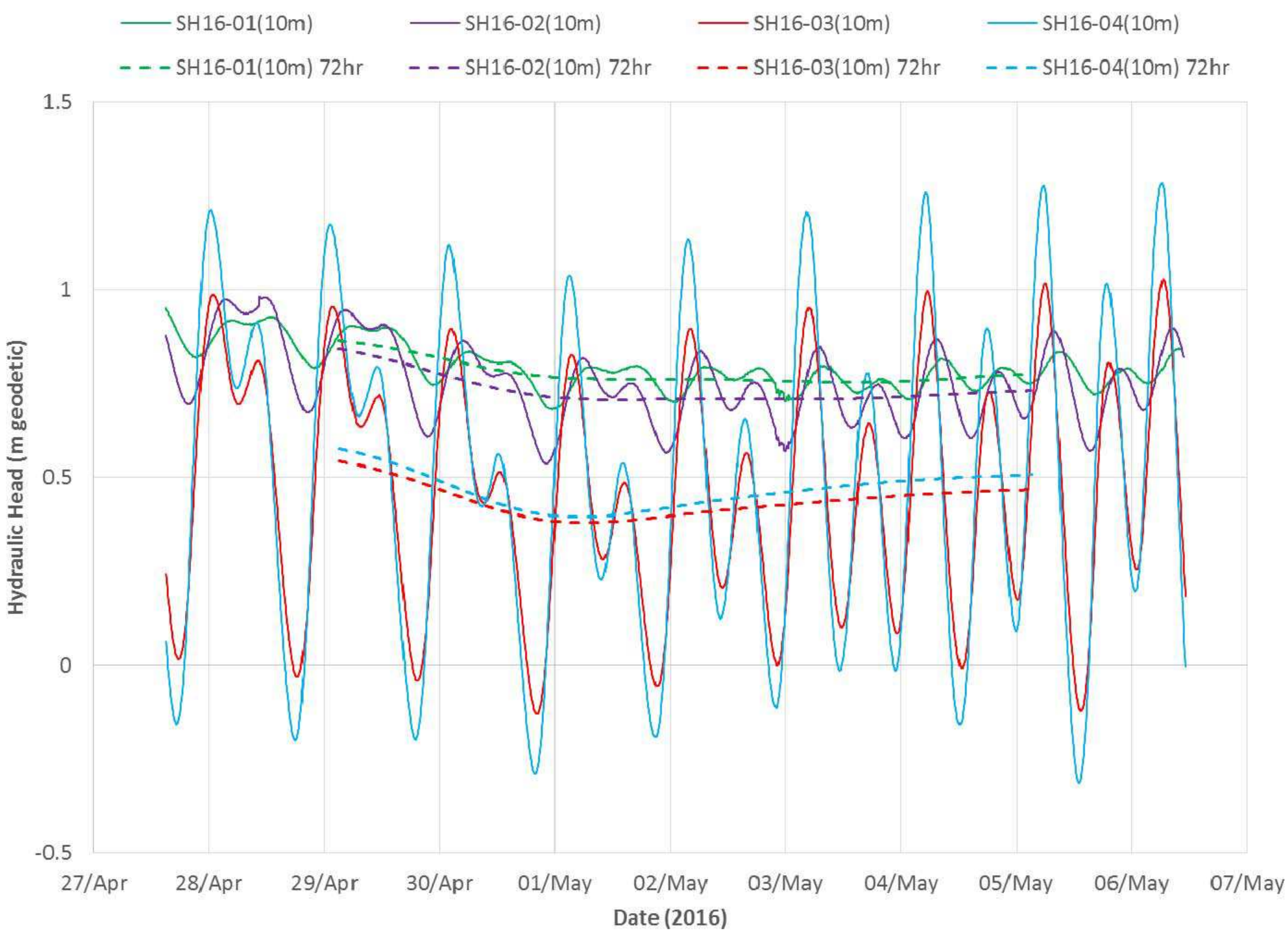
Golder Associates Ltd., 2015. Geotechnical Interpretive Report - AIWWTP Transient Mitigation and Outfall - Predesign. Submitted to CDM Smith Canada ULC.

Serfes, M.E., 1991. Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations. Ground Water, vol. 29, no. 4, pp. 549-555.

Slichter, C.S., 1898, Theoretical investigations of the motion of ground waters: United States Geological Survey, 19th Annual Report, p 295-384.

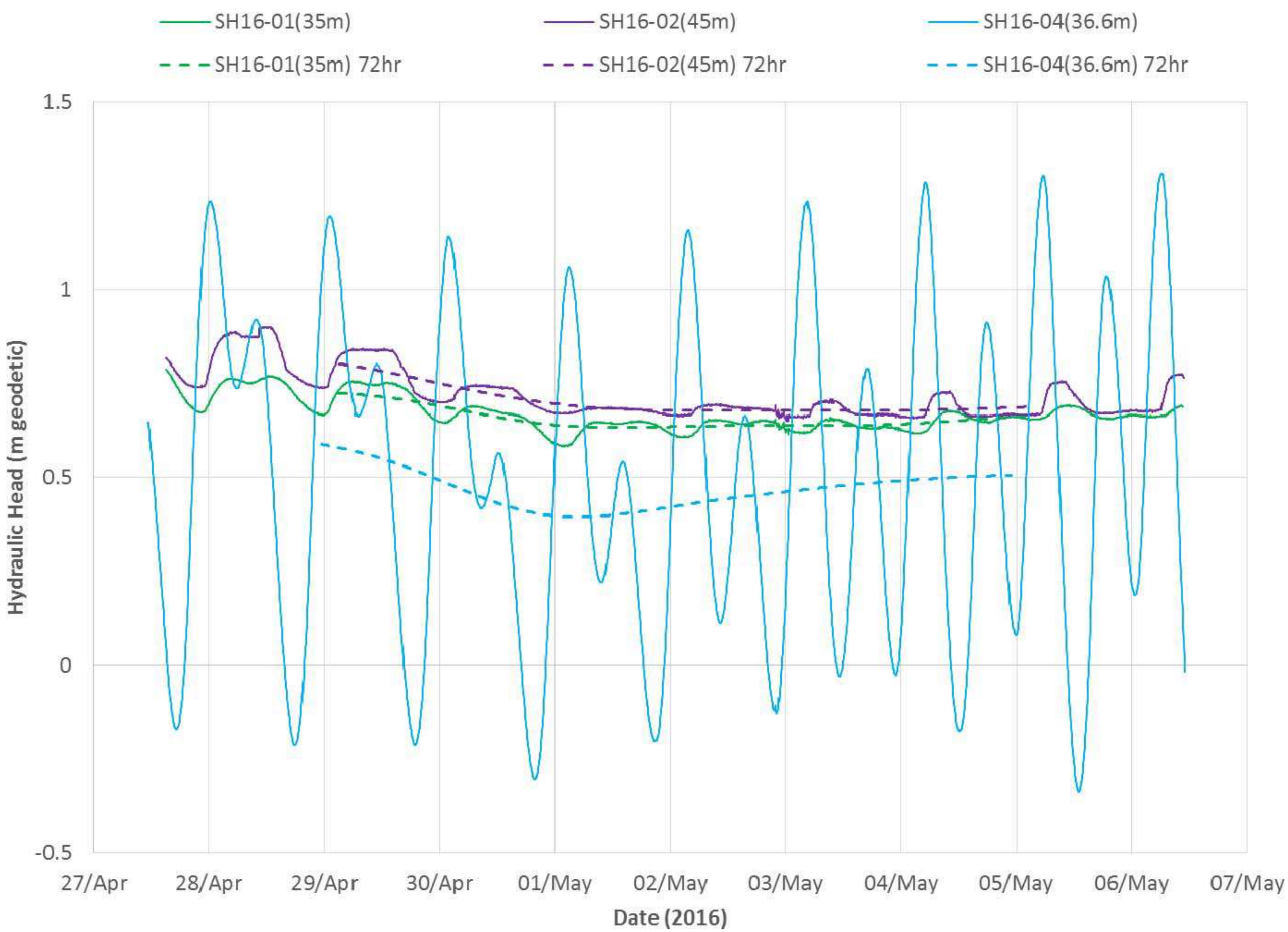
Terzaghi, K., 1925, Principles of soil mechanics: Engineering News-Record, v. 95, p 832.

Zamarin, J.A. 1928. Calculation of ground-water flow (in Russian). Trudey I.V.H. Taskeni.



Note:
To go from m geodetic to CGVD28-GVRD, add 100 m

CLIENT CDM SMITH			PROJECT ANNACIS ISLAND WWTP TRANSIENT MITIGATION AND OUTFALL DELTA, BC
CONSULTANT Golder Associates	YYYY-MM-DD	2017-03-01	TITLE **CONTINUOUS AND 72HR MOVING AVERAGE HYDRAULIC HEADS – 10 M DEPTH APRIL 27 TO MAY 6, 2016**
	PREPARED	NF	
	DESIGNED	NF	
	REVIEWED	DWC	
	APPROVED	DWC	PROJECT NO. **1525010** PHASE **605/605.3** REV. **B** FIGURE **1a**



Notes:
SH16-04(36.6m) is screened in Unit 5; however, hydraulic heads are considered representative of Unit 3B at this location.

To go from m geodetic to CGVD28-GVRD, add 100 m

CLIENT
CDM SMITH

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-03-01
PREPARED	NF
DESIGNED	NF
REVIEWED	DWC
APPROVED	DWC

PROJECT
ANNACIS ISLAND WWTP TRANSIENT MITIGATION AND OUTFALL
DELTA, BC

TITLE
CONTINUOUS AND 72HR MOVING AVERAGE HYDRAULIC HEADS – INTERVAL 35 M TO 45 M DEPTH
APRIL 27 TO MAY 6, 2016

PROJECT NO.	PHASE	REV.	FIGURE
1525010	605/605.3	B	1b

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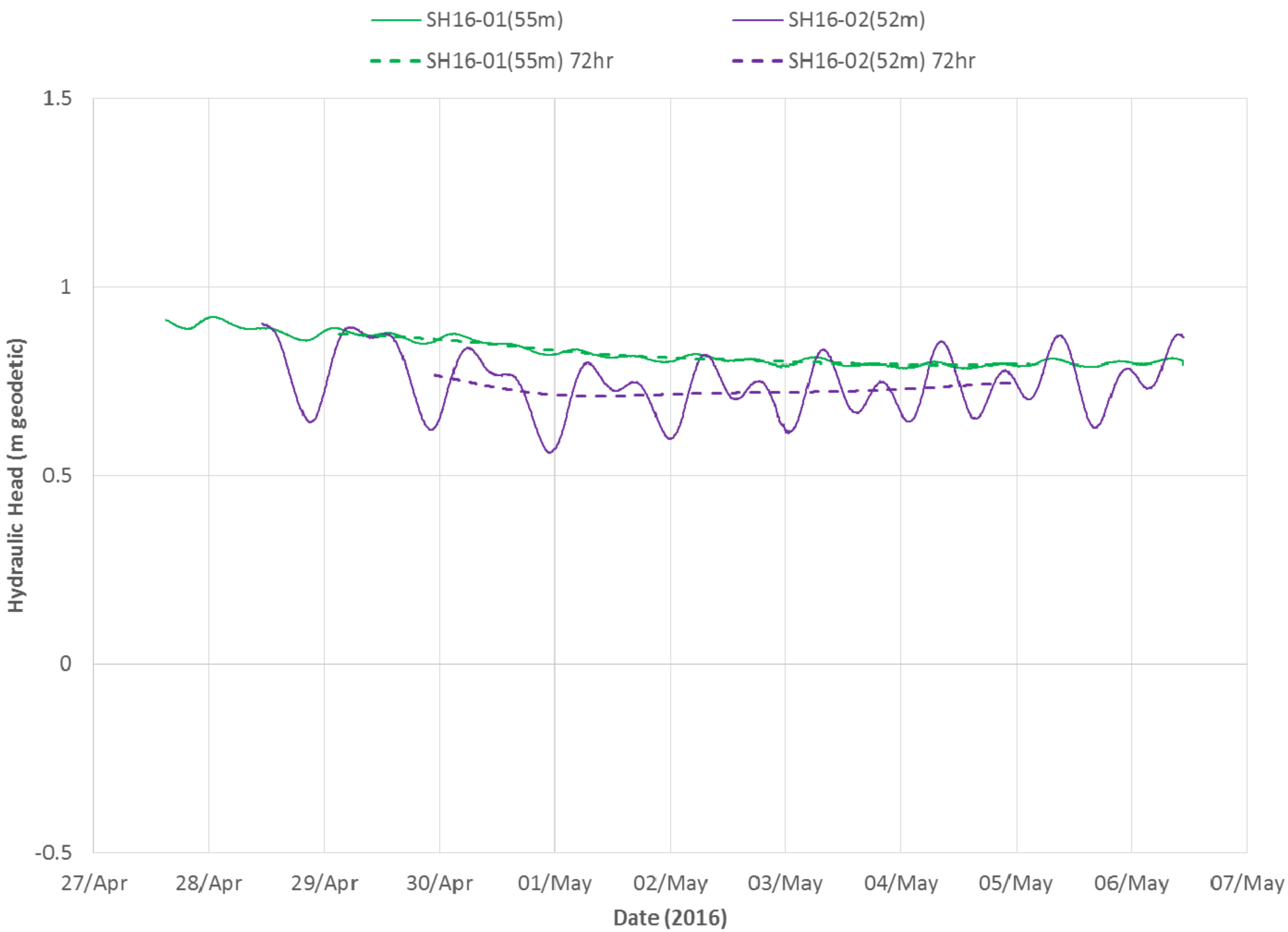
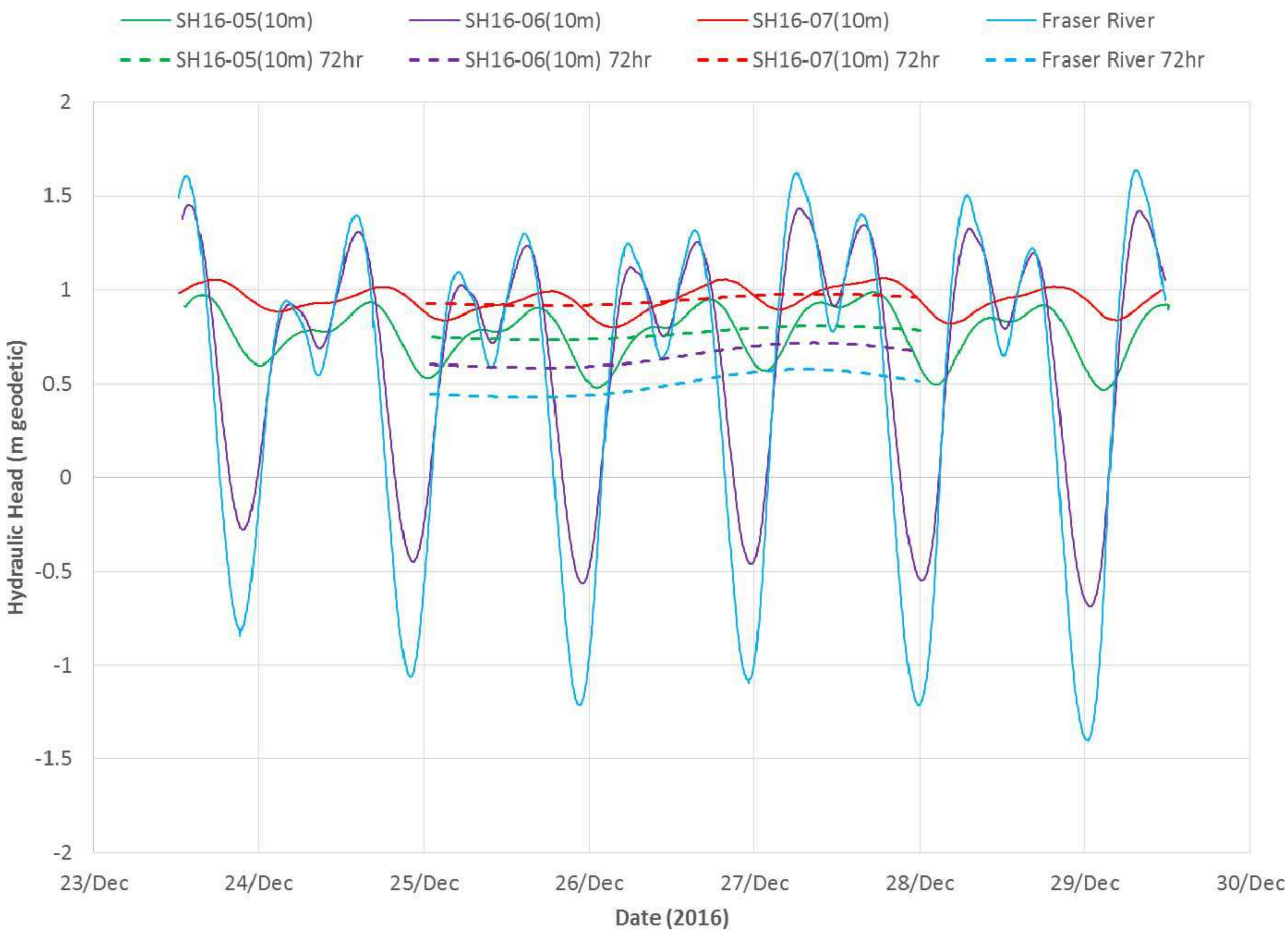


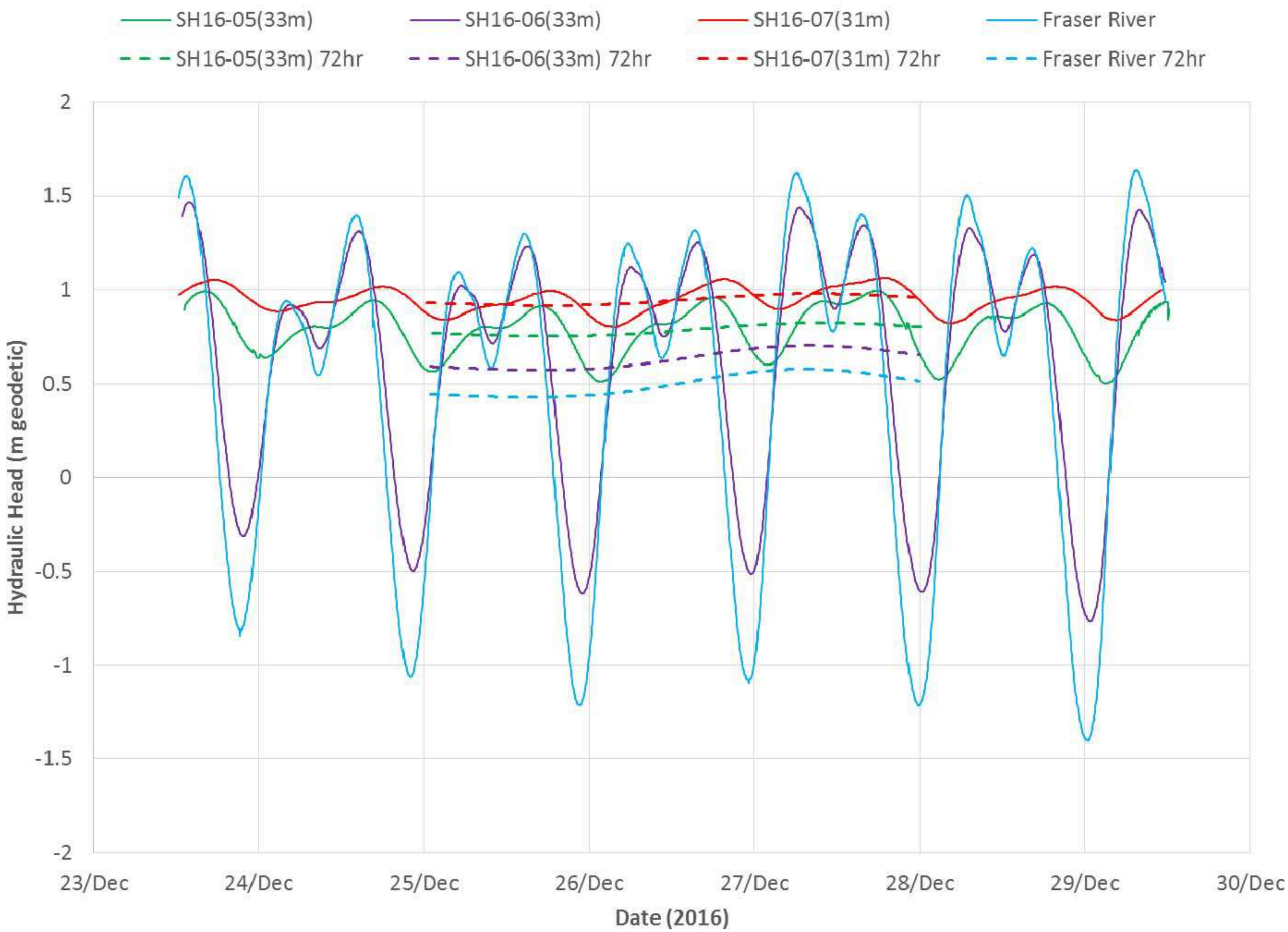
Note:
To go from m geodetic to CGVD28-GVRD, add 100 m

CLIENT	CDM SMITH
PROJECT	ANNACIS ISLAND WWTP TRANSIENT MITIGATION AND OUTFALL DELTA, BC
CONSULTANT	Golder Associates
YYYY-MM-DD	2017-03-01
PREPARED	NF
DESIGNED	NF
REVIEWED	DWC
APPROVED	DWC
TITLE	**CONTINUOUS AND 72HR MOVING AVERAGE HYDRAULIC HEADS – INTERVAL 52 M TO 55 M DEPTH APRIL 27 TO MAY 6, 2016**
PROJECT NO.	1525010
PHASE	605/605.3
REV.	B
FIGURE	1c



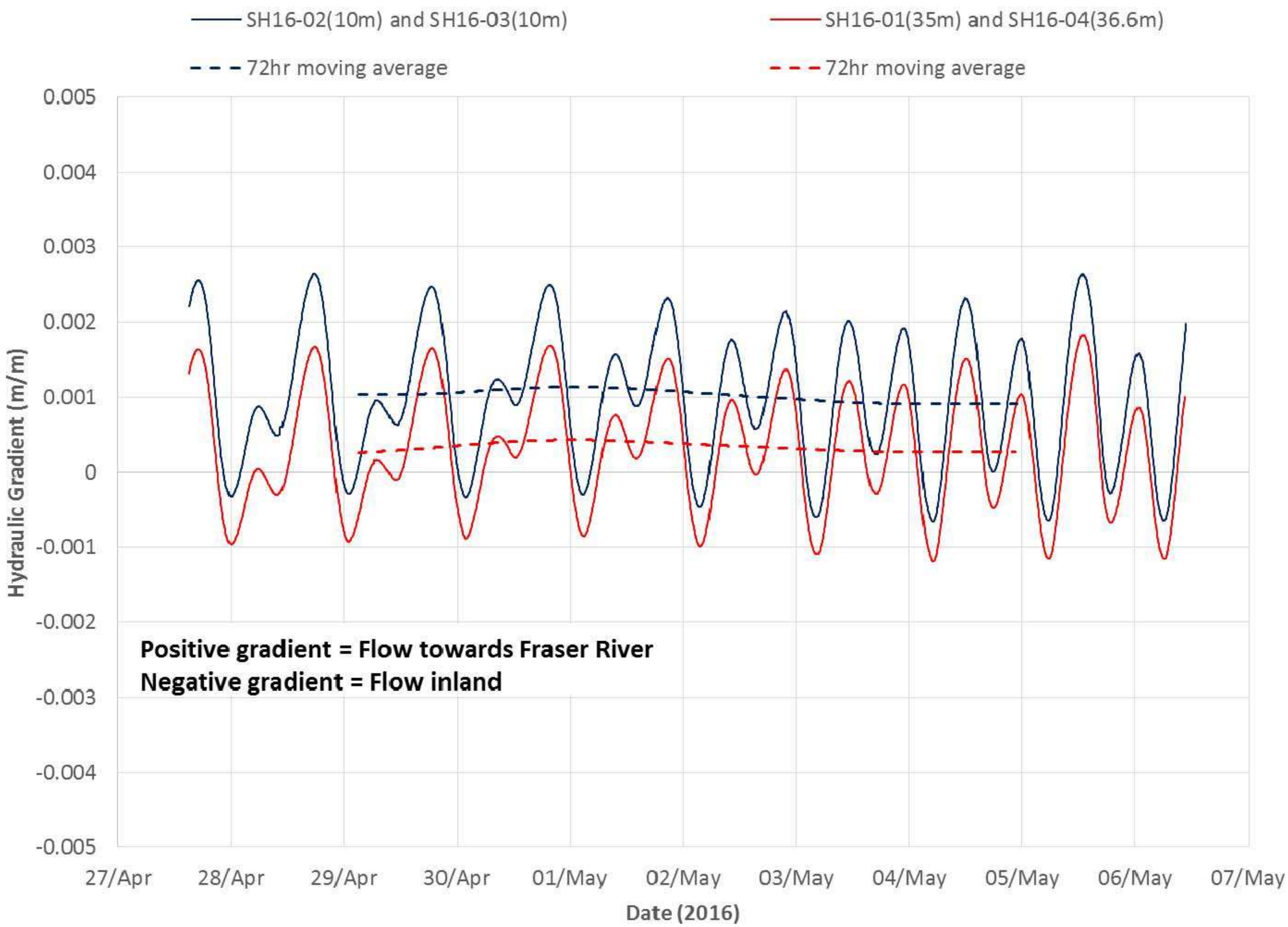
Note:
To go from m geodetic to CGVD28-GVRD, add 100 m

CLIENT	CDM SMITH
PROJECT	ANNACIS ISLAND WWTP TRANSIENT MITIGATION AND OUTFALL DELTA, BC
CONSULTANT	Golder Associates
YYYY-MM-DD	2017-03-01
PREPARED	NF
DESIGNED	NF
REVIEWED	DWC
APPROVED	DWC
TITLE	**CONTINUOUS AND 72HR MOVING AVERAGE HYDRAULIC HEADS – 10 M DEPTH DECEMBER 23 TO 29, 2016**
PROJECT NO.	1525010
PHASE	605/605.3
REV.	B
FIGURE	2a



Note:
To go from m geodetic to CGVD28-GVRD, add 100 m

CLIENT CDM SMITH			PROJECT ANNACIS ISLAND WWTP TRANSIENT MITIGATION AND OUTFALL DELTA, BC
CONSULTANT Golder Associates	YYYY-MM-DD	2017-03-01	TITLE **CONTINUOUS AND 72HR MOVING AVERAGE HYDRAULIC HEADS – INTERVAL 31 M TO 33 M DEPTH DECEMBER 23 TO 29, 2016**
	PREPARED	NF	
	DESIGNED	NF	
	REVIEWED	DWC	
	APPROVED	DWC	PROJECT NO. 1525010 · PHASE 605/605.3 · REV. B · FIGURE **2b**



CLIENT
CDM SMITH

PROJECT
ANNACIS ISLAND WWTP TRANSIENT MITIGATION AND OUTFALL
DELTA, BC

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-01
PREPARED	NF
DESIGNED	NF
REVIEWED	DWC
APPROVED	DWC

TITLE
INSTANTANEOUS AND 72HR MOVING AVERAGE HYDRAULIC GRADIENTS – WELL PAIRS AT 10 M AND 35 M DEPTH
APRIL 27 TO MAY 6, 2016

PROJECT NO.	PHASE	REV.	FIGURE
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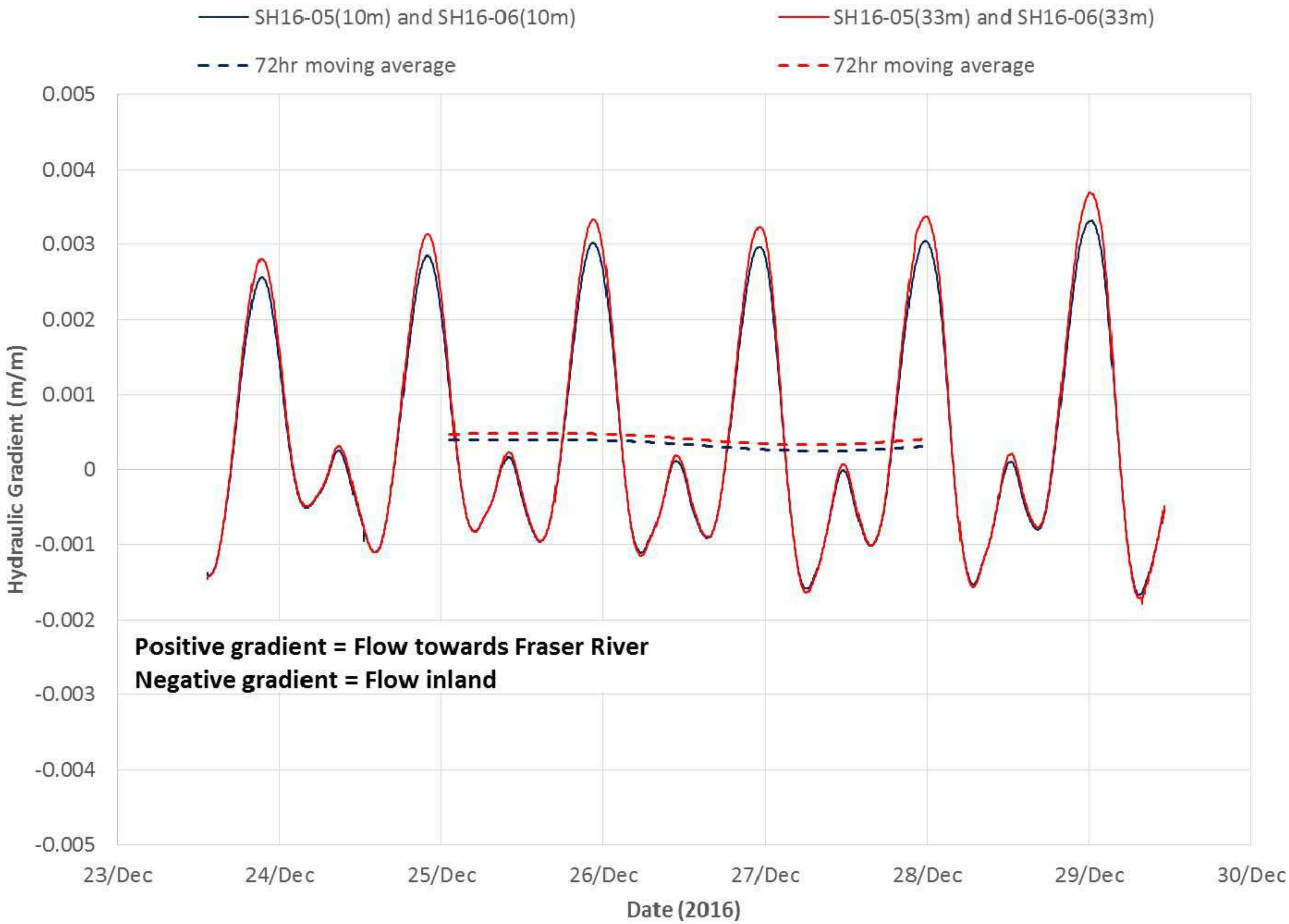
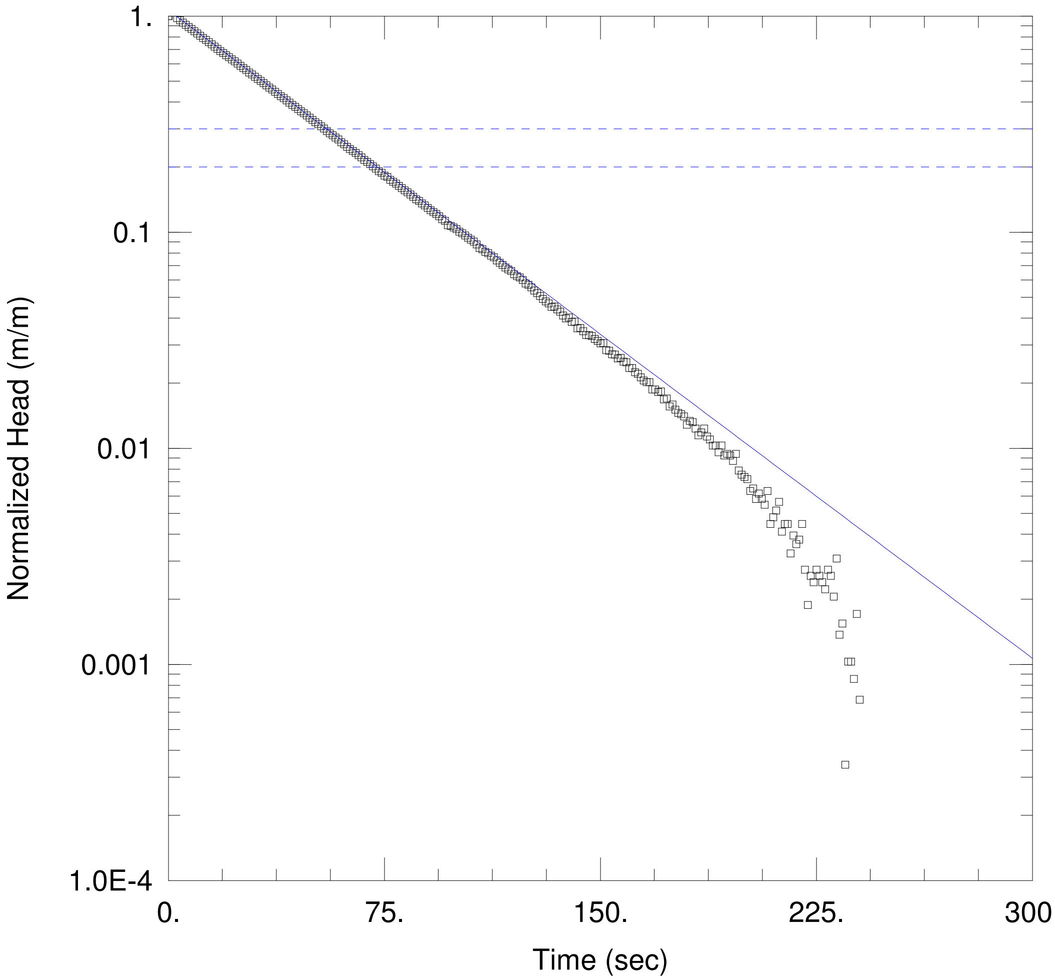


CLIENT CDM SMITH	PROJECT ANNACIS ISLAND WWTP TRANSIENT MITIGATION AND OUTFALL DELTA, BC
CONSULTANT Golder Associates YYYY-MM-DD 2017-03-01 PREPARED NF DESIGNED NF REVIEWED DWC APPROVED DWC	TITLE **INSTANTANEOUS AND 72HR MOVING AVERAGE HYDRAULIC GRADIENTS – WELL PAIRS AT 10 M AND 33 M DEPTH** **DECEMBER 23 TO 29, 2016**
	PROJECT NO. **1525010** PHASE **605/605.3** REV. **B** FIGURE **4**

ATTACHMENT 1

Slug Test Reports



SH16-01(10M) - TEST 1

Data Set: O:\...\SH16-01(10)_Test1.aqt
Date: 03/01/17 Time: 15:52:28

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-01(10m)

AQUIFER DATA

Saturated Thickness: 7.1 m Anisotropy Ratio (Kz/Kr): 1.

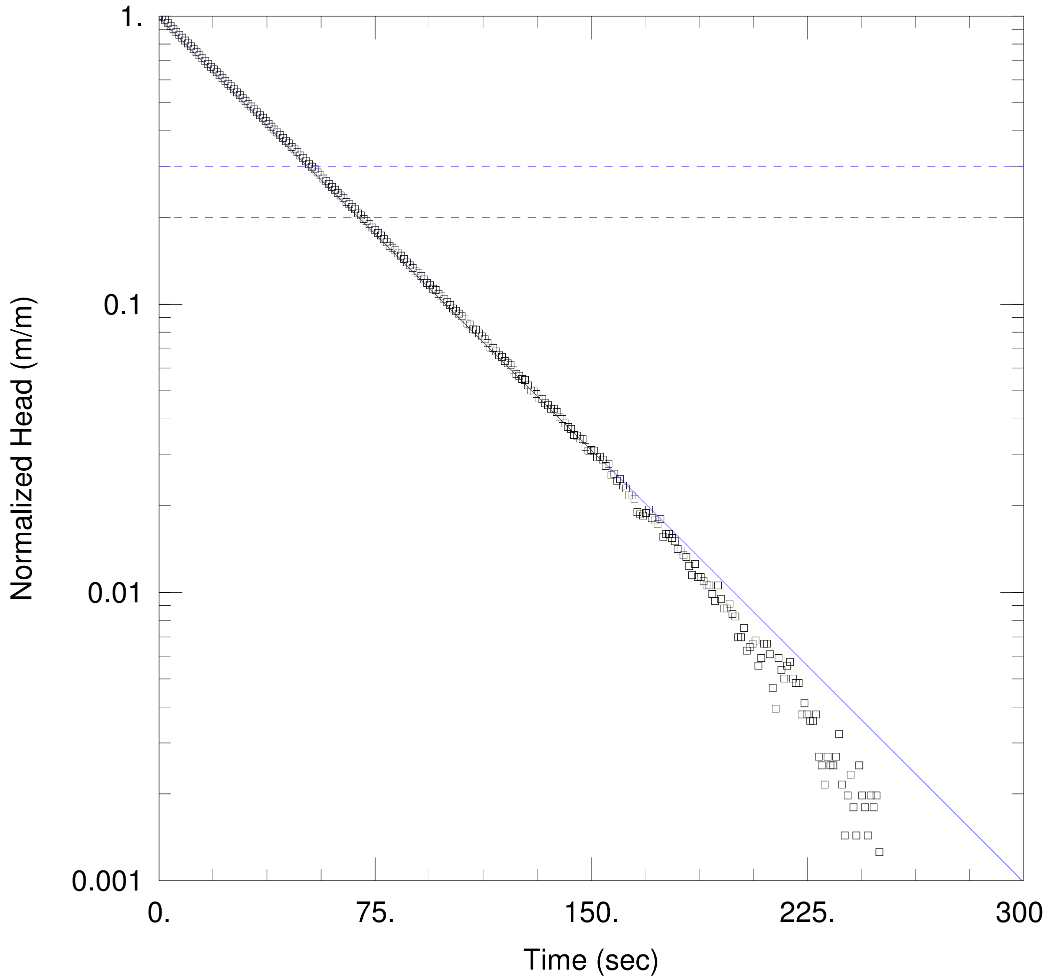
WELL DATA (SH16-01(10m))

Initial Displacement: 0.5834 m
Total Well Penetration Depth: 4.27 m
Casing Radius: 0.026 m
Static Water Column Height: 6.13 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.1E-5 m/sec y0 = 0.62 m



SH16-01(10M) - TEST 2

Data Set: O:\...\SH16-01(10)_Test2.aqt
Date: 03/01/17
Time: 15:53:08

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-01(10m)

AQUIFER DATA

Saturated Thickness: 7.1 m
Anisotropy Ratio (Kz/Kr): 1.

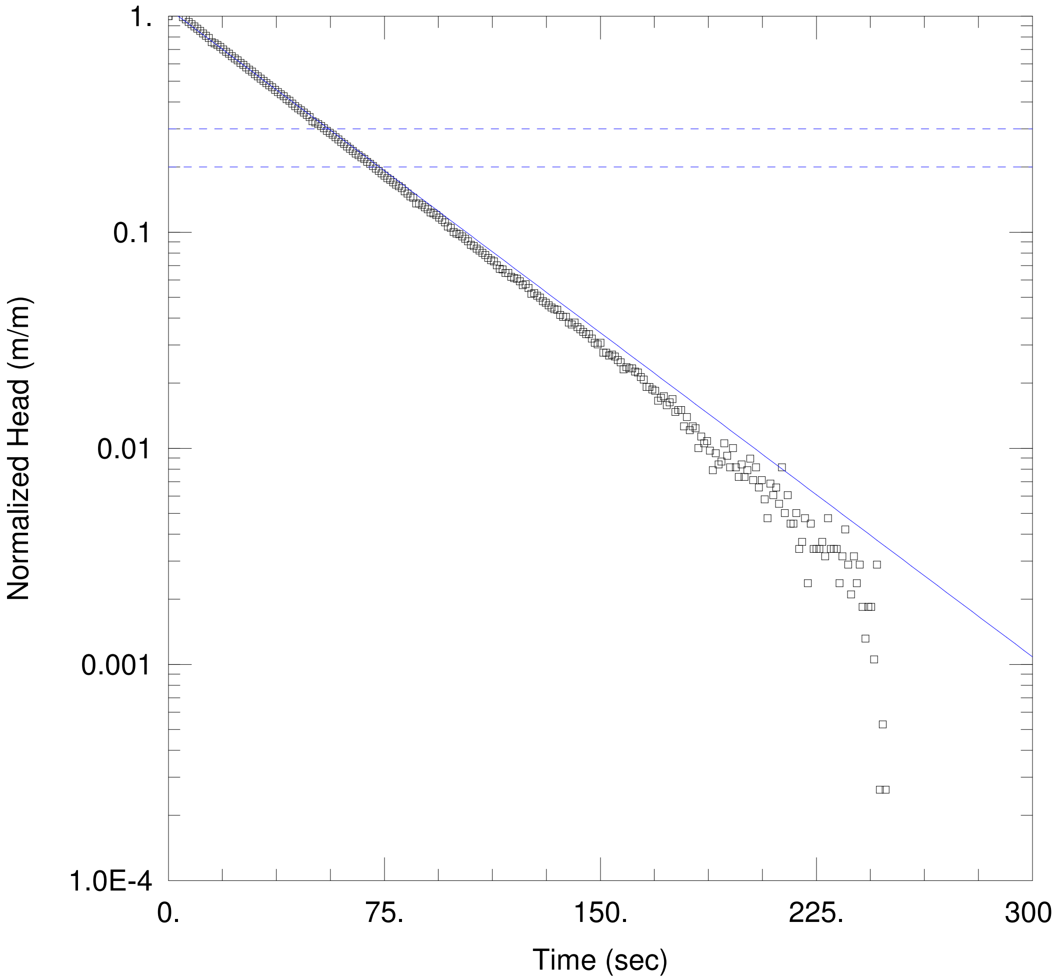
WELL DATA (SH16-01(10m))

Initial Displacement: 0.558 m
Static Water Column Height: 6.13 m
Total Well Penetration Depth: 4.27 m
Screen Length: 1.5 m
Casing Radius: 0.026 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.1E-5 m/sec
y0 = 0.55 m



SH16-01(10M) - TEST 3

Data Set: O:\...\SH16-01(10)_Test3.aqt
Date: 03/01/17 Time: 15:53:39

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-01(10m)

AQUIFER DATA

Saturated Thickness: 7.1 m Anisotropy Ratio (Kz/Kr): 1.

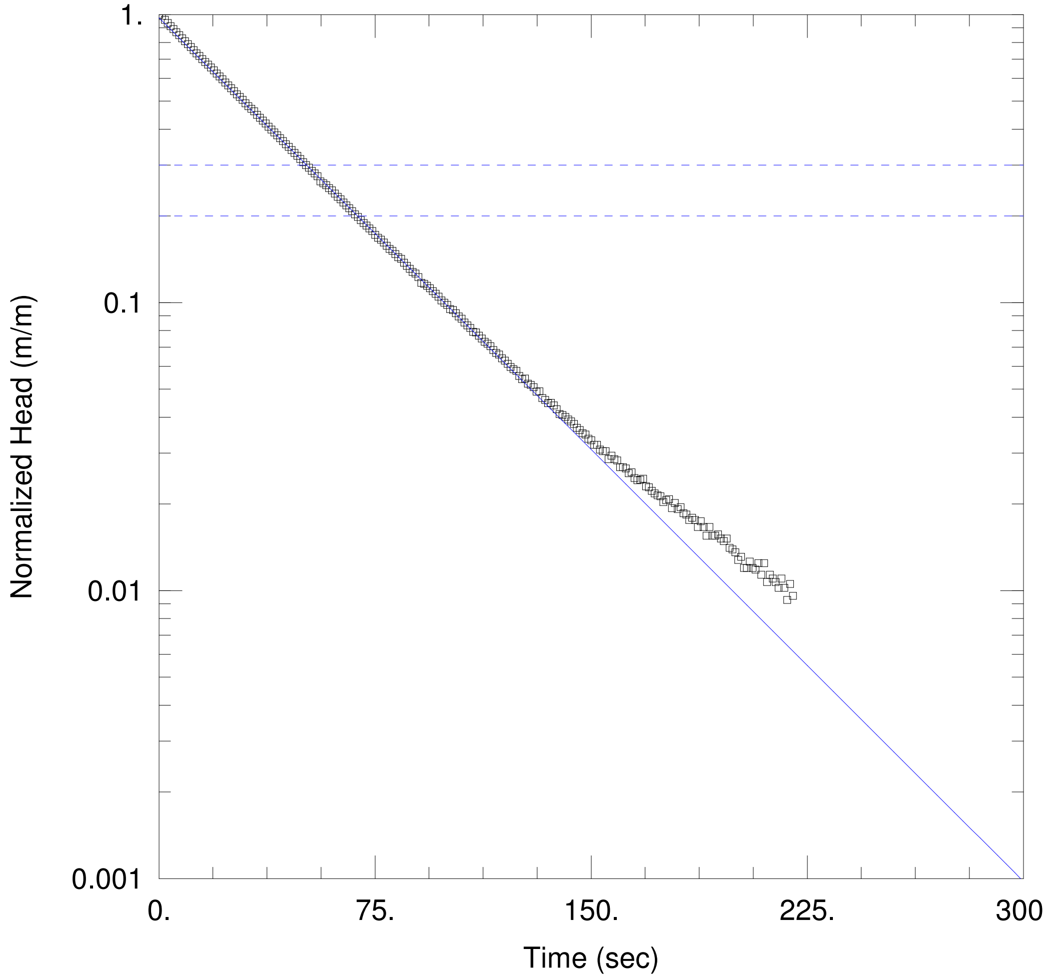
WELL DATA (SH16-01(10m))

Initial Displacement: 0.3796 m
Total Well Penetration Depth: 4.27 m
Casing Radius: 0.026 m
Static Water Column Height: 6.13 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.1E-5 m/sec y0 = 0.41 m



SH16-01(10M) - TEST 4

Data Set: O:\...\SH16-01(10)_Test4.aqt
Date: 03/01/17 Time: 15:54:08

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-01(10m)

AQUIFER DATA

Saturated Thickness: 7.1 m Anisotropy Ratio (Kz/Kr): 1.

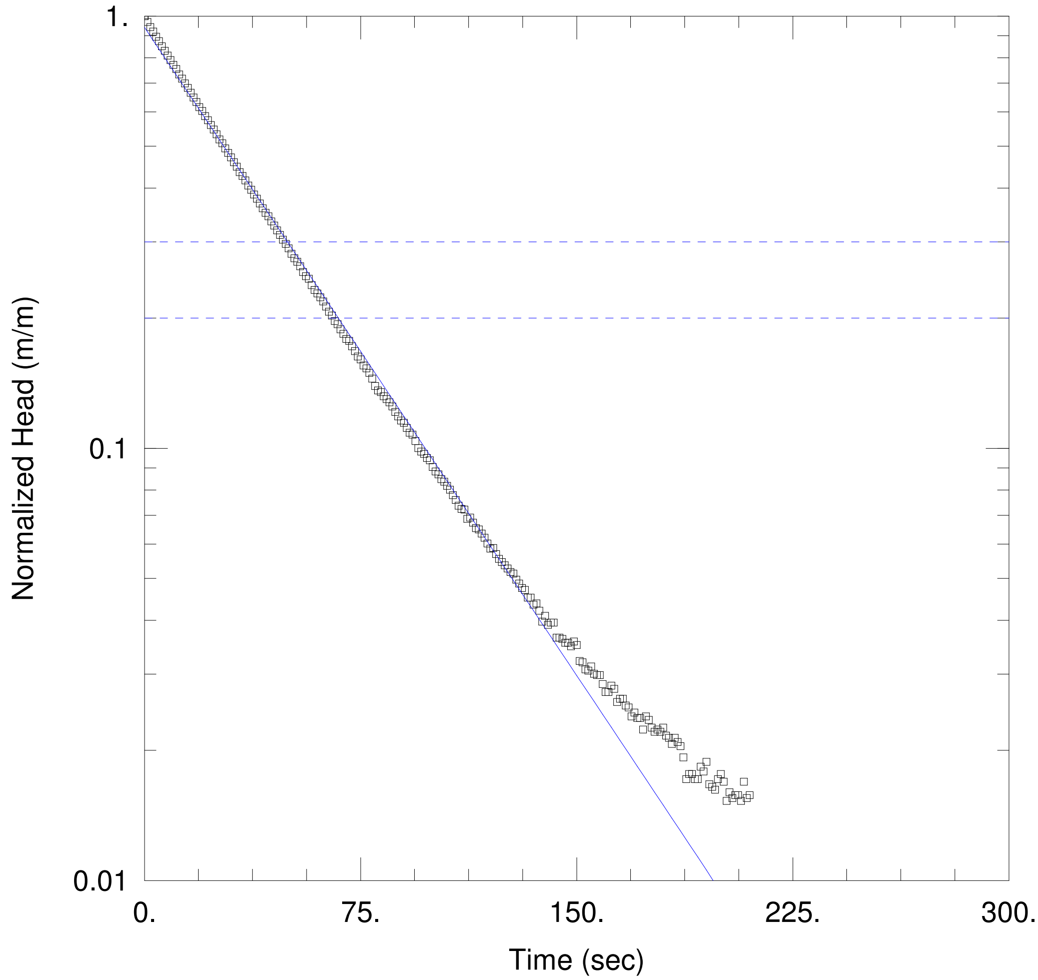
WELL DATA (SH16-01(10m))

Initial Displacement: 0.6261 m
Total Well Penetration Depth: 4.27 m
Casing Radius: 0.026 m
Static Water Column Height: 6.13 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.1E-5 m/sec y0 = 0.61 m



SH16-01(10M) - TEST 5

Data Set: O:\...\SH16-01(10)_Test5.aqt
Date: 03/01/17 Time: 15:54:31

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-01(10m)

AQUIFER DATA

Saturated Thickness: 7.1 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SH16-01(10m))

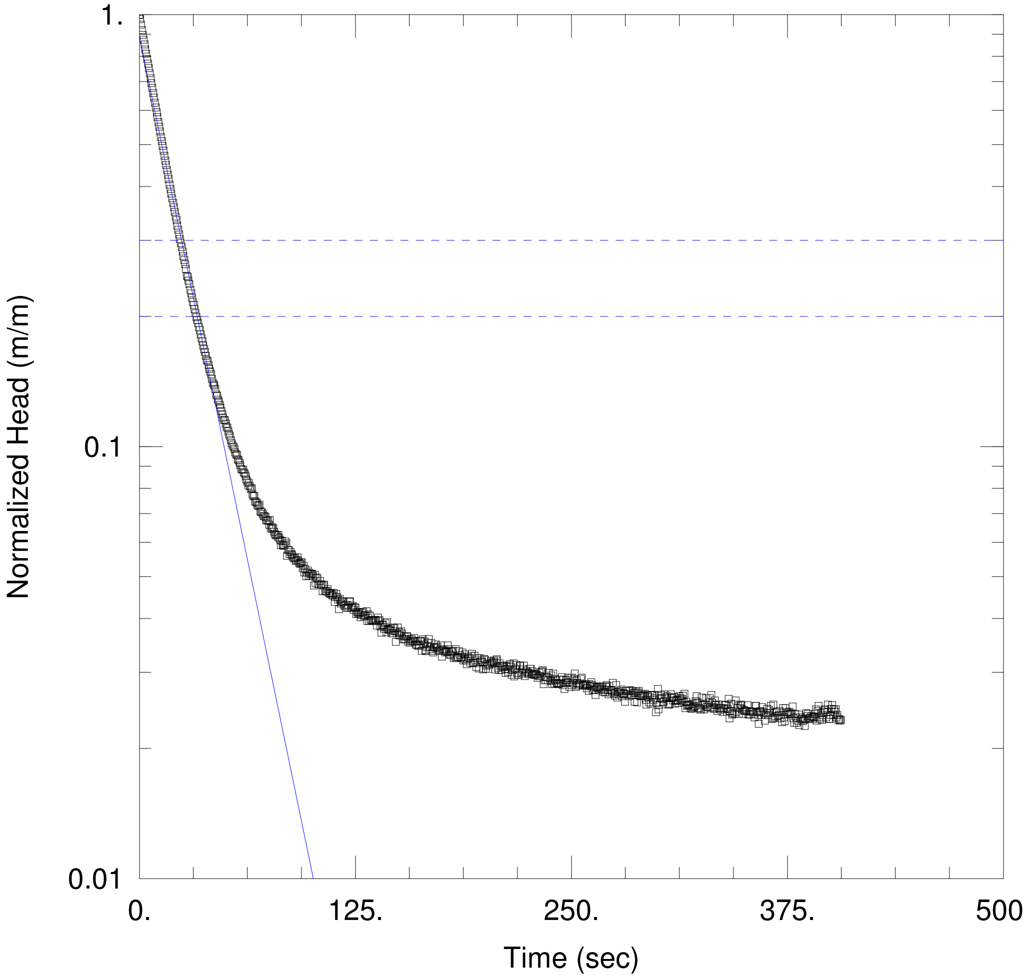
Initial Displacement: 0.4253 m
Total Well Penetration Depth: 4.27 m
Casing Radius: 0.026 m

Static Water Column Height: 6.13 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.1E-5 m/sec y0 = 0.4 m



SH16-01(35M)

Data Set: O:\...\SH16-01(35m)_Test2.aqt
Date: 03/01/17 Time: 15:56:20

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-01(35)

AQUIFER DATA

Saturated Thickness: 37.5 m Anisotropy Ratio (Kz/Kr): 1.

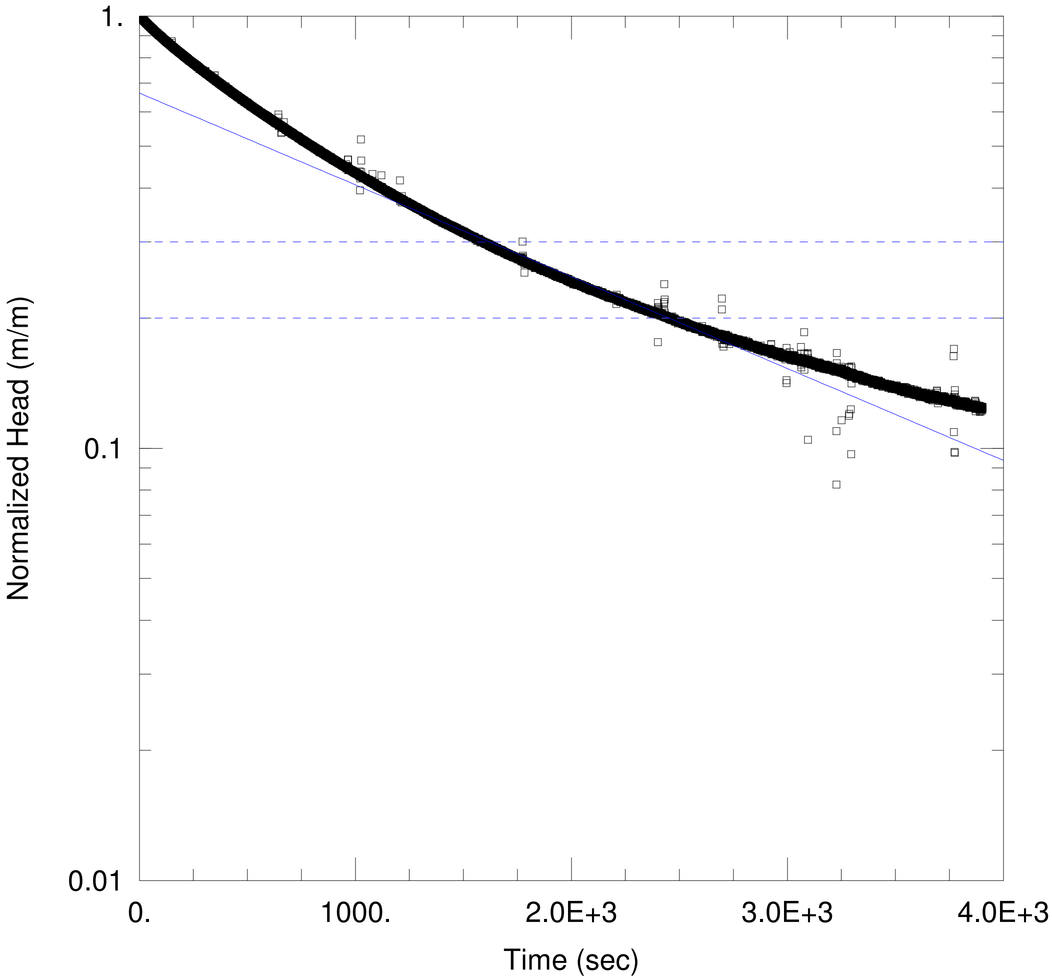
WELL DATA (SH16-01(35m))

Initial Displacement: 1.06 m
Total Well Penetration Depth: 22.02 m
Casing Radius: 0.026 m
Static Water Column Height: 31.05 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.4E-5 m/sec
y0 = 0.94 m



SH16-01(55M)

Data Set: O:\...\SH16-01(55m)_Test1.aqt
Date: 03/01/17 Time: 15:57:18

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-01(55m)

AQUIFER DATA

Saturated Thickness: 24.5 m Anisotropy Ratio (Kz/Kr): 1.

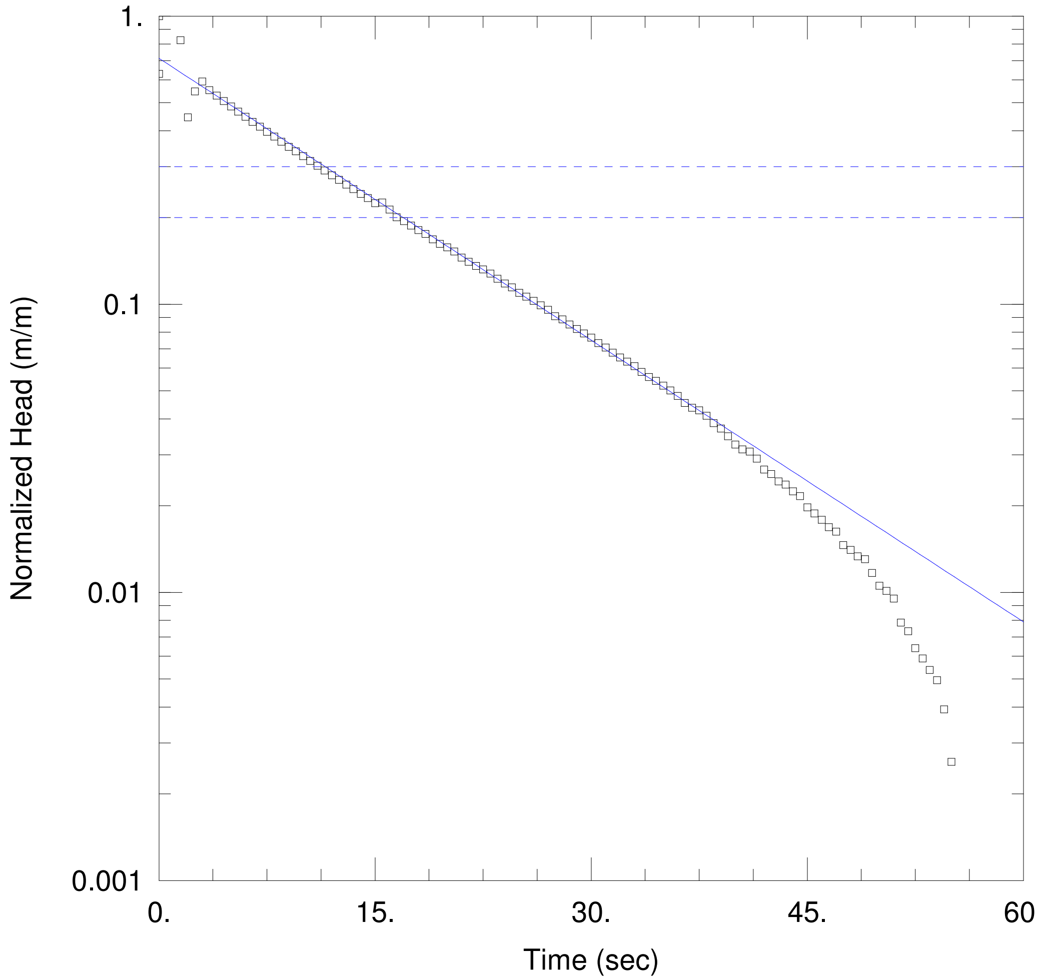
WELL DATA (SH16-01(55m))

Initial Displacement: 1.01 m Static Water Column Height: 51.3 m
Total Well Penetration Depth: 4.69 m Screen Length: 1.5 m
Casing Radius: 0.026 m Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.2E-7 m/sec y0 = 0.67 m



SH16-02(10M) - TEST 1

Data Set: O:\...\SH16-02(10m)_Test1.aqt
Date: 03/01/17 Time: 15:59:47

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-02(10m)

AQUIFER DATA

Saturated Thickness: 7.1 m
Anisotropy Ratio (Kz/Kr): 1.

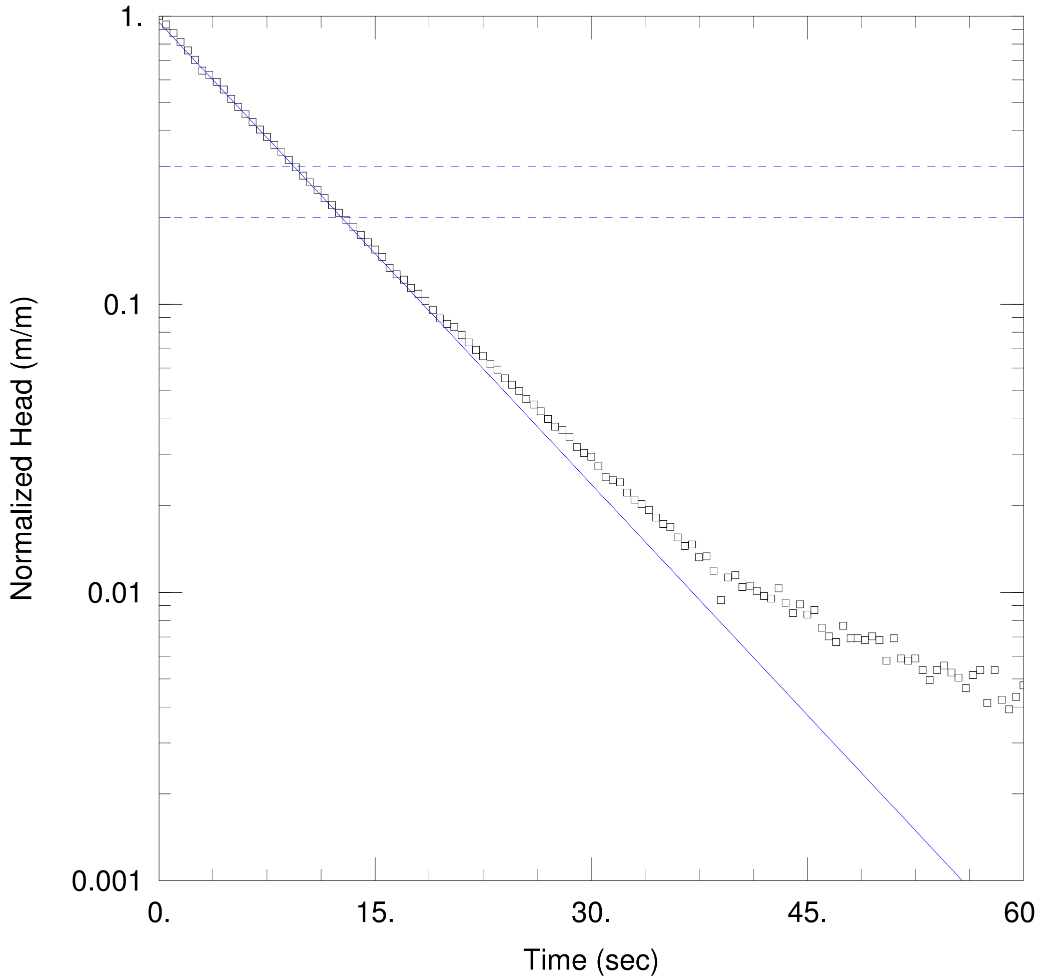
WELL DATA (SH16-02(10m))

Initial Displacement: 0.9679 m
Total Well Penetration Depth: 4.34 m
Casing Radius: 0.026 m
Static Water Column Height: 7.03 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.6E-5 m/sec
y0 = 0.69 m



SH16-02(10M) - TEST 2

Data Set: O:\...\SH16-02(10m)_Test2.aqt
Date: 03/01/17 Time: 16:00:17

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-02(10m)

AQUIFER DATA

Saturated Thickness: 7.1 m
Anisotropy Ratio (Kz/Kr): 1.

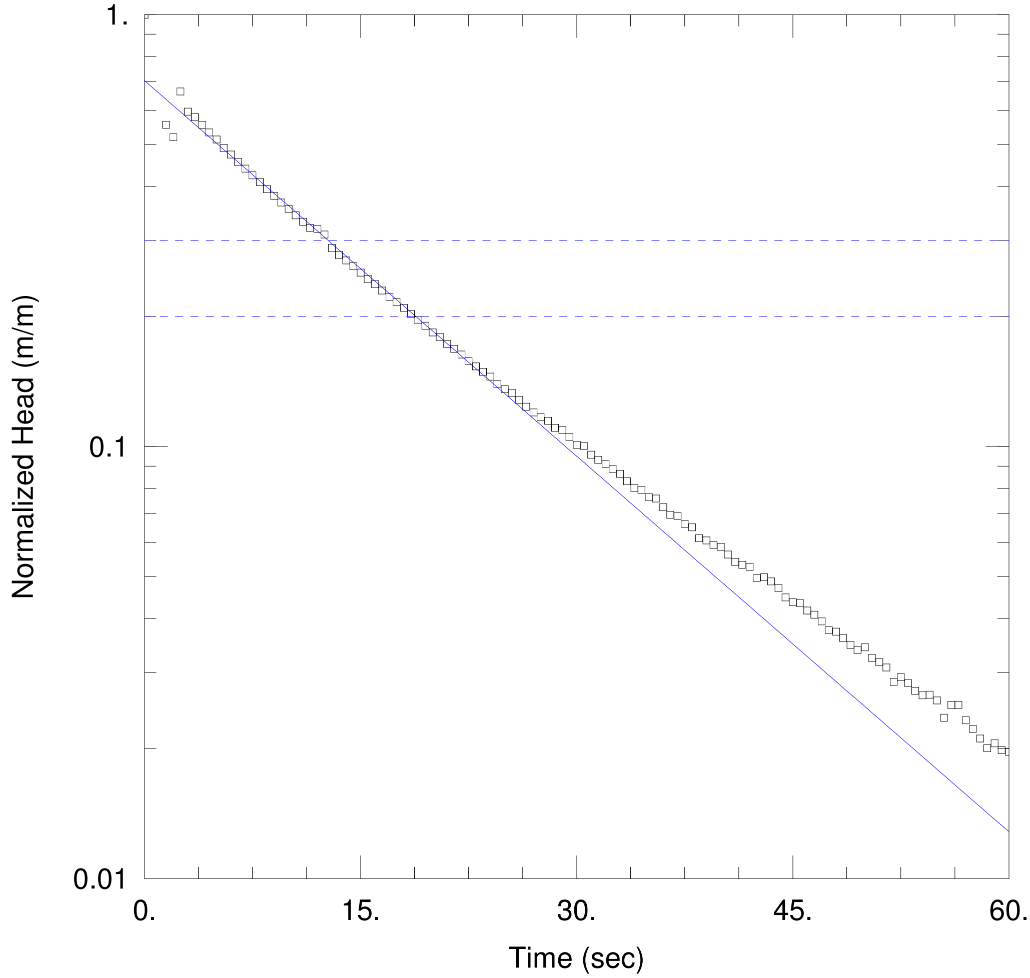
WELL DATA (SH16-02(10m))

Initial Displacement: 0.9679 m
Total Well Penetration Depth: 4.34 m
Casing Radius: 0.026 m
Static Water Column Height: 7.03 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 5.9E-5 m/sec
y0 = 0.92 m



SH16-02(10M) - TEST 3

Data Set: O:\...\SH16-02(10m)_Test3.aqt
Date: 03/01/17 Time: 16:01:16

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-02(10m)

AQUIFER DATA

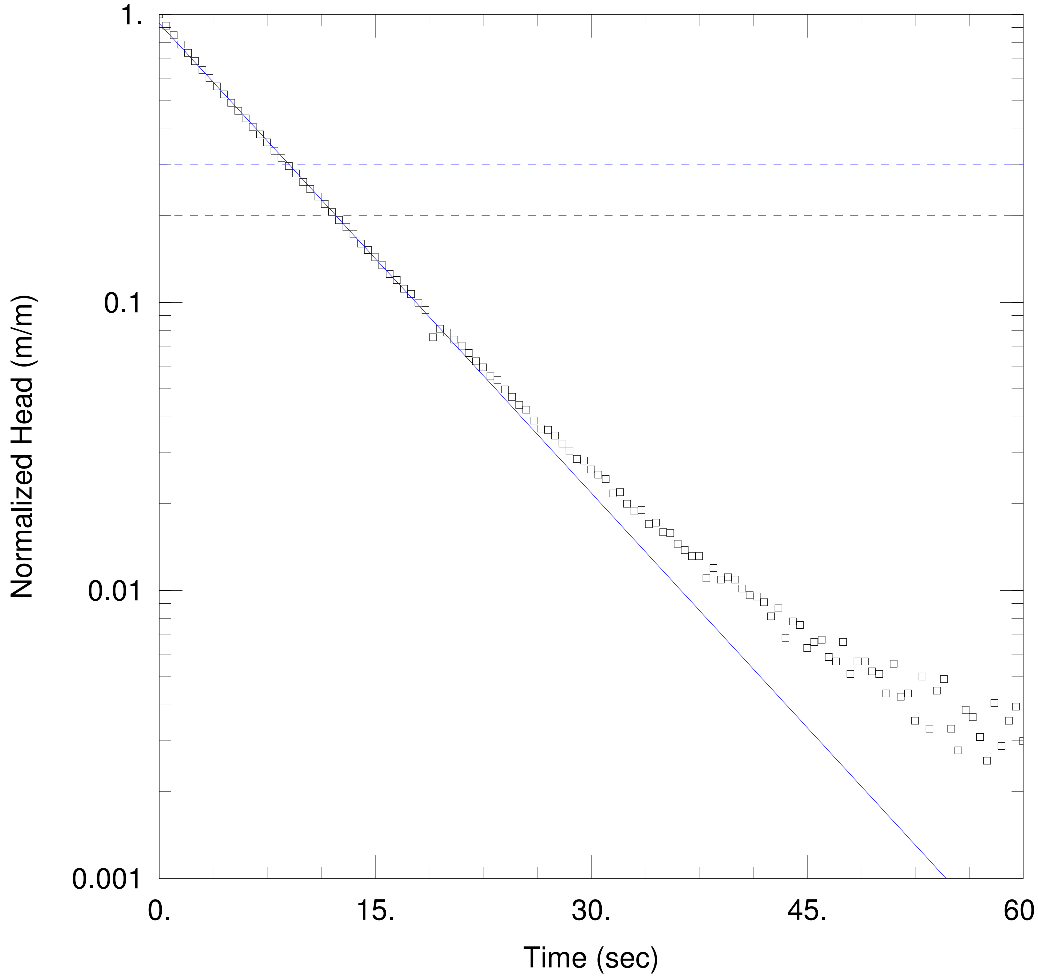
Saturated Thickness: 7.1 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SH16-02(10m))

Initial Displacement: 0.9679 m
Static Water Column Height: 7.03 m
Total Well Penetration Depth: 4.34 m
Screen Length: 1.5 m
Casing Radius: 0.026 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 3.2E-5 m/sec
y0 = 0.68 m



SH16-02(10M) - TEST 4

Data Set: O:\...\SH16-02(10m)_Test4.aqt
Date: 03/01/17 Time: 16:01:37

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-02(10m)

AQUIFER DATA

Saturated Thickness: 7.1 m Anisotropy Ratio (Kz/Kr): 1.

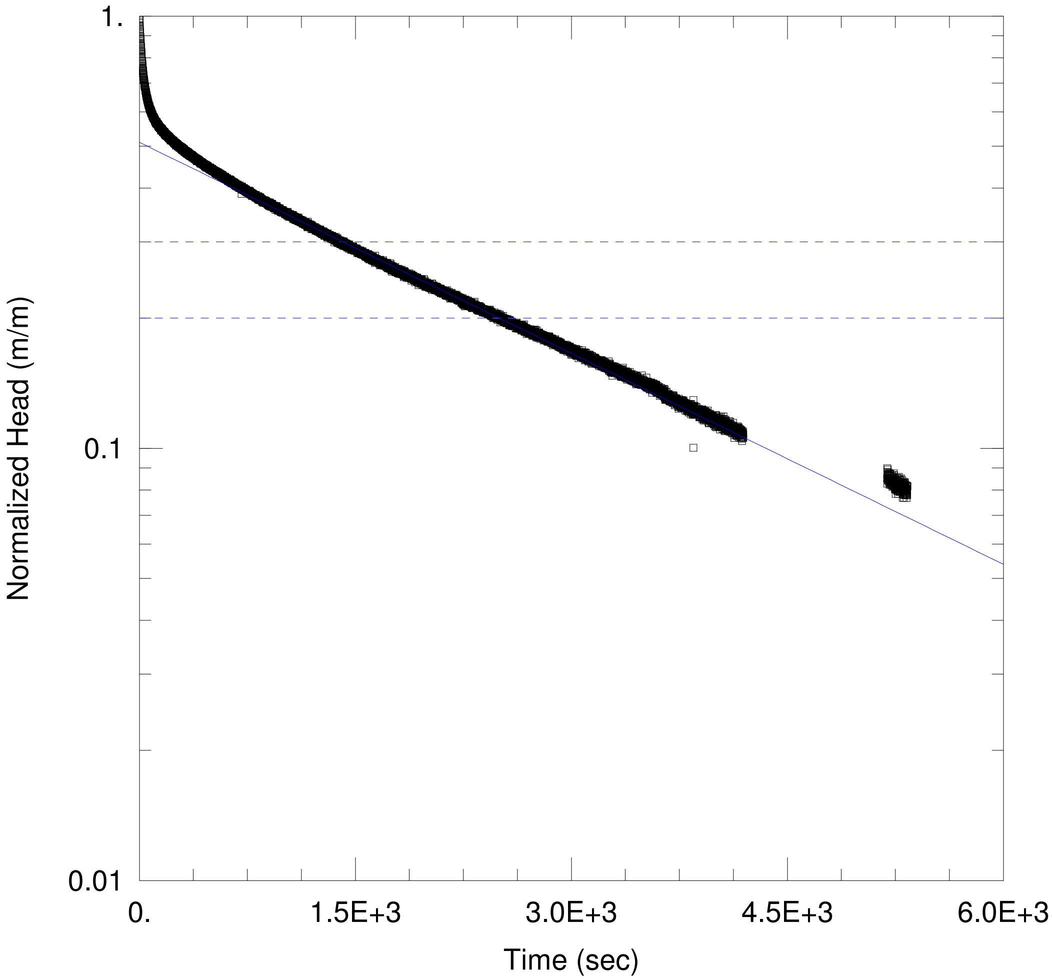
WELL DATA (SH16-02(10m))

Initial Displacement: 0.9366 m
Total Well Penetration Depth: 4.34 m
Casing Radius: 0.026 m
Static Water Column Height: 7.03 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 6.0E-5 m/sec
y0 = 0.87 m



SH16-02(45M)

Data Set: O:\...\SH16-02(45m)_Test1.aqt
Date: 03/01/17
Time: 16:02:14

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-02(45m)

AQUIFER DATA

Saturated Thickness: 42.3 m
Anisotropy Ratio (Kz/Kr): 1.

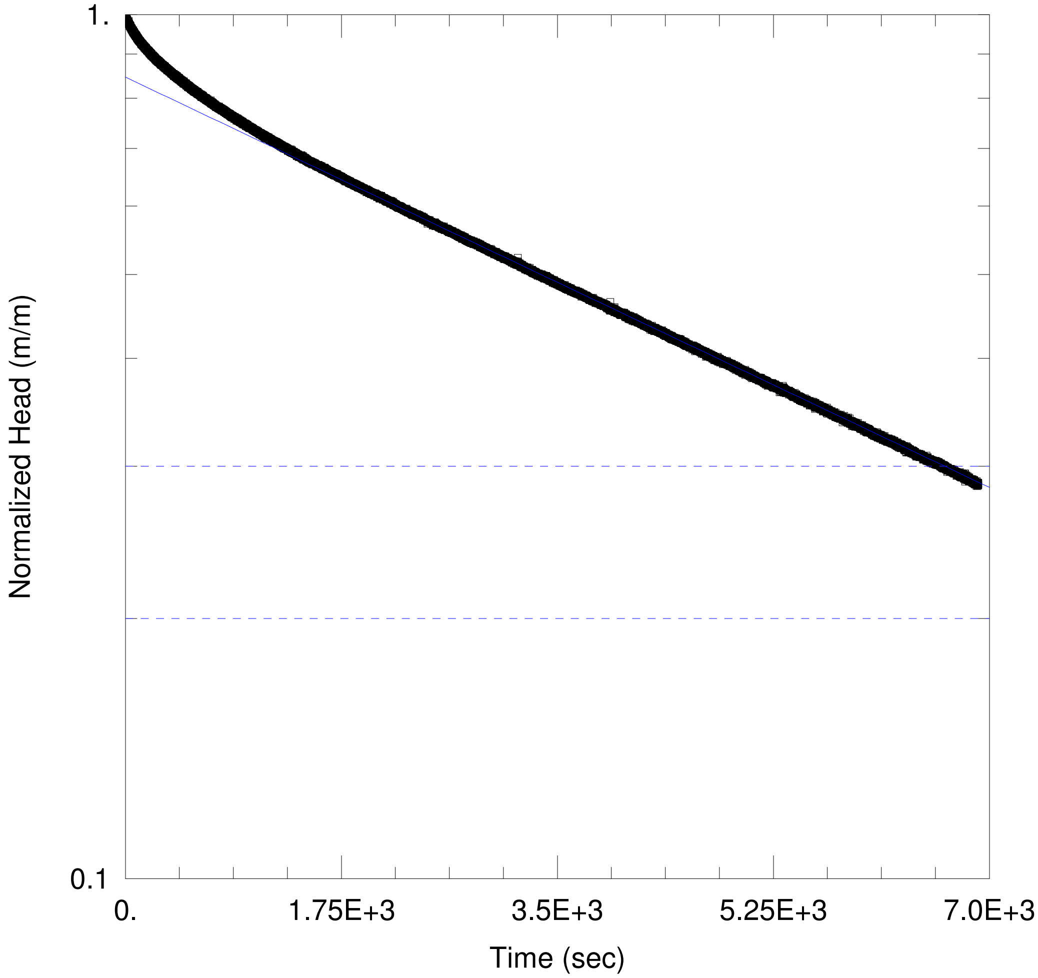
WELL DATA (SH16-02(45m))

Initial Displacement: 0.9607 m
Total Well Penetration Depth: 39.57 m
Casing Radius: 0.026 m
Static Water Column Height: 42.21 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.3E-7 m/sec
y0 = 0.49 m



SH16-02(52M)

Data Set: O:\...\SH16-02(52m)_Test1.aqt
Date: 03/01/17 Time: 16:03:04

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-02(52m)

AQUIFER DATA

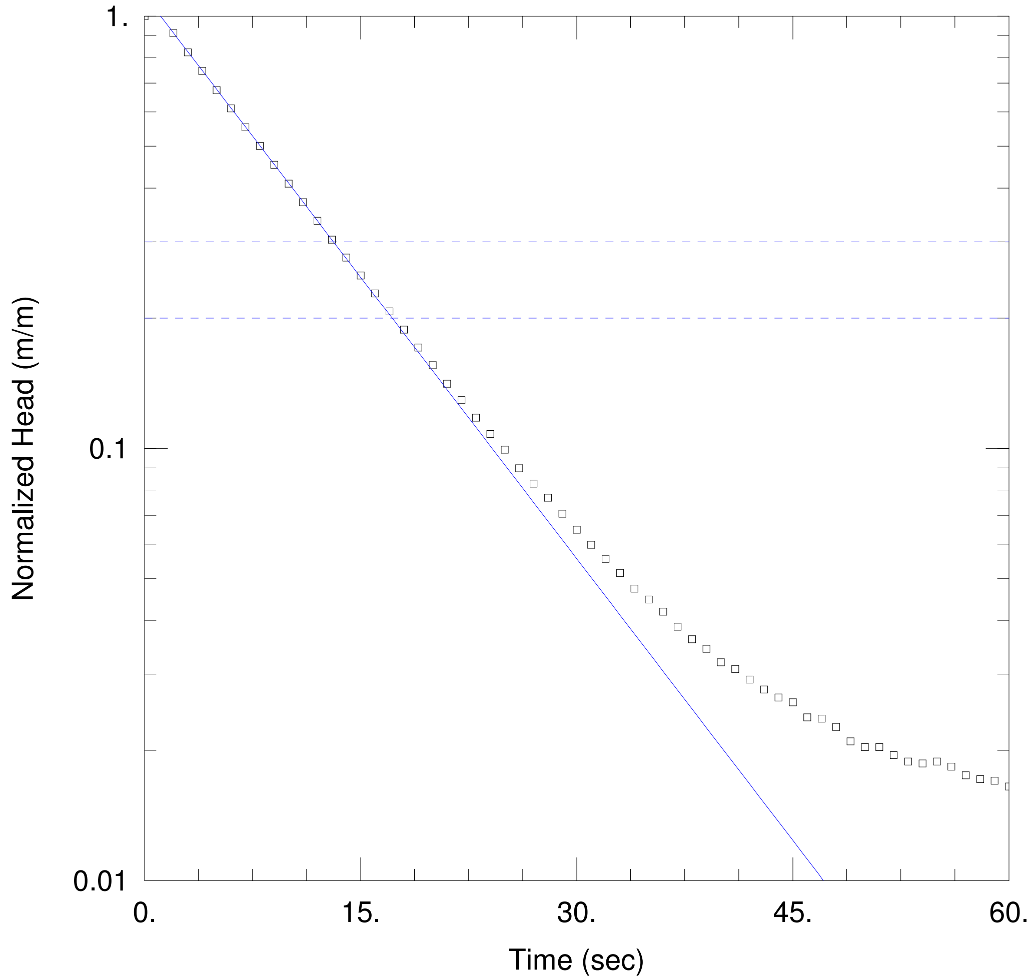
Saturated Thickness: 28.6 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SH16-02(52m))

Initial Displacement: 1.04 m Static Water Column Height: 49.89 m
Total Well Penetration Depth: 4.81 m Screen Length: 1.5 m
Casing Radius: 0.026 m Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice
K = 7.0E-8 m/sec y0 = 0.88 m



SH16-03(10M) - TEST 1

Data Set: O:\...\SH16-03(10m)_Test1.aqt
Date: 03/01/17 Time: 16:03:56

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-03(10m)

AQUIFER DATA

Saturated Thickness: 23.5 m Anisotropy Ratio (Kz/Kr): 1.

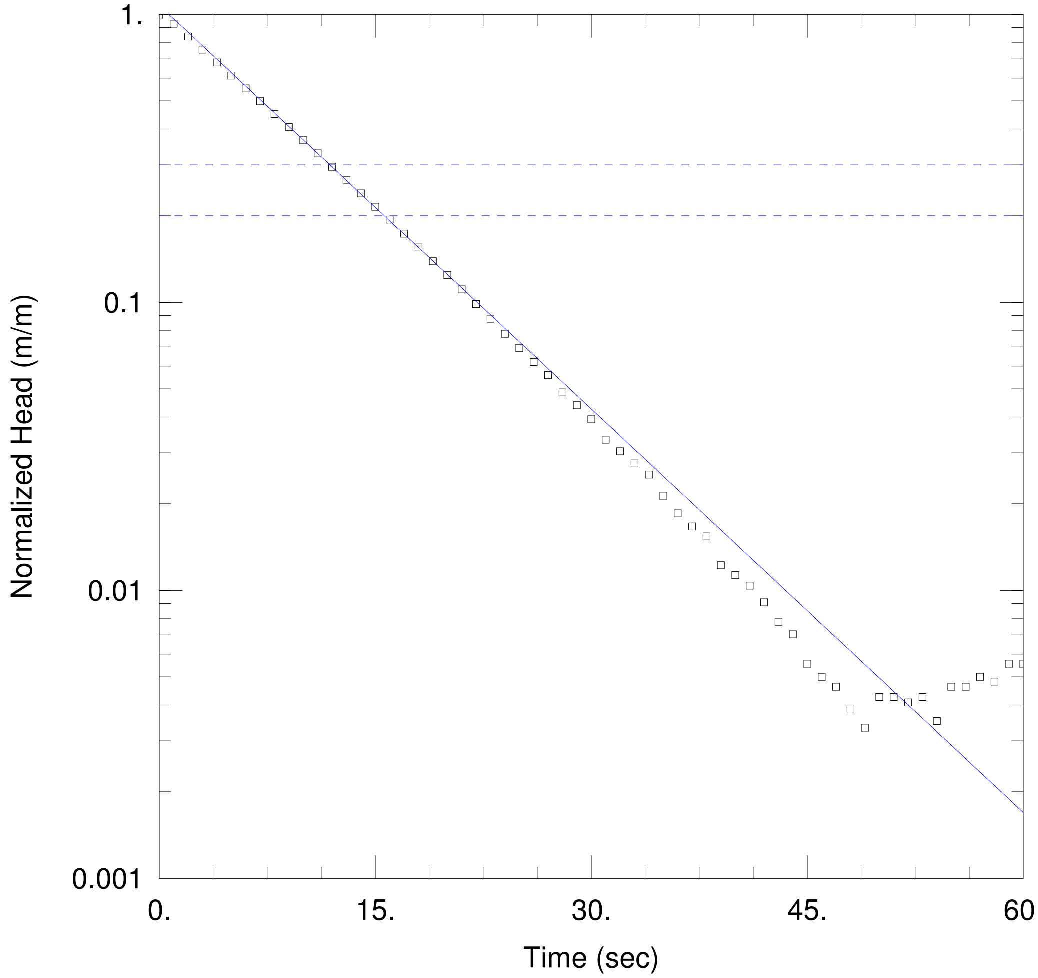
WELL DATA (SH16-03(10m))

Initial Displacement: 0.6 m Static Water Column Height: 6.31 m
Total Well Penetration Depth: 2.29 m Screen Length: 1.5 m
Casing Radius: 0.026 m Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 4.0E-5 m/sec y0 = 0.67 m



SH16-03(10M) - TEST 2

Data Set: O:\...\SH16-03(10m)_Test2.aqt
Date: 03/01/17
Time: 16:04:21

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-03(10m)

AQUIFER DATA

Saturated Thickness: 23.5 m
Anisotropy Ratio (Kz/Kr): 1.

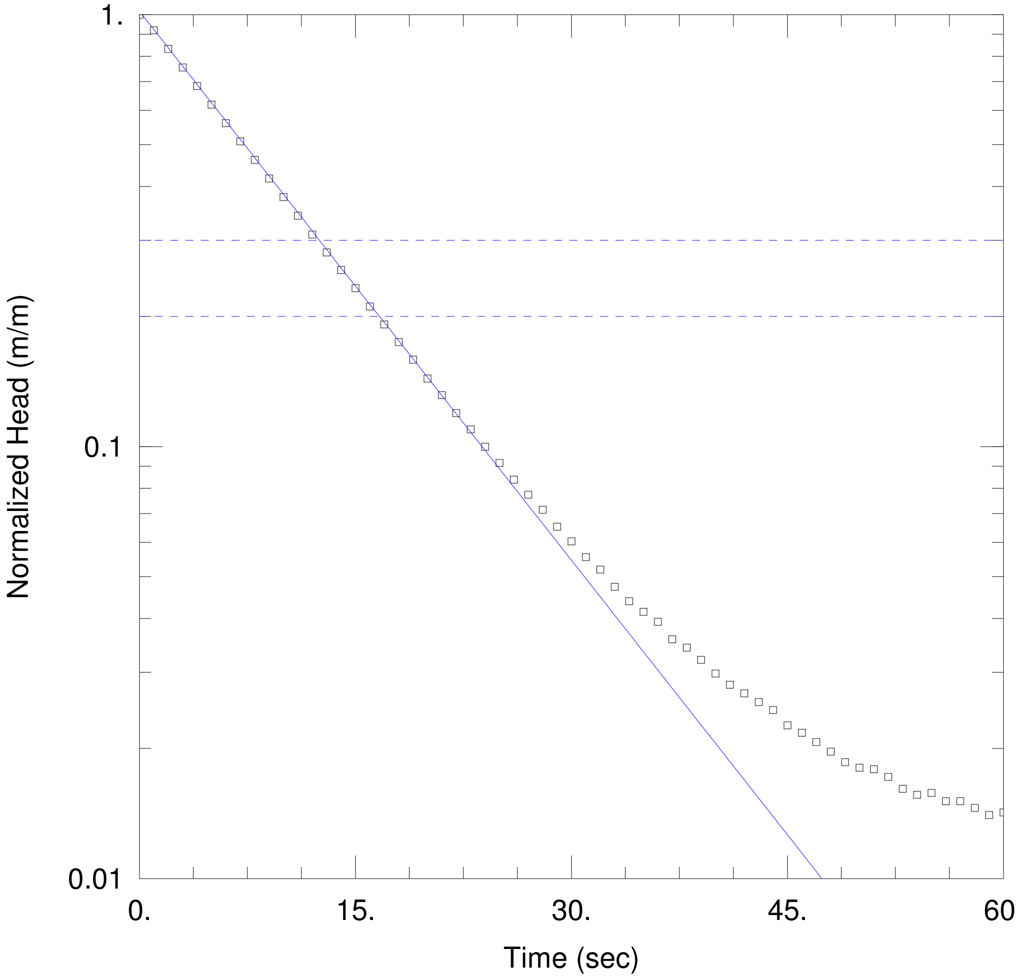
WELL DATA (SH16-03(10m))

Initial Displacement: 0.54 m
Static Water Column Height: 6.31 m
Total Well Penetration Depth: 2.29 m
Screen Length: 1.5 m
Casing Radius: 0.026 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 4.3E-5 m/sec
y0 = 0.58 m



SH16-03(10M) - TEST 3

Data Set: O:\...\SH16-03(10m)_Test3.aqt
Date: 03/01/17 Time: 16:04:38

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-03(10m)

AQUIFER DATA

Saturated Thickness: 23.5 m
Anisotropy Ratio (Kz/Kr): 1.

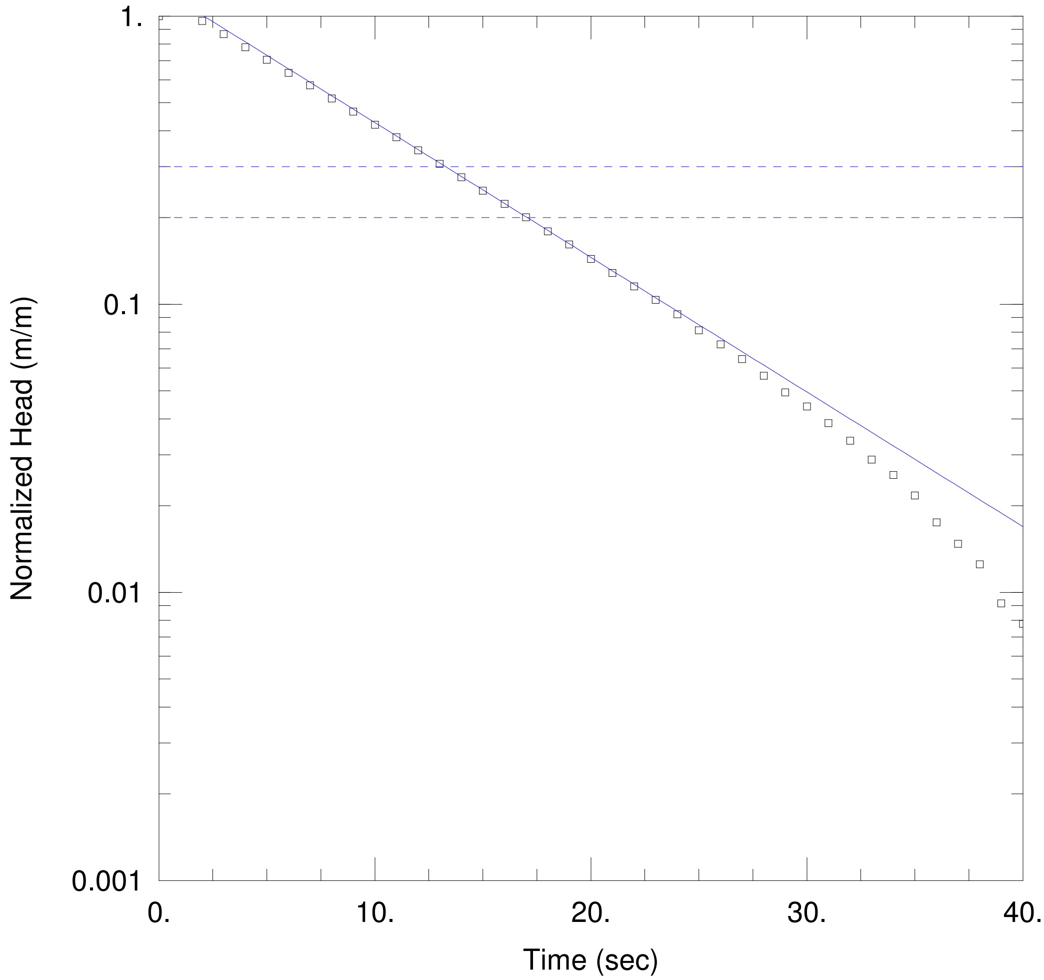
WELL DATA (SH16-03(10m))

Initial Displacement: 0.57 m
Total Well Penetration Depth: 2.29 m
Casing Radius: 0.026 m
Static Water Column Height: 6.31 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.9E-5 m/sec
y0 = 0.58 m



SH16-03(10M) - TEST 4

Data Set: O:\...\SH16-03(10m)_Test4.aqt
Date: 03/01/17 Time: 16:04:55

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-03(10m)

AQUIFER DATA

Saturated Thickness: 23.5 m Anisotropy Ratio (Kz/Kr): 1.

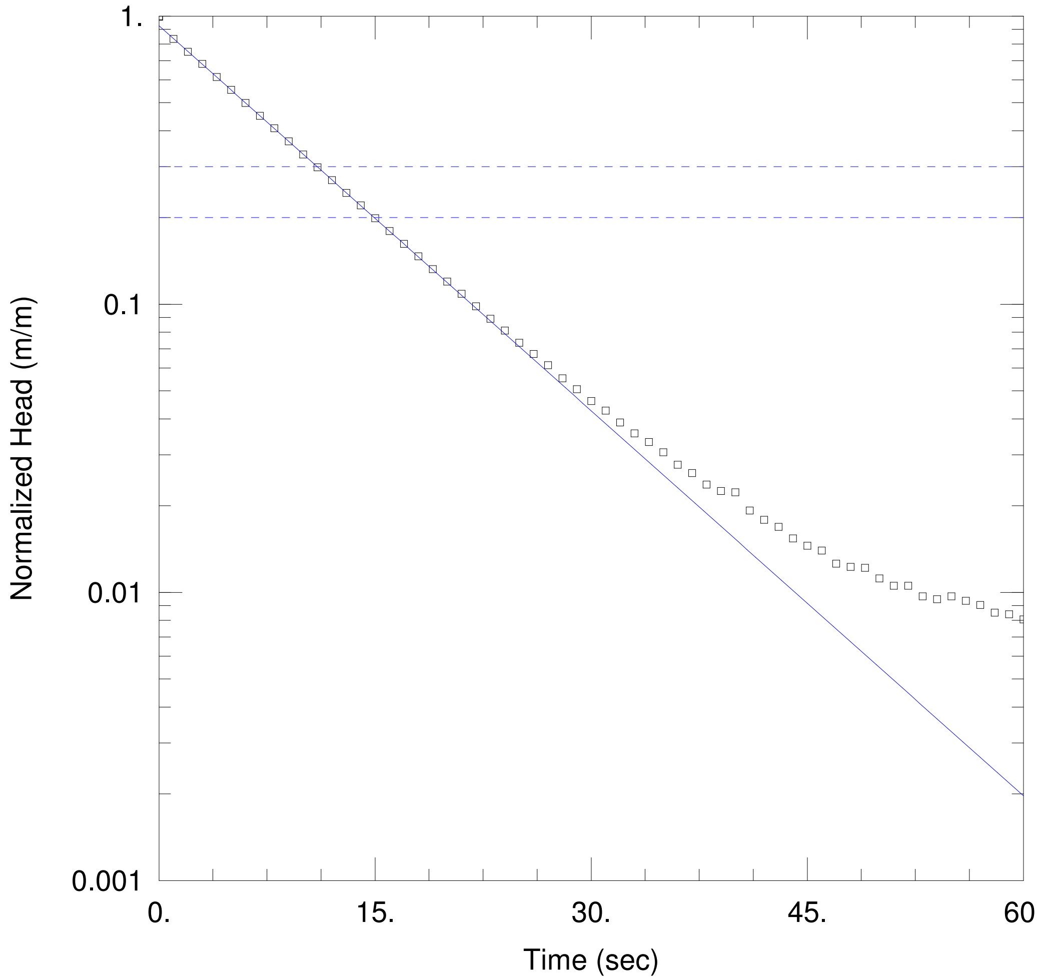
WELL DATA (SH16-03(10m))

Initial Displacement: 0.36 m Static Water Column Height: 6.31 m
Total Well Penetration Depth: 2.29 m Screen Length: 1.5 m
Casing Radius: 0.026 m Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 4.3E-5 m/sec y0 = 0.45 m



SH16-03(10M) - TEST 5

Data Set: O:\...\SH16-03(10m)_Test5.aqt
Date: 03/01/17 Time: 16:05:12

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-03(10m)

AQUIFER DATA

Saturated Thickness: 23.5 m Anisotropy Ratio (Kz/Kr): 1.

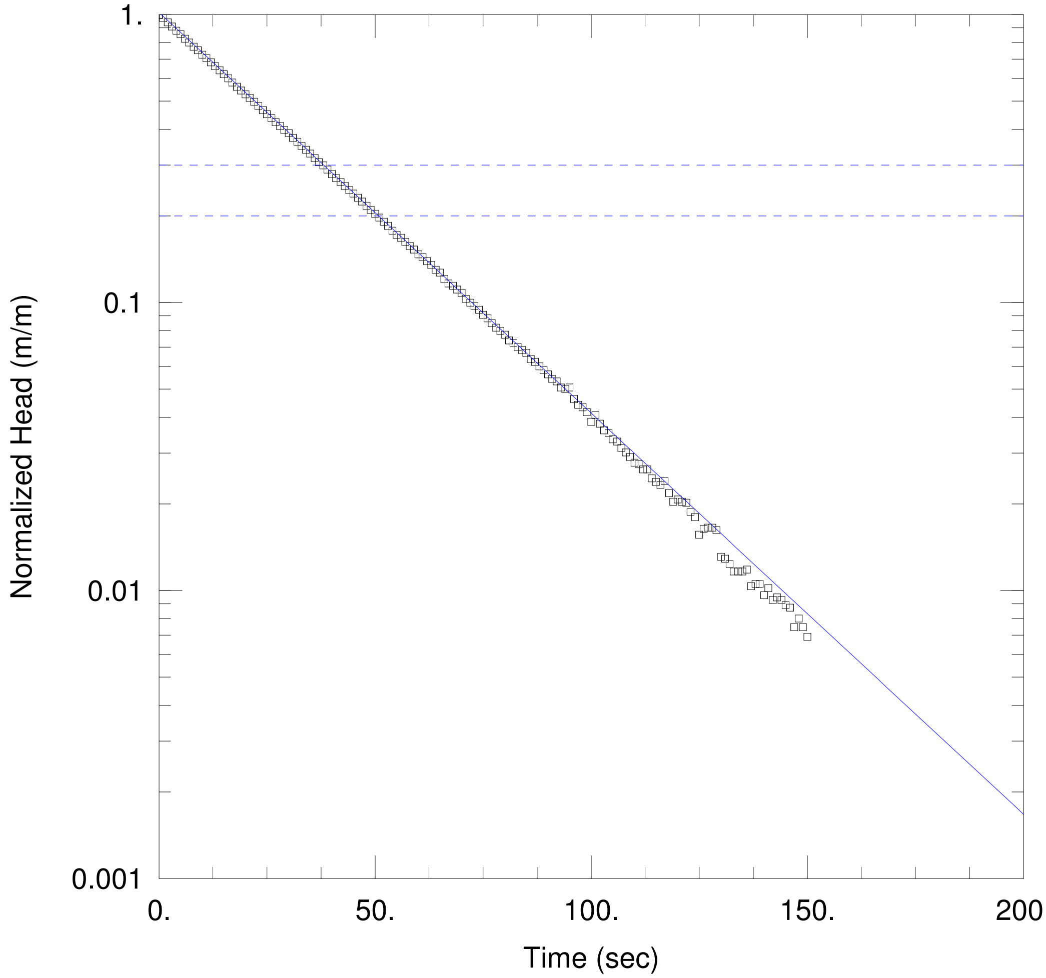
WELL DATA (SH16-03(10m))

Initial Displacement: 0.93 m Static Water Column Height: 6.31 m
Total Well Penetration Depth: 2.29 m Screen Length: 1.5 m
Casing Radius: 0.026 m Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 4.1E-5 m/sec y0 = 0.86 m



SH16-04(10M) - TEST 1

Data Set: O:\...\SH16-04(10m)_Test1.aqt
Date: 03/01/17 Time: 16:09:23

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-04(10m)

AQUIFER DATA

Saturated Thickness: 32.3 m Anisotropy Ratio (Kz/Kr): 1.

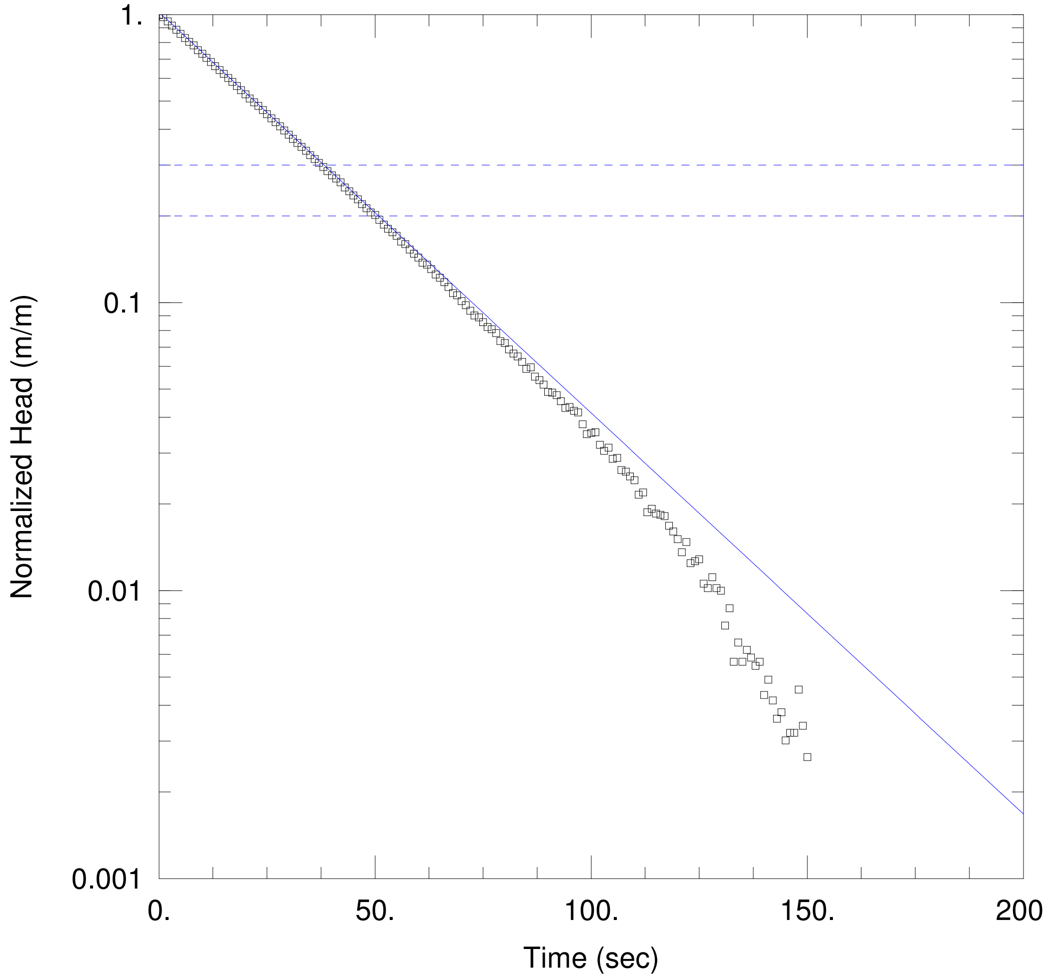
WELL DATA (SH16-04(10m))

Initial Displacement: 0.55 m Static Water Column Height: 5.74 m
Total Well Penetration Depth: 2.64 m Screen Length: 1.5 m
Casing Radius: 0.026 m Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.3E-5 m/sec y0 = 0.56 m



SH16-04(10M) - TEST 2

Data Set: O:\...\SH16-04(10m)_Test2.aqt
Date: 03/01/17
Time: 16:09:43

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-04(10m)

AQUIFER DATA

Saturated Thickness: 32.3 m
Anisotropy Ratio (Kz/Kr): 1.

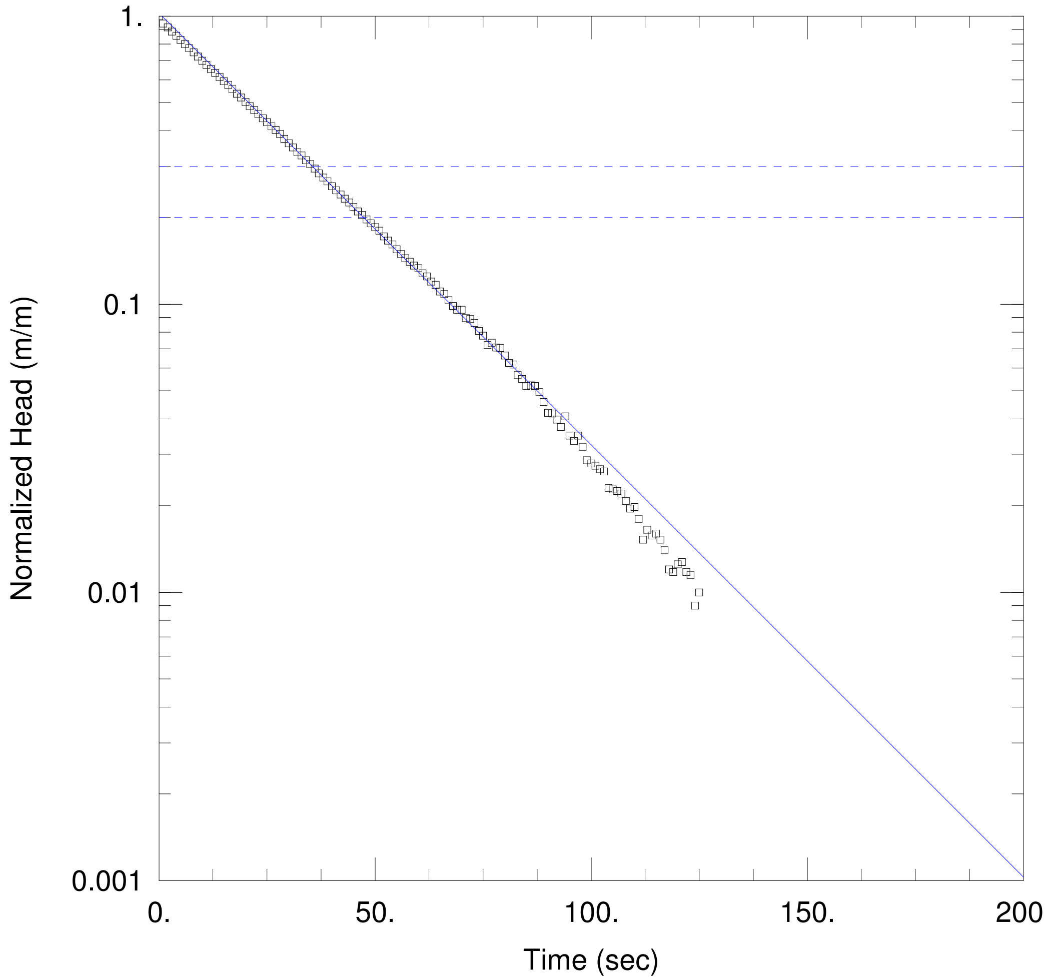
WELL DATA (SH16-04(10m))

Initial Displacement: 0.53 m
Static Water Column Height: 5.74 m
Total Well Penetration Depth: 2.64 m
Screen Length: 1.5 m
Casing Radius: 0.026 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.3E-5 m/sec
y0 = 0.54 m



SH16-04(10M) - TEST 3

Data Set: O:\...\SH16-04(10m)_Test3.aqt
Date: 03/01/17 Time: 16:10:10

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-04(10m)

AQUIFER DATA

Saturated Thickness: 32.3 m Anisotropy Ratio (Kz/Kr): 1.

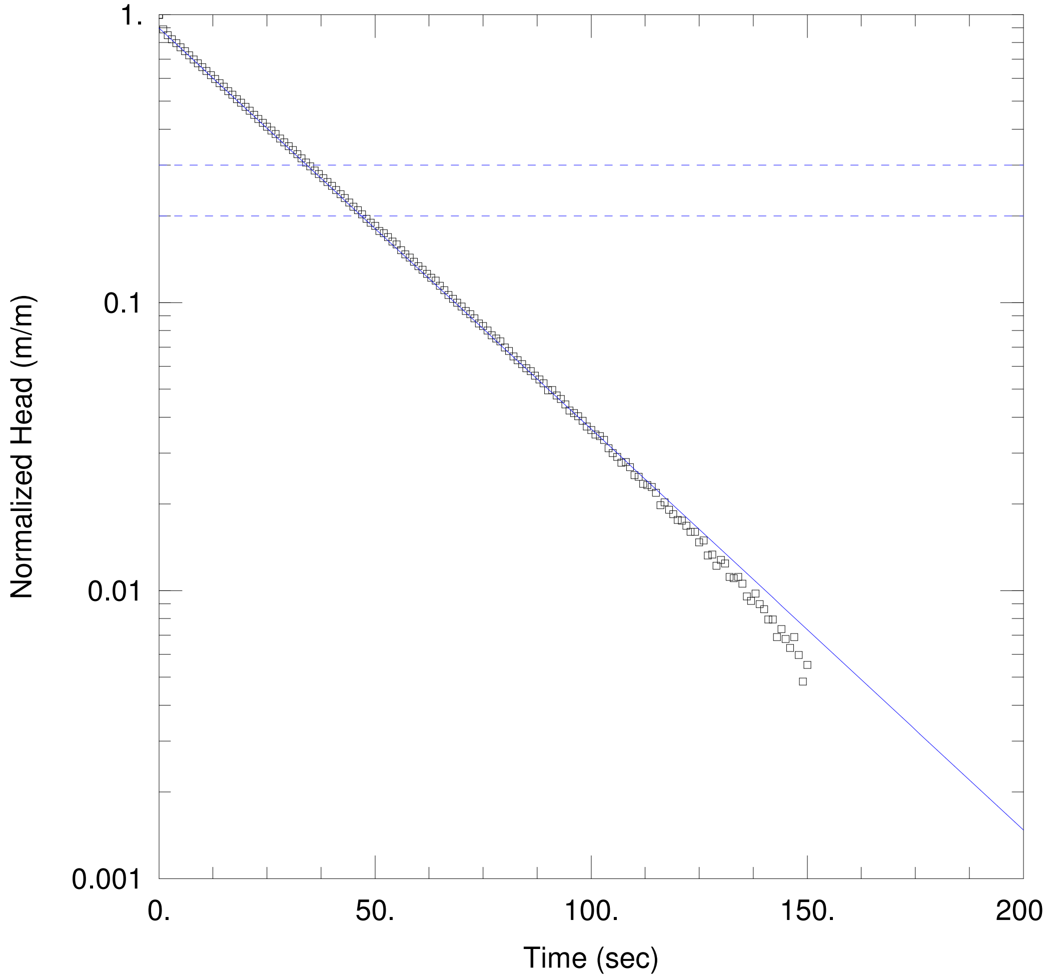
WELL DATA (SH16-04(10m))

Initial Displacement: 0.4 m Static Water Column Height: 5.74 m
Total Well Penetration Depth: 2.64 m Screen Length: 1.5 m
Casing Radius: 0.026 m Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.4E-5 m/sec y0 = 0.41 m



SH16-04(10M) - TEST 4

Data Set: O:\...\SH16-04(10m)_Test4.aqt
Date: 03/01/17
Time: 16:10:39

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-04(10m)

AQUIFER DATA

Saturated Thickness: 32.3 m
Anisotropy Ratio (Kz/Kr): 1.

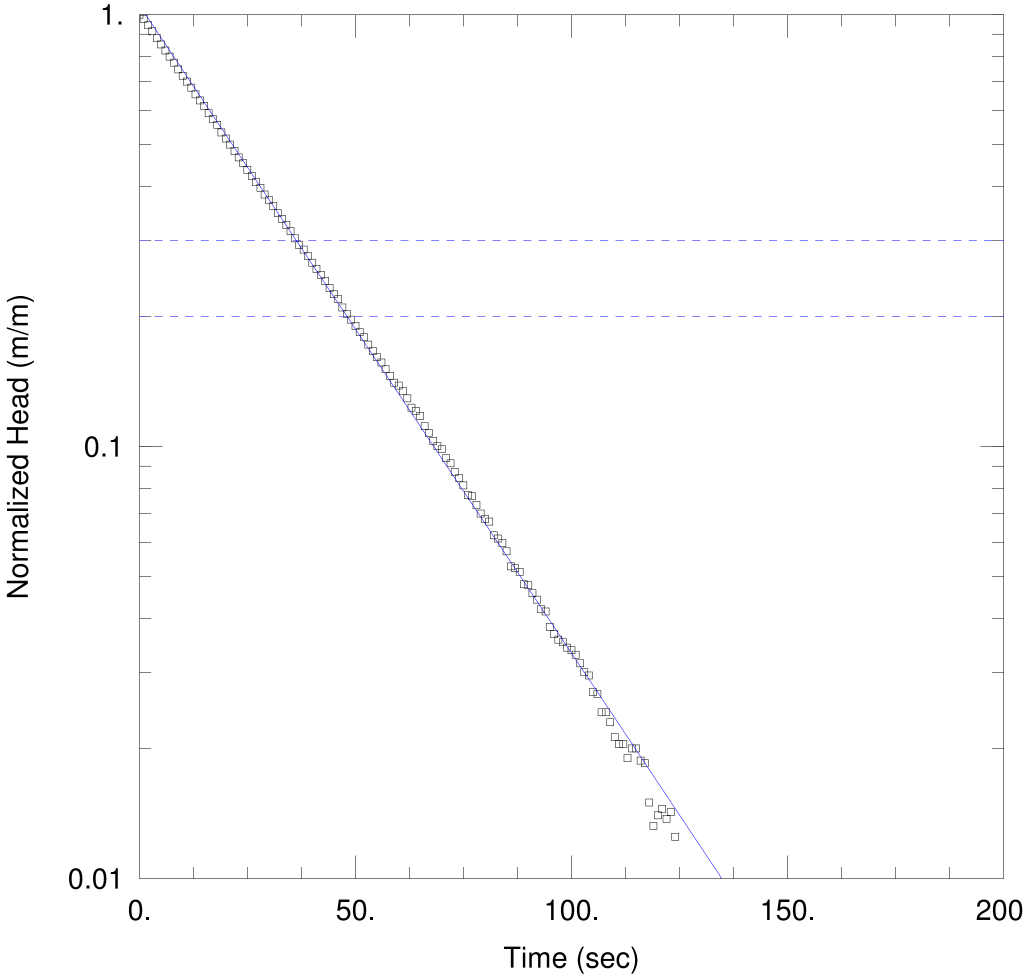
WELL DATA (SH16-04(10m))

Initial Displacement: 0.87 m
Static Water Column Height: 5.74 m
Total Well Penetration Depth: 2.64 m
Screen Length: 1.5 m
Casing Radius: 0.026 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.3E-5 m/sec
y0 = 0.78 m



SH16-04(10M) - TEST 5

Data Set: O:\...\SH16-04(10m)_Test5.aqt
Date: 03/01/17 Time: 16:11:07

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-04(10)

AQUIFER DATA

Saturated Thickness: 32.3 m Anisotropy Ratio (Kz/Kr): 1.

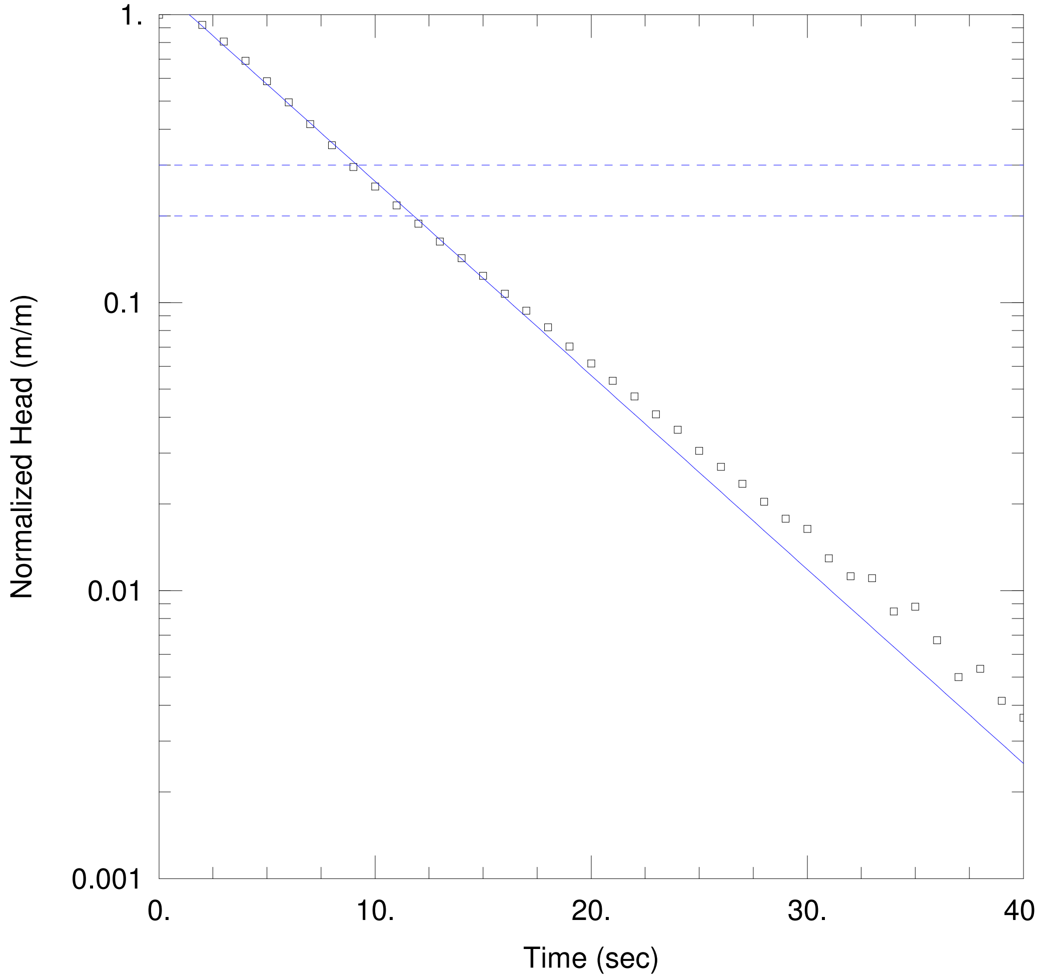
WELL DATA (SH16-04(10m))

Initial Displacement: 0.4 m
Total Well Penetration Depth: 2.64 m
Casing Radius: 0.026 m
Static Water Column Height: 5.74 m
Screen Length: 1.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.4E-5 m/sec y0 = 0.42 m



SH16-04(36.6M) - TEST 1

Data Set: O:\...\SH16-04(36.6m)_Test1.aqt
Date: 03/01/17
Time: 16:11:36

PROJECT INFORMATION

Company: Golder Associates
Client: CDM Smith
Project: 1525010
Test Well: SH16-04(36.6m)

AQUIFER DATA

Saturated Thickness: 32.3 m
Anisotropy Ratio (Kz/Kr): 1.

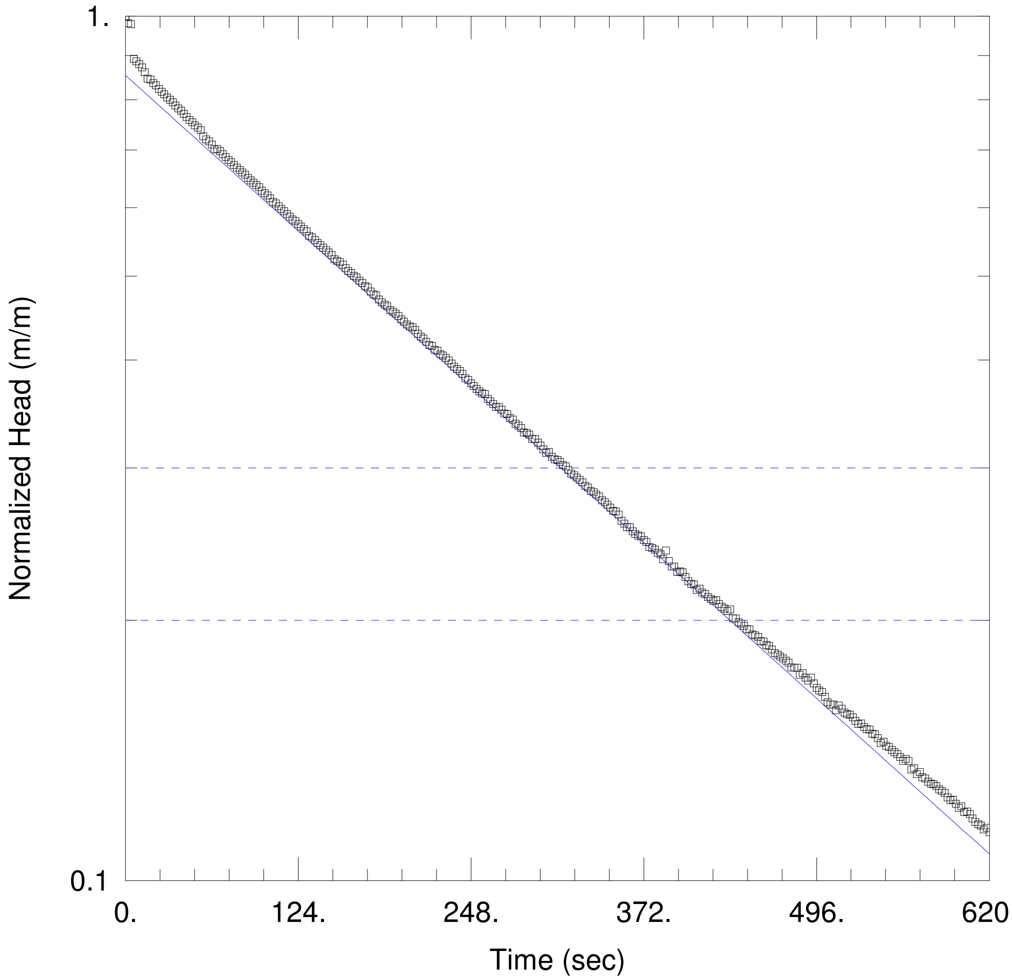
WELL DATA (SH16-04(36.6m))

Initial Displacement: 0.58 m
Total Well Penetration Depth: 29.37 m
Casing Radius: 0.026 m
Static Water Column Height: 32.52 m
Screen Length: 0.5 m
Well Radius: 0.089 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.00016 m/sec
y0 = 0.72 m



SH16-05(10M)

Data Set: O:\...\SH16-05(10m).aqt
Date: 03/01/17 Time: 16:12:53

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-05(10m)
Test Date: 29-Dec-2016

AQUIFER DATA

Saturated Thickness: 9.1 m Anisotropy Ratio (Kz/Kr): 1.

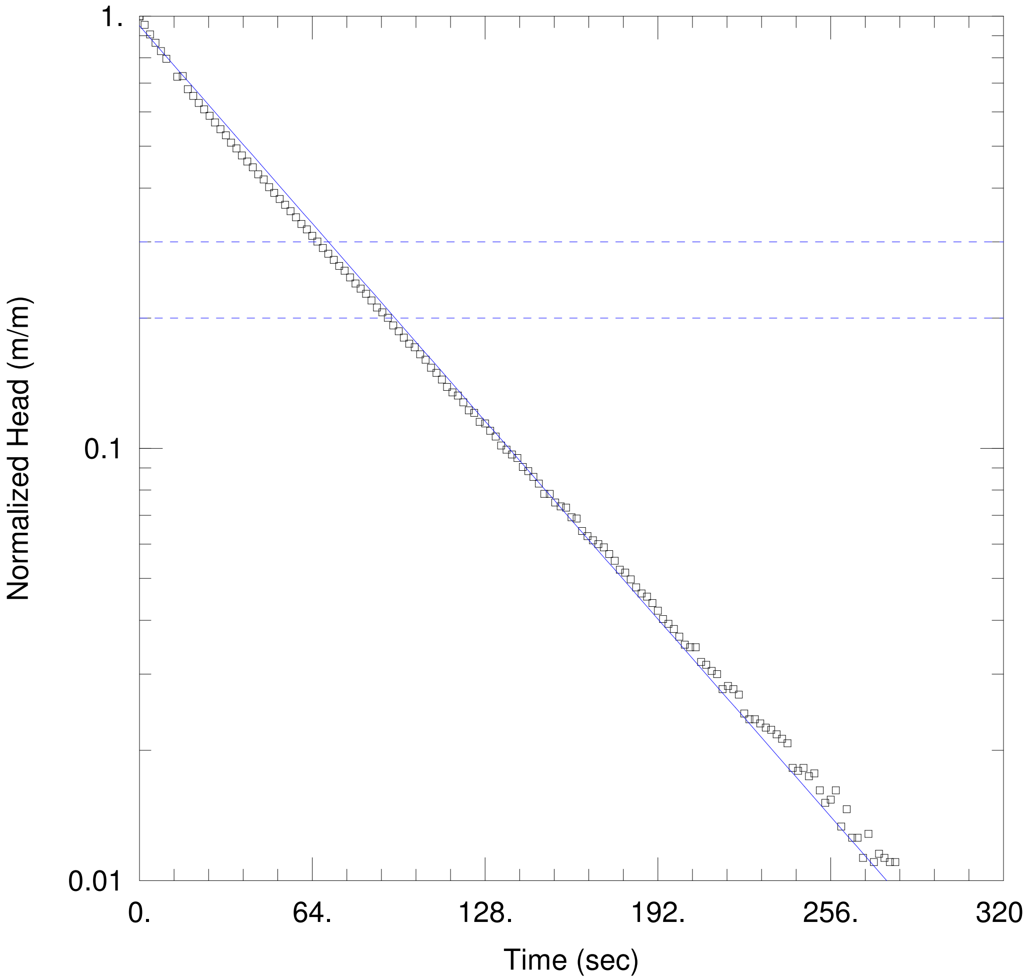
WELL DATA (SH16-05(10m))

Initial Displacement: 0.445 m Static Water Column Height: 7.25 m
Total Well Penetration Depth: 4.995 m Screen Length: 1.52 m
Casing Radius: 0.026 m Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.7E-6 m/sec y0 = 0.38 m



SH16-05(33M)

Data Set: O:\...\SH16-05M(33m).aqt
Date: 03/01/17
Time: 16:13:05

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-05(33m)
Test Date: 29-Dec-2016

AQUIFER DATA

Saturated Thickness: 20.3 m
Anisotropy Ratio (Kz/Kr): 1.

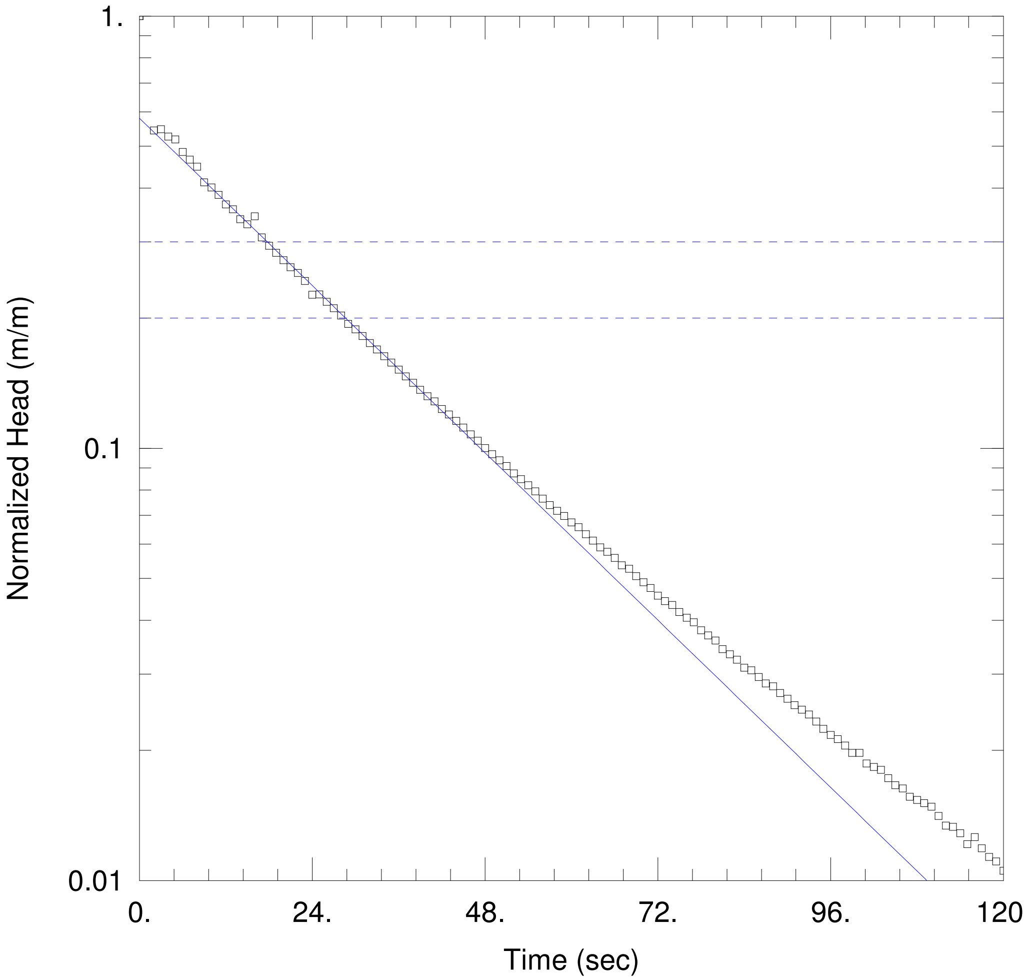
WELL DATA (SH16-05(33m))

Initial Displacement: 0.39 m
Total Well Penetration Depth: 5.19 m
Casing Radius: 0.026 m
Static Water Column Height: 28.98 m
Screen Length: 1.52 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 8.0E-6 m/sec
y0 = 0.37 m



SH16-06(10M) - TEST 1

Data Set: O:\...\SH16-06(10m)_Test1.aqt
Date: 03/01/17 Time: 16:13:37

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-06(10m)
Test Date: 12-Dec-2016

AQUIFER DATA

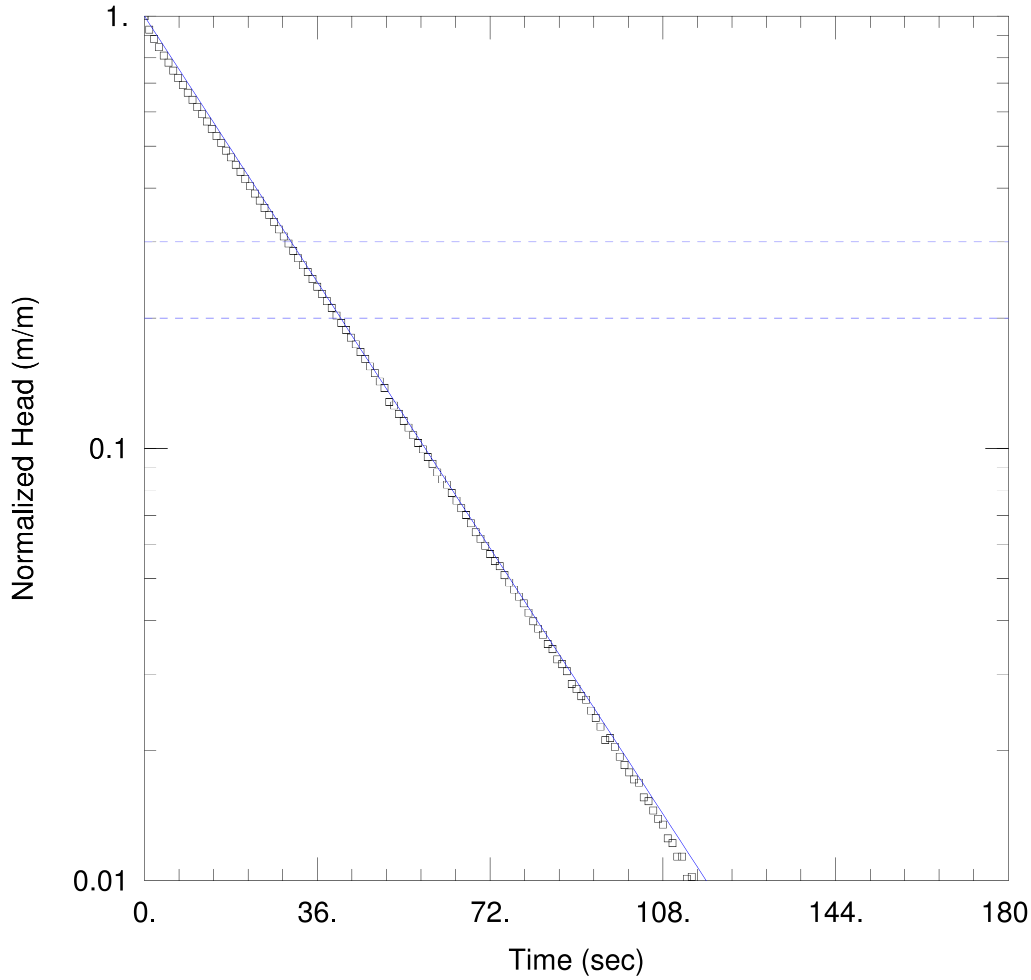
Saturated Thickness: 23. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SH16-06(10m))

Initial Displacement: 1.12 m
Static Water Column Height: 6.37 m
Total Well Penetration Depth: 3.61 m
Screen Length: 1.52 m
Casing Radius: 0.026 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 1.7E-5 m/sec
y0 = 0.65 m



SH16-06(10M) - TEST 2

Data Set: O:\...\SH16-06(10m)_Test2.aqt
Date: 03/01/17 Time: 16:13:46

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-06(10m)
Test Date: 12-Dec-2016

AQUIFER DATA

Saturated Thickness: 23. m
Anisotropy Ratio (Kz/Kr): 1.

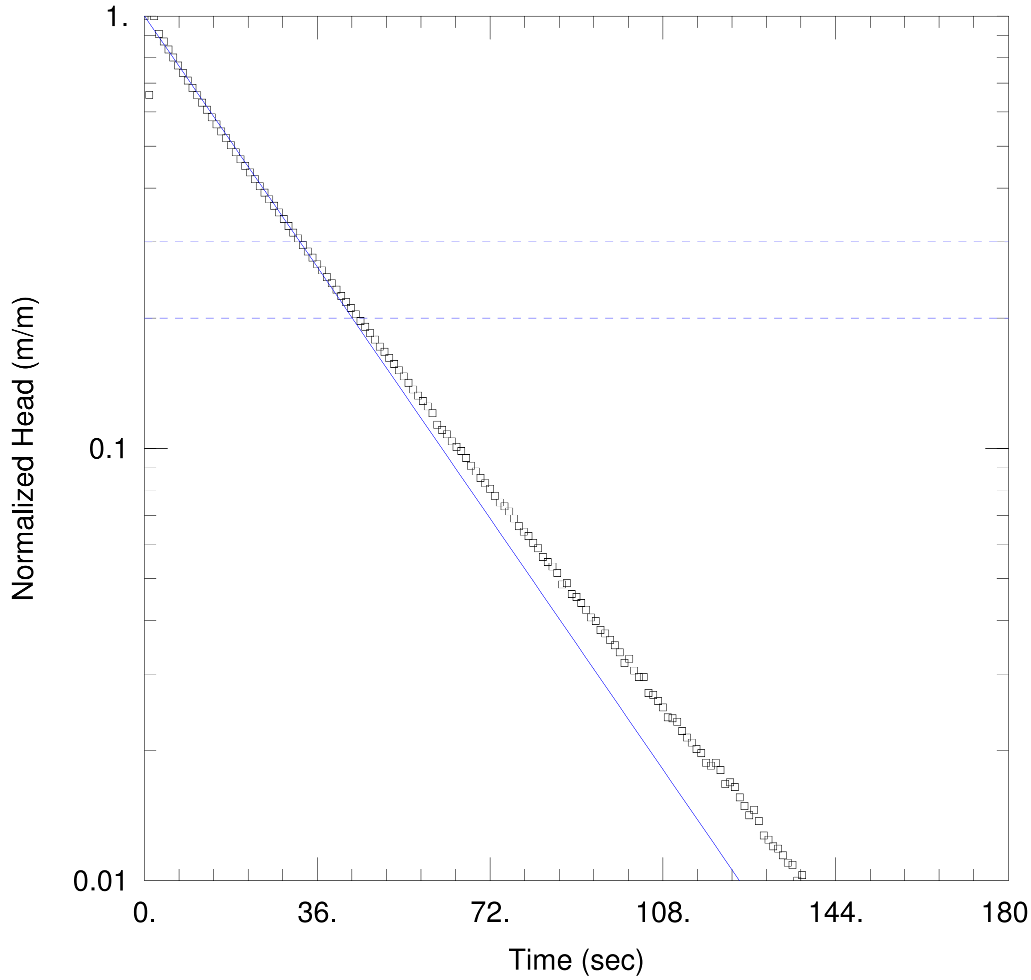
WELL DATA (SH16-06(10m))

Initial Displacement: 0.951 m
Total Well Penetration Depth: 3.61 m
Casing Radius: 0.026 m
Static Water Column Height: 6.39 m
Screen Length: 1.52 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.8E-5 m/sec
y0 = 0.95 m



SH16-06(10M) - TEST 3

Data Set: O:\...\SH16-06(10m)_Test3.aqt
Date: 03/01/17 Time: 16:13:55

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-06(10m)
Test Date: 12-Dec-2016

AQUIFER DATA

Saturated Thickness: 23. m
Anisotropy Ratio (Kz/Kr): 1.

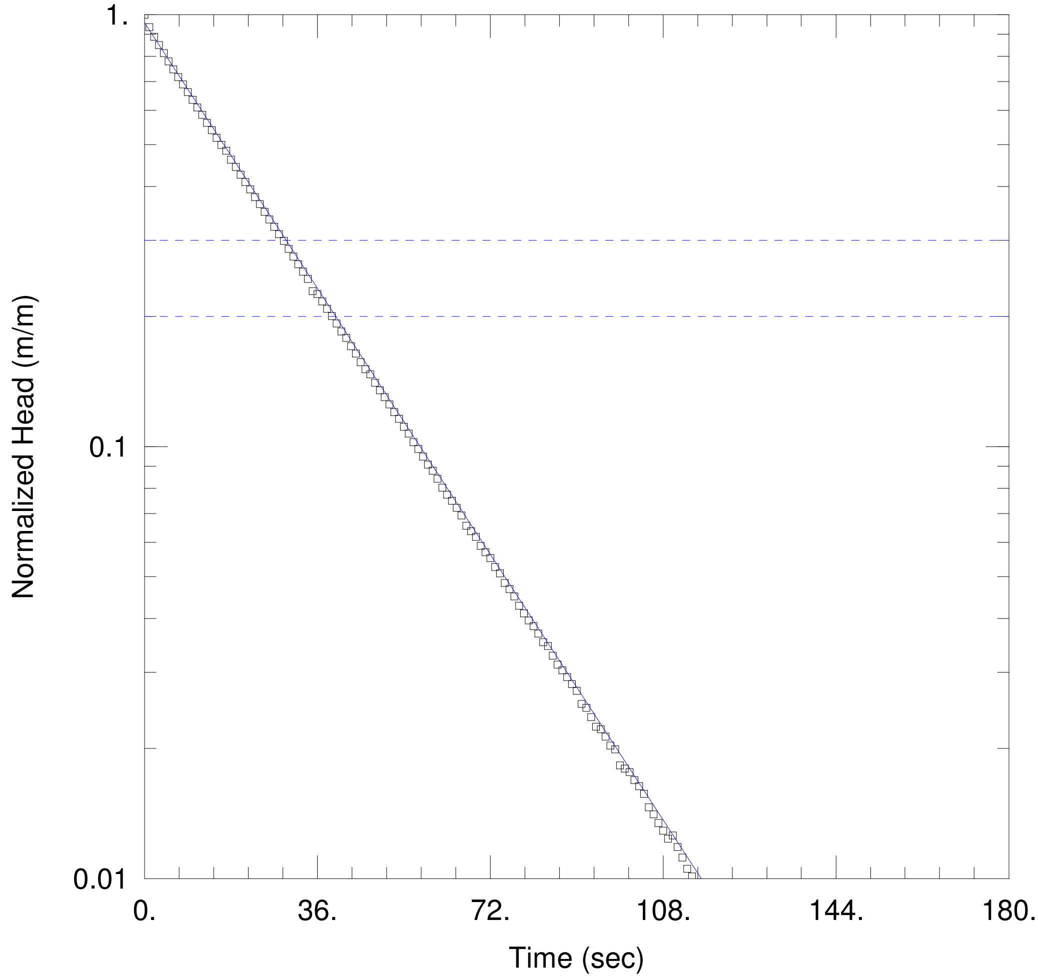
WELL DATA (SH16-06(10m))

Initial Displacement: 0.7 m
Static Water Column Height: 6.4 m
Total Well Penetration Depth: 3.61 m
Screen Length: 1.52 m
Casing Radius: 0.026 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.7E-5 m/sec
y0 = 0.7 m



SH16-06(10M) - TEST 4

Data Set: O:\...\SH16-06(10m)_Test4.aqt
Date: 03/01/17
Time: 16:14:01

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-06(10m)
Test Date: 12-Dec-2016

AQUIFER DATA

Saturated Thickness: 23. m
Anisotropy Ratio (Kz/Kr): 1.

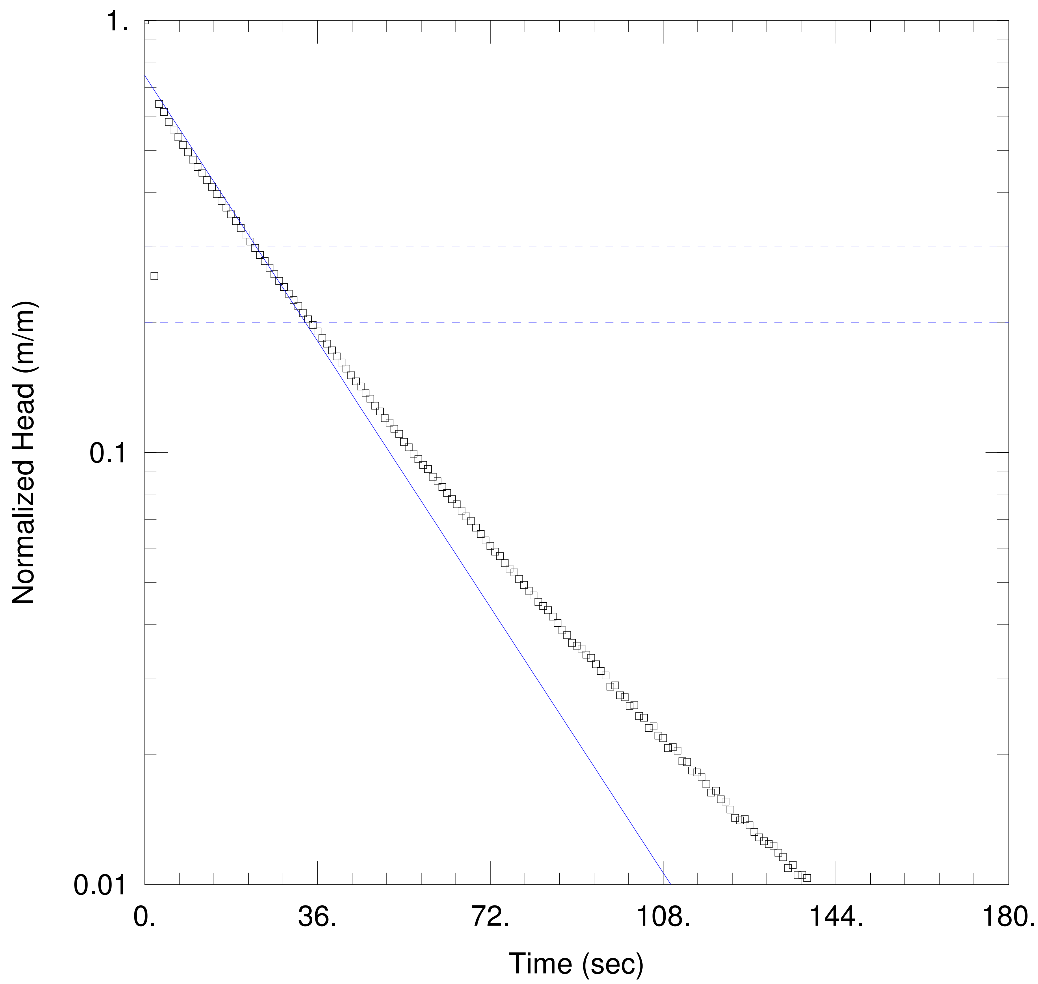
WELL DATA (SH16-06(10m))

Initial Displacement: 0.93 m
Static Water Column Height: 6.43 m
Total Well Penetration Depth: 3.61 m
Screen Length: 1.52 m
Casing Radius: 0.026 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.8E-5 m/sec
y0 = 0.89 m



SH16-06(10M) - TEST 5

Data Set: O:\...\SH16-06(10m)_Test5.aqt
Date: 03/01/17 Time: 16:14:07

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-06(10m)
Test Date: 12-Dec-2016

AQUIFER DATA

Saturated Thickness: 23. m
Anisotropy Ratio (Kz/Kr): 1.

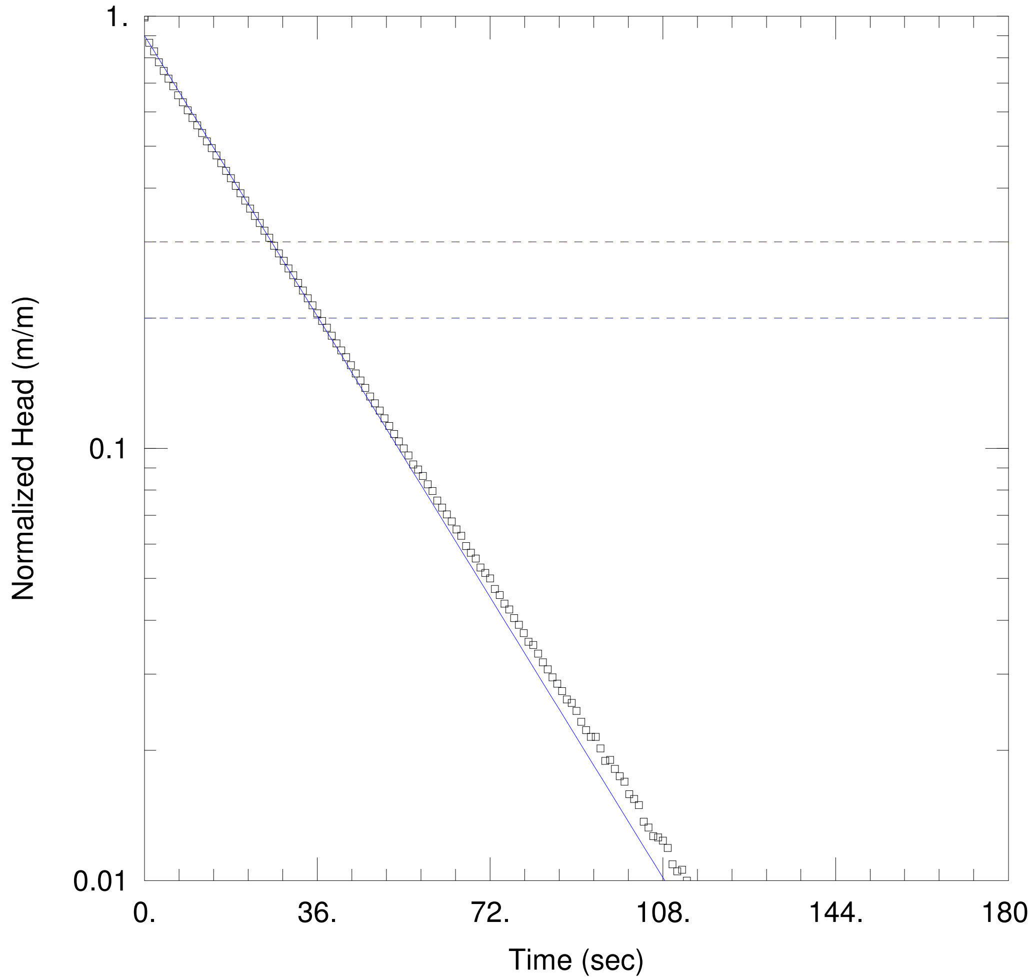
WELL DATA (SH16-06(10m))

Initial Displacement: 1.074 m
Static Water Column Height: 6.46 m
Total Well Penetration Depth: 3.61 m
Screen Length: 1.52 m
Casing Radius: 0.026 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.8E-5 m/sec
y0 = 0.8 m



SH16-06(10M) - TEST 6

Data Set: O:\...\SH16-06(10m)_Test6.aqt
Date: 03/01/17
Time: 16:14:12

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-06(10m)
Test Date: 12-Dec-2016

AQUIFER DATA

Saturated Thickness: 23. m
Anisotropy Ratio (Kz/Kr): 1.

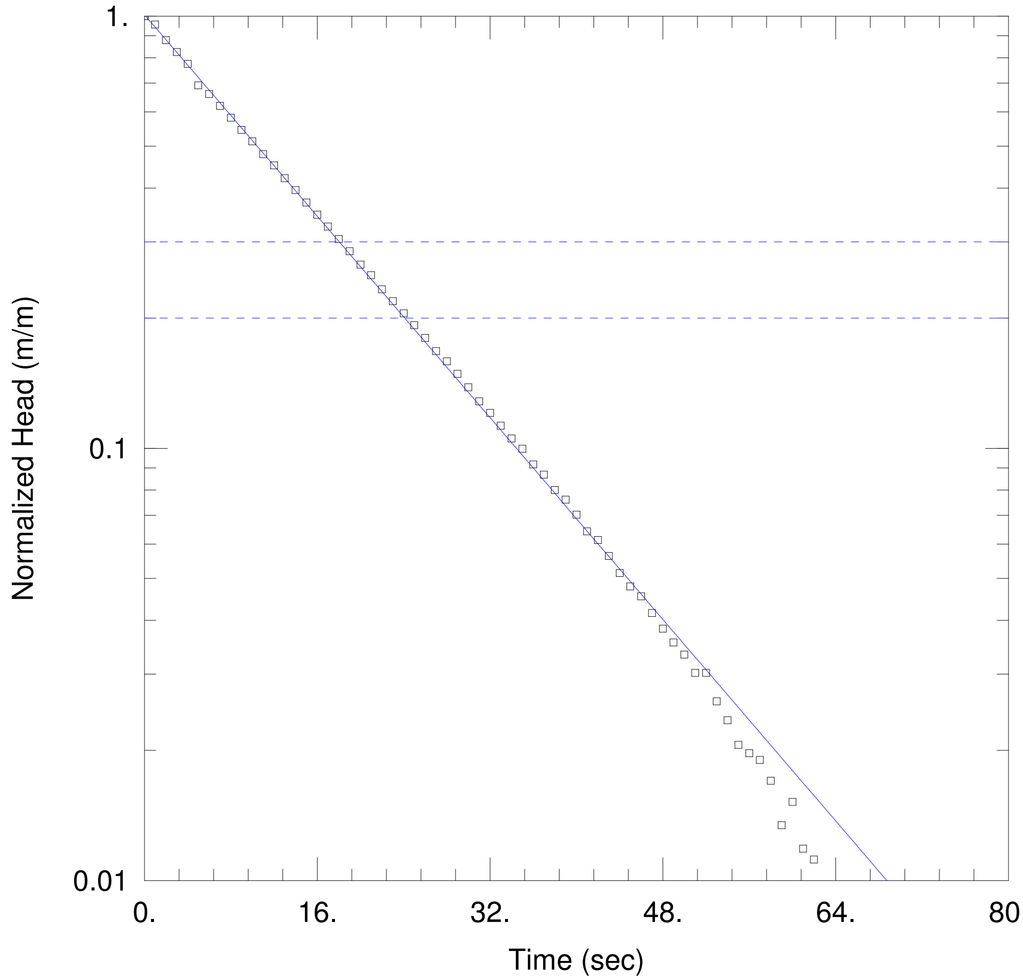
WELL DATA (SH16-06(10m))

Initial Displacement: 1.01 m
Static Water Column Height: 6.49 m
Total Well Penetration Depth: 3.61 m
Screen Length: 1.52 m
Casing Radius: 0.026 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.9E-5 m/sec
y0 = 0.91 m



SH16-06(33M)

Data Set: O:\...\SH16-06(33).aqt
Date: 03/01/17 | Time: 16:14:22

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-06(33m)
Test Date: 12-Dec-2016

AQUIFER DATA

Saturated Thickness: 11.4 m | Anisotropy Ratio (Kz/Kr): 1.

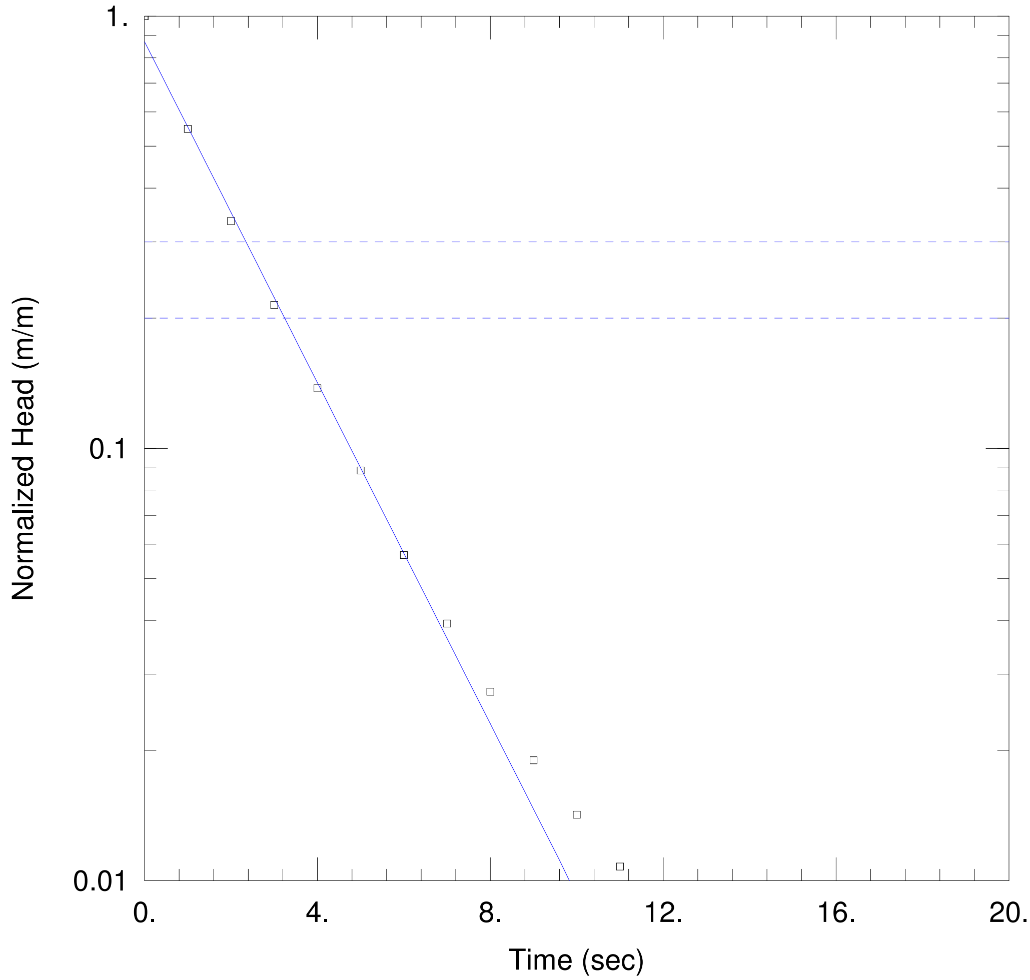
WELL DATA (SH16-06(33m))

Initial Displacement: 0.447 m | Static Water Column Height: 30.68 m
Total Well Penetration Depth: 3.81 m | Screen Length: 1.52 m
Casing Radius: 0.026 m | Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined | Solution Method: Bouwer-Rice

K = 3.2E-5 m/sec | y0 = 0.45 m



SH16-07(10M) - TEST 1

Data Set: O:\...\SH16-07(10m)_Test1.aqt
Date: 03/01/17 Time: 16:14:31

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(10m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m
Anisotropy Ratio (Kz/Kr): 1.

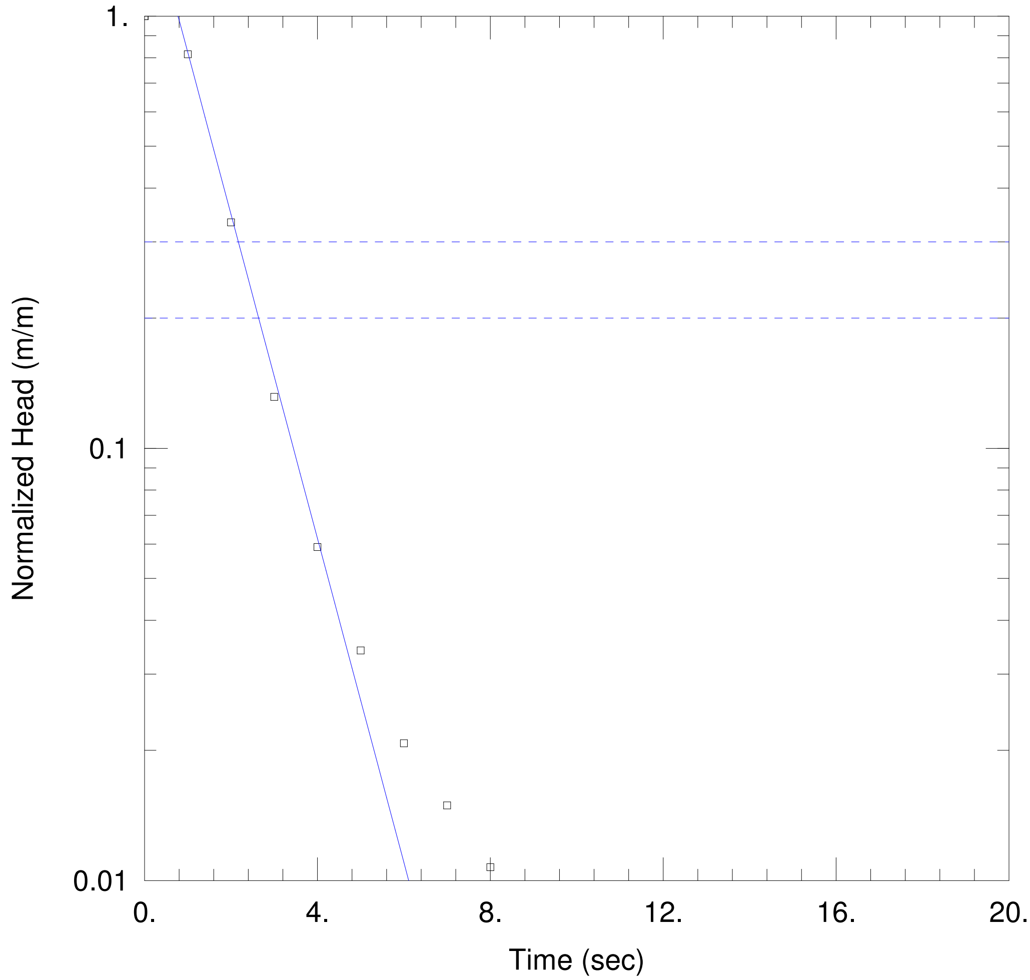
WELL DATA (SH16-07(10m))

Initial Displacement: 0.585 m
Total Well Penetration Depth: 3.07 m
Casing Radius: 0.026 m
Static Water Column Height: 7.8 m
Screen Length: 1.52 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.0002 m/sec
y0 = 0.51 m



SH16-07(10M) - TEST 2

Data Set: O:\...\SH16-07(10m)_Test2.aqt
Date: 03/01/17
Time: 16:14:37

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(10m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m
Anisotropy Ratio (Kz/Kr): 1.

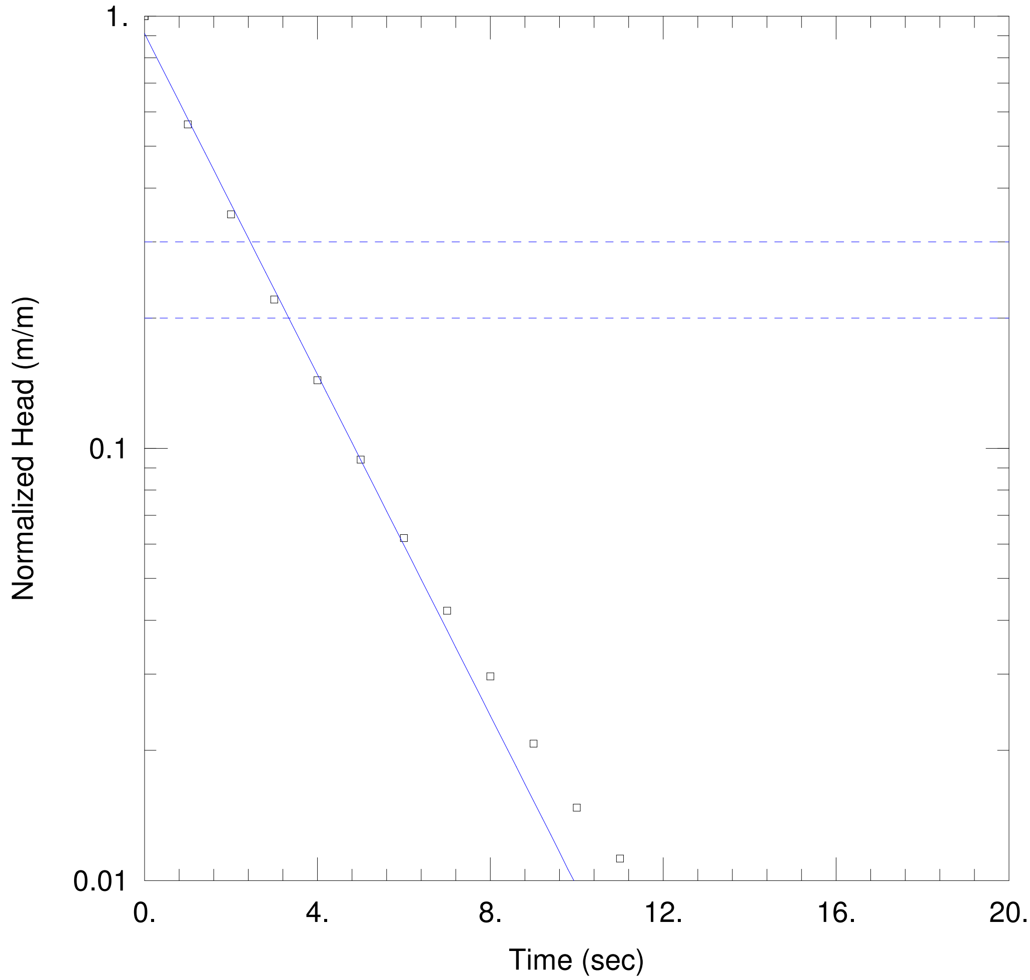
WELL DATA (SH16-07(10m))

Initial Displacement: 0.717 m
Static Water Column Height: 7.8 m
Total Well Penetration Depth: 3.07 m
Screen Length: 1.52 m
Casing Radius: 0.026 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.00038 m/sec
y0 = 1.4 m



SH16-07(10M) - TEST 3

Data Set: O:\...\SH16-07(10m)_Test3.aqt
Date: 03/01/17 Time: 16:14:42

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(10m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m
Anisotropy Ratio (Kz/Kr): 1.

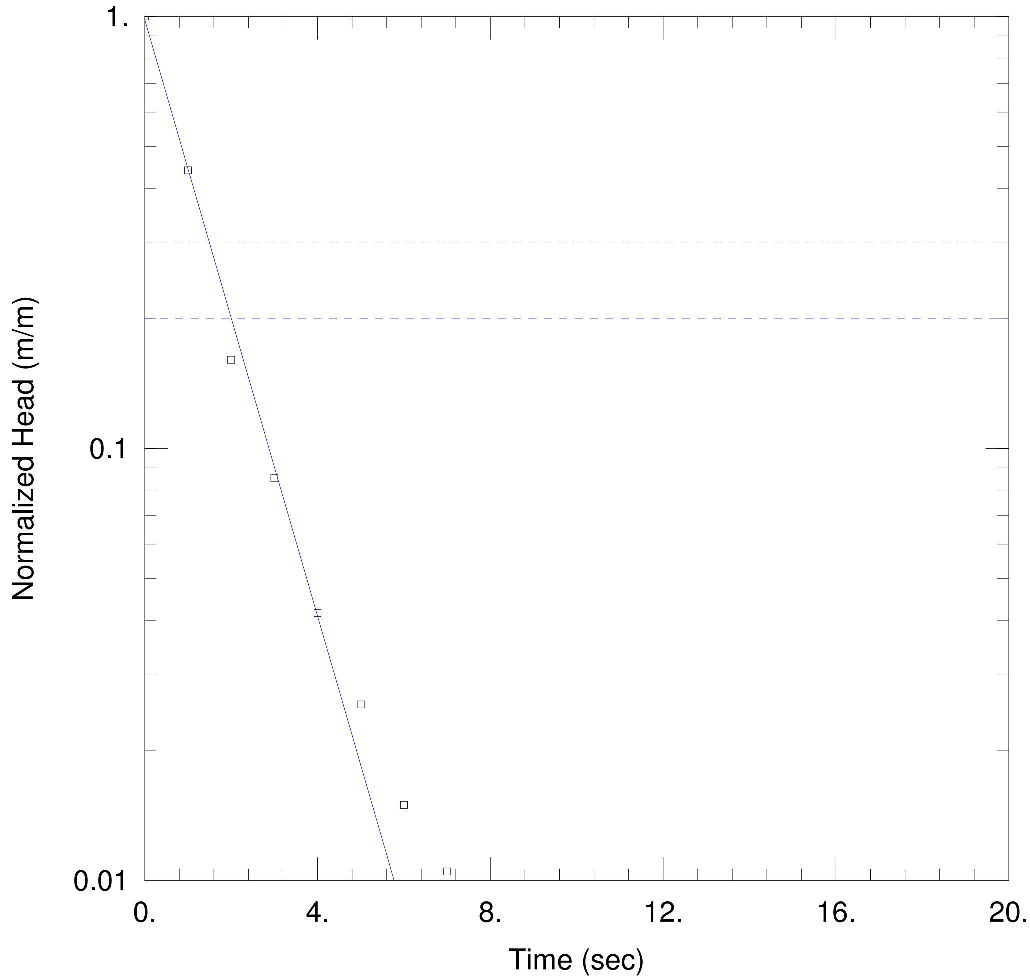
WELL DATA (SH16-07(10m))

Initial Displacement: 0.516 m
Total Well Penetration Depth: 3.07 m
Casing Radius: 0.026 m
Static Water Column Height: 7.8 m
Screen Length: 1.52 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.0002 m/sec
y0 = 0.47 m



SH16-07(10M) - TEST 4

Data Set: O:\...\SH16-07(10m)_Test4.aqt
Date: 03/01/17 Time: 16:14:48

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(10m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m Anisotropy Ratio (Kz/Kr): 1.

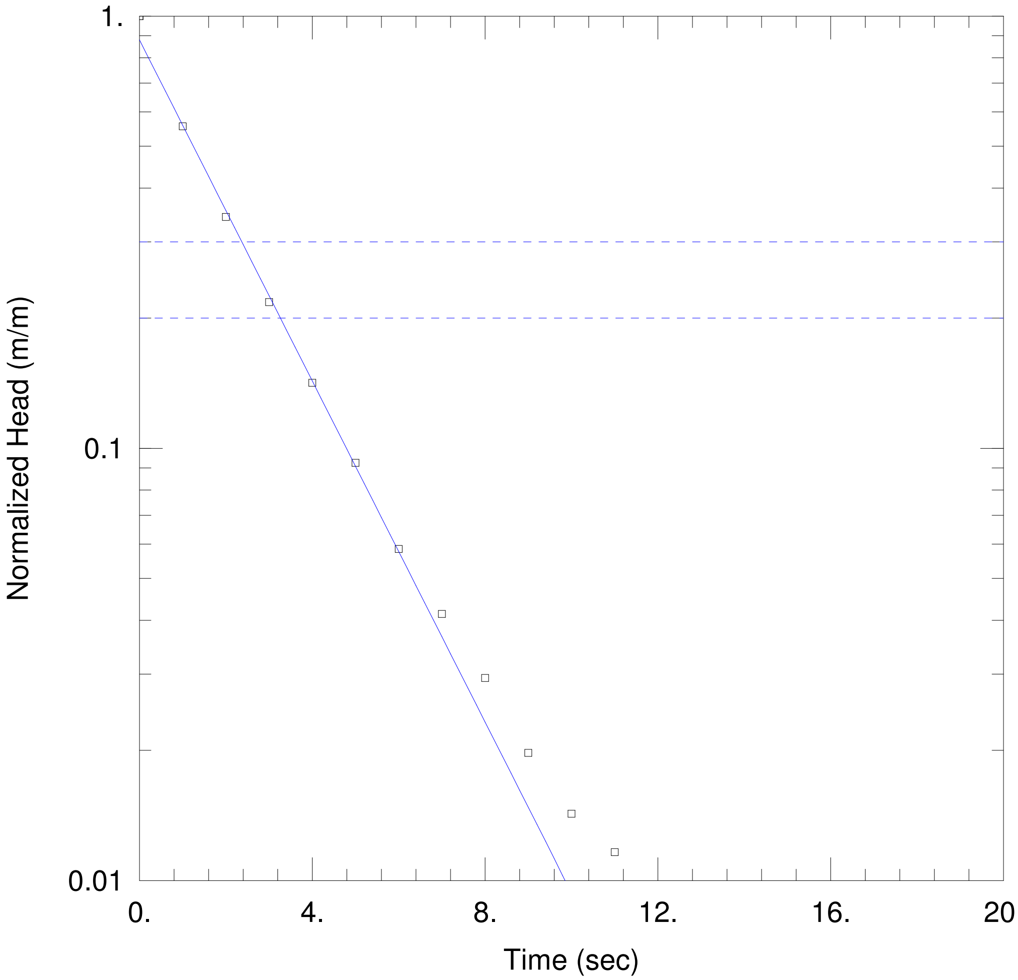
WELL DATA (SH16-07(10m))

Initial Displacement: 1.231 m Static Water Column Height: 7.8 m
Total Well Penetration Depth: 3.07 m Screen Length: 1.52 m
Casing Radius: 0.026 m Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.00035 m/sec y0 = 1.21 m



SH16-07(10M) - TEST 5

Data Set: O:\...\SH16-07(10m)_Test5.aqt
Date: 03/01/17
Time: 16:14:53

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(10m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m
Anisotropy Ratio (Kz/Kr): 1.

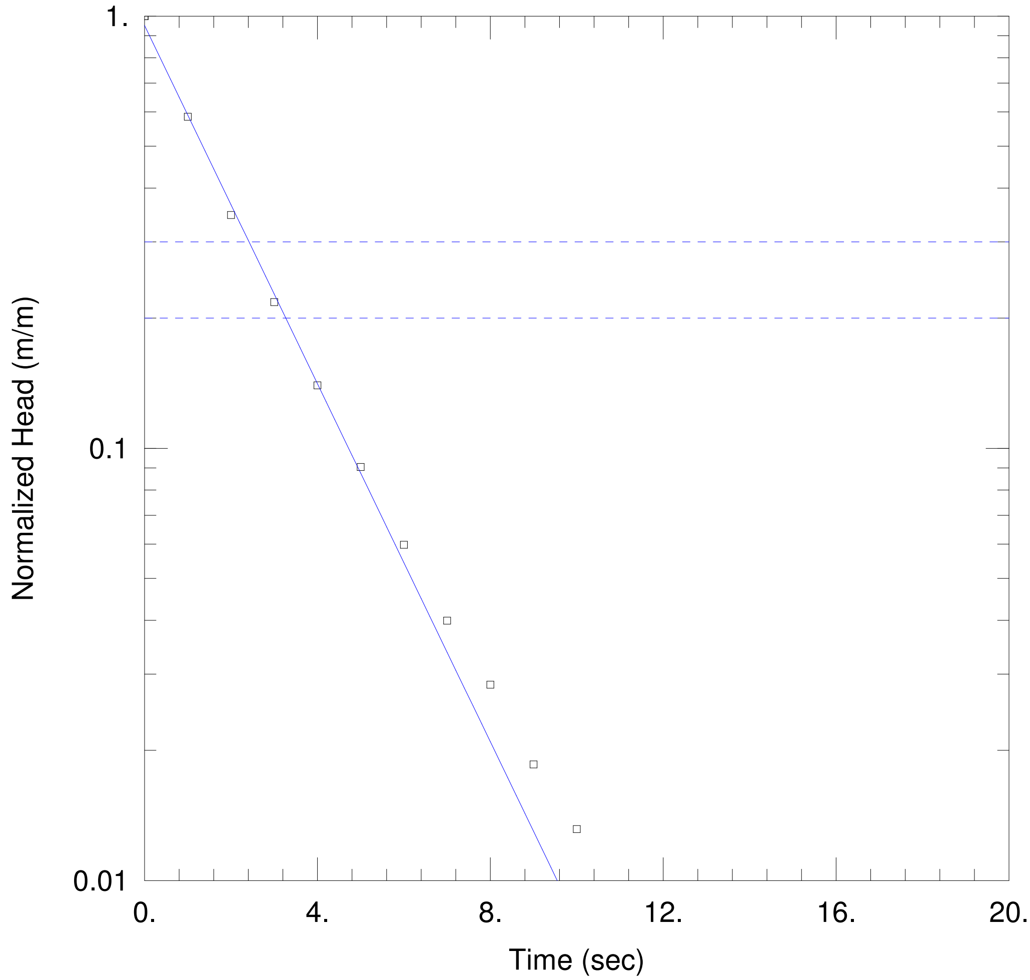
WELL DATA (SH16-07(10m))

Initial Displacement: 0.568 m
Static Water Column Height: 7.8 m
Total Well Penetration Depth: 3.07 m
Screen Length: 1.52 m
Casing Radius: 0.026 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.0002 m/sec
y0 = 0.5 m



SH16-07(10M) - TEST 6

Data Set: O:\...\SH16-07(10m)_Test6.aqt
Date: 03/01/17 Time: 16:14:58

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(10m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m Anisotropy Ratio (Kz/Kr): 1.

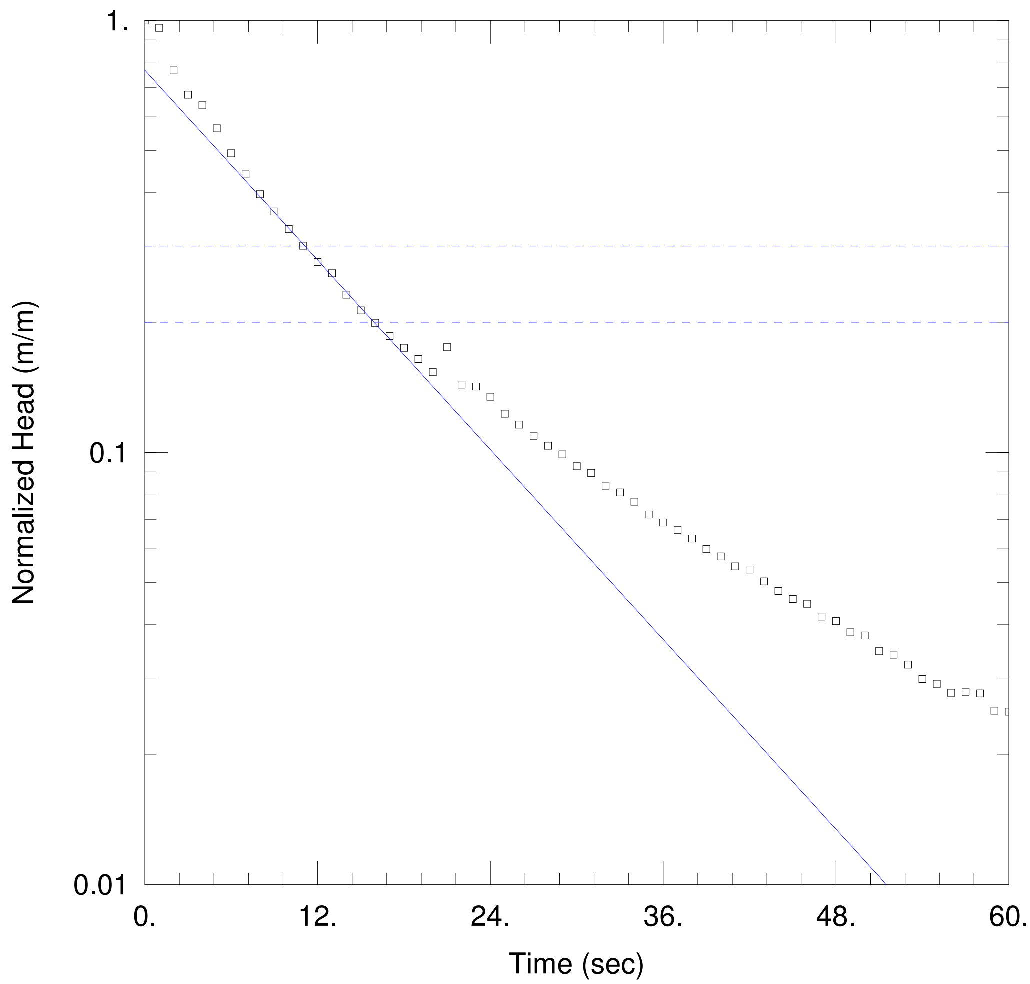
WELL DATA (SH16-07(10m))

Initial Displacement: 0.684 m Static Water Column Height: 7.8 m
Total Well Penetration Depth: 3.07 m Screen Length: 1.52 m
Casing Radius: 0.026 m Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.00021 m/sec y0 = 0.65 m



SH16-07(31M) - TEST 1

Data Set: O:\...\SH16-07(31m)_Test1.aqt
Date: 03/01/17 Time: 16:15:08

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(31m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m Anisotropy Ratio (Kz/Kr): 1.

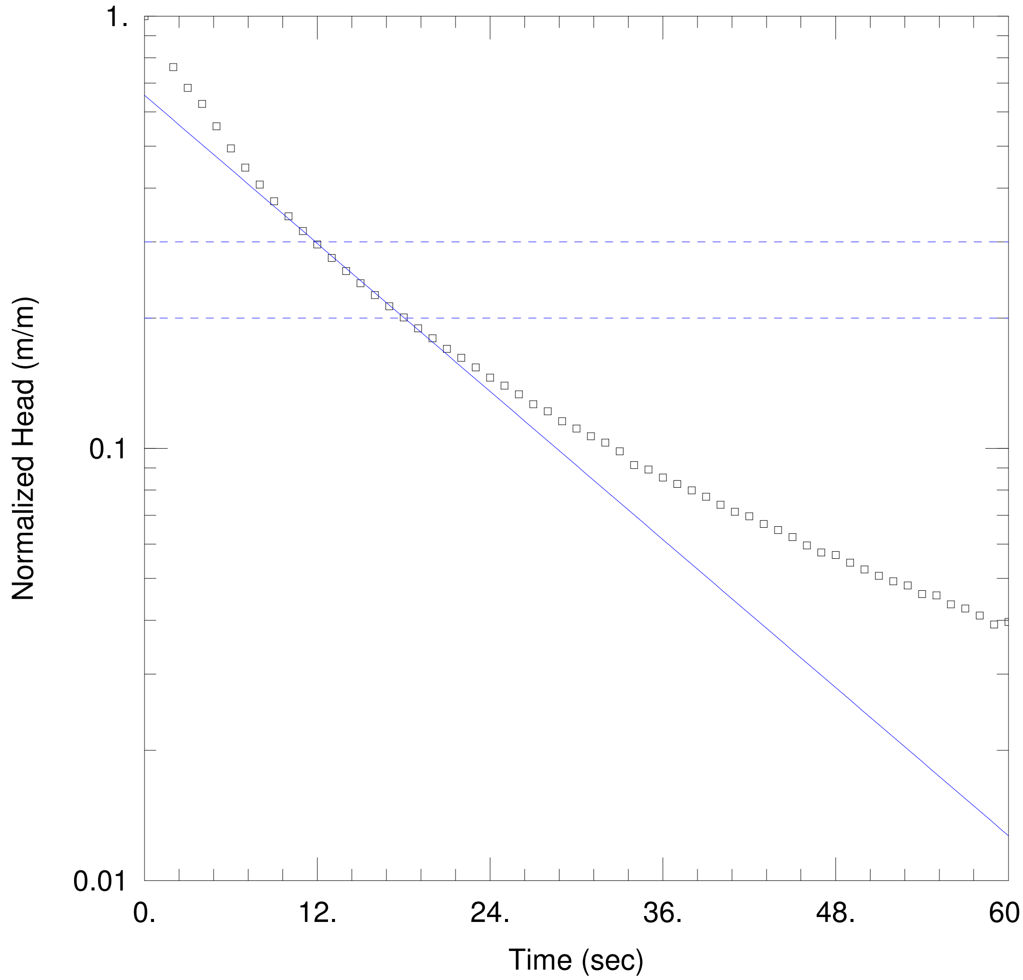
WELL DATA (SH16-07(31m))

Initial Displacement: 0.9 m
Total Well Penetration Depth: 24.58 m
Casing Radius: 0.026 m
Static Water Column Height: 29.25 m
Screen Length: 1.52 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 5.0E-5 m/sec y0 = 0.69 m



SH16-07(31M) - TEST 2

Data Set: O:\...\SH16-07(31m)_Test2.aqt
Date: 03/01/17 Time: 16:15:14

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(31m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m
Anisotropy Ratio (Kz/Kr): 1.

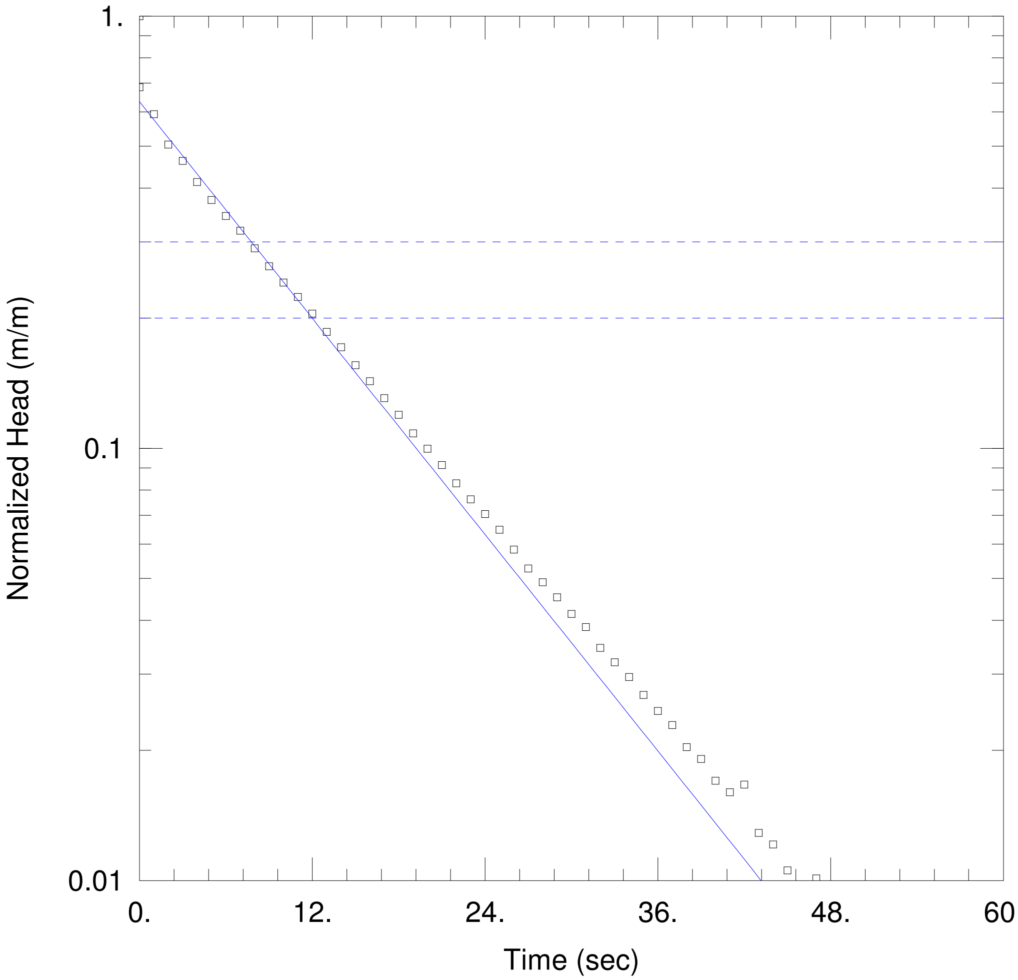
WELL DATA (SH16-07M)

Initial Displacement: 0.9 m
Total Well Penetration Depth: 24.58 m
Casing Radius: 0.026 m
Static Water Column Height: 29.25 m
Screen Length: 1.52 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 3.9E-5 m/sec
y0 = 0.59 m



SH16-07(31M) - TEST 3

Data Set: O:\...\SH16-07(31m)_Test3.aqt
Date: 03/01/17 Time: 16:15:18

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(31m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m Anisotropy Ratio (Kz/Kr): 1.

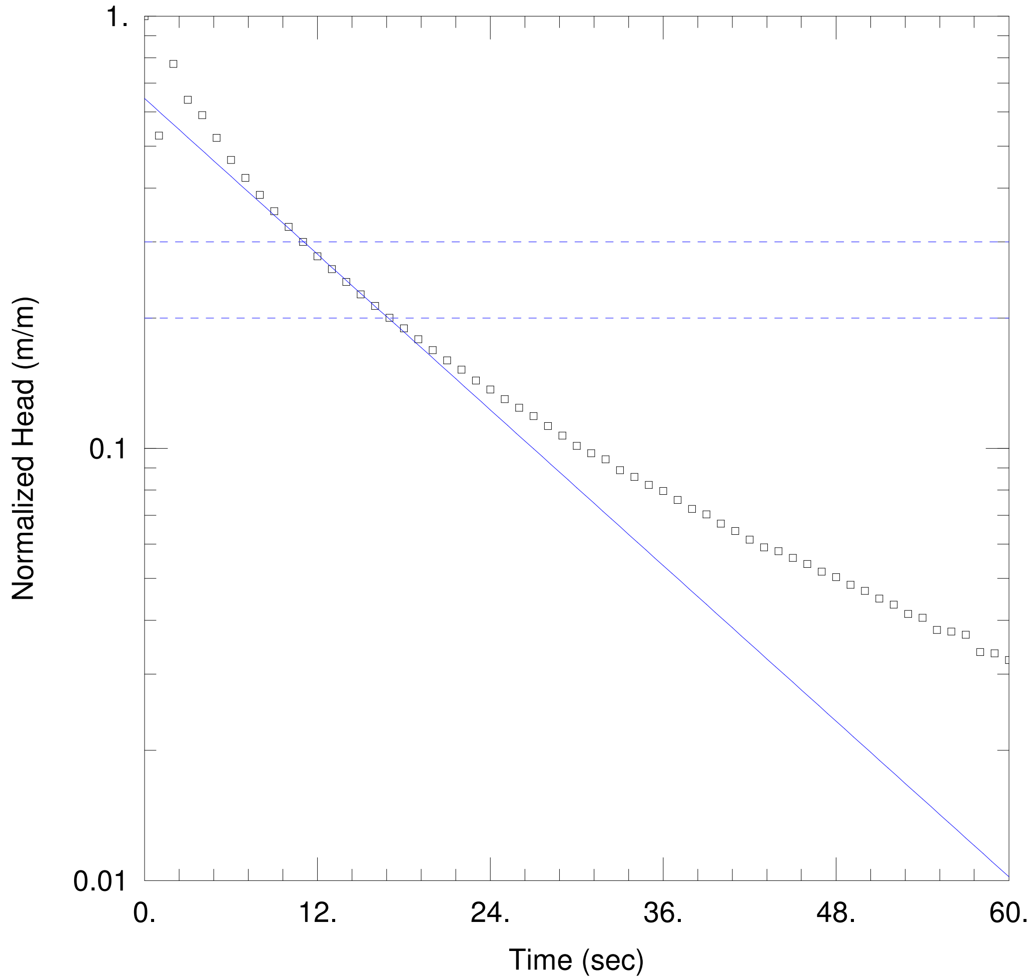
WELL DATA (SH16-07(31m))

Initial Displacement: 0.9 m Static Water Column Height: 29.25 m
Total Well Penetration Depth: 24.58 m Screen Length: 1.52 m
Casing Radius: 0.026 m Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 5.7E-5 m/sec y0 = 0.57 m



SH16-07(31M) - TEST 4

Data Set: O:\...\SH16-07(31m)_Test4.aqt
Date: 03/01/17 Time: 16:15:35

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(31m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m Anisotropy Ratio (Kz/Kr): 1.

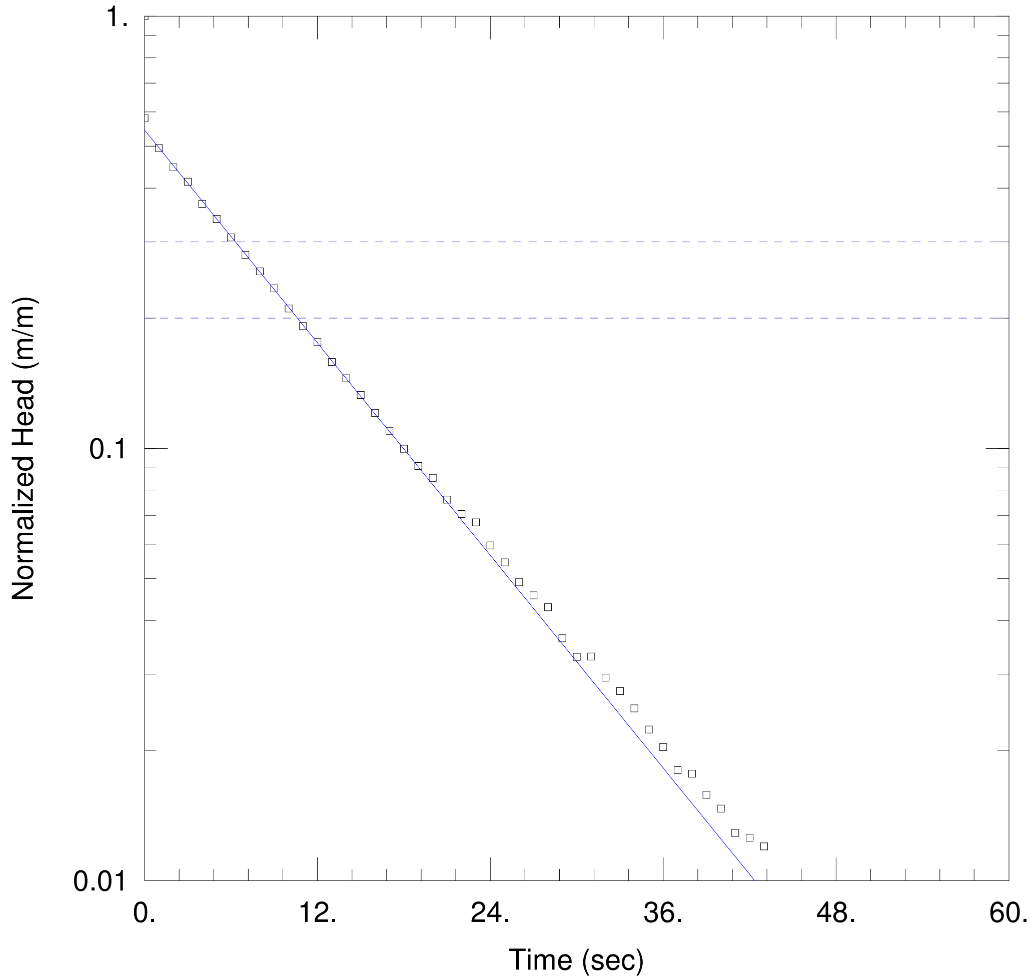
WELL DATA (SH16-07(31m))

Initial Displacement: 0.9 m
Total Well Penetration Depth: 24.58 m
Casing Radius: 0.026 m
Static Water Column Height: 29.25 m
Screen Length: 1.52 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 4.1E-5 m/sec y0 = 0.58 m



SH16-07(31M) - TEST 5

Data Set: O:\...\SH16-07(31m)_Test5.aqt
Date: 03/01/17 Time: 16:15:41

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: Annacis Island WWTP
Project: 1525010
Location: Delta, BC
Test Well: SH16-07(31m)
Test Date: 8-Dec-2016

AQUIFER DATA

Saturated Thickness: 31.9 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SH16-07(31m))

Initial Displacement: 0.9 m
Static Water Column Height: 29.25 m
Total Well Penetration Depth: 24.58 m
Screen Length: 1.52 m
Casing Radius: 0.026 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 5.6E-5 m/sec
y0 = 0.49 m

ATTACHMENT 2

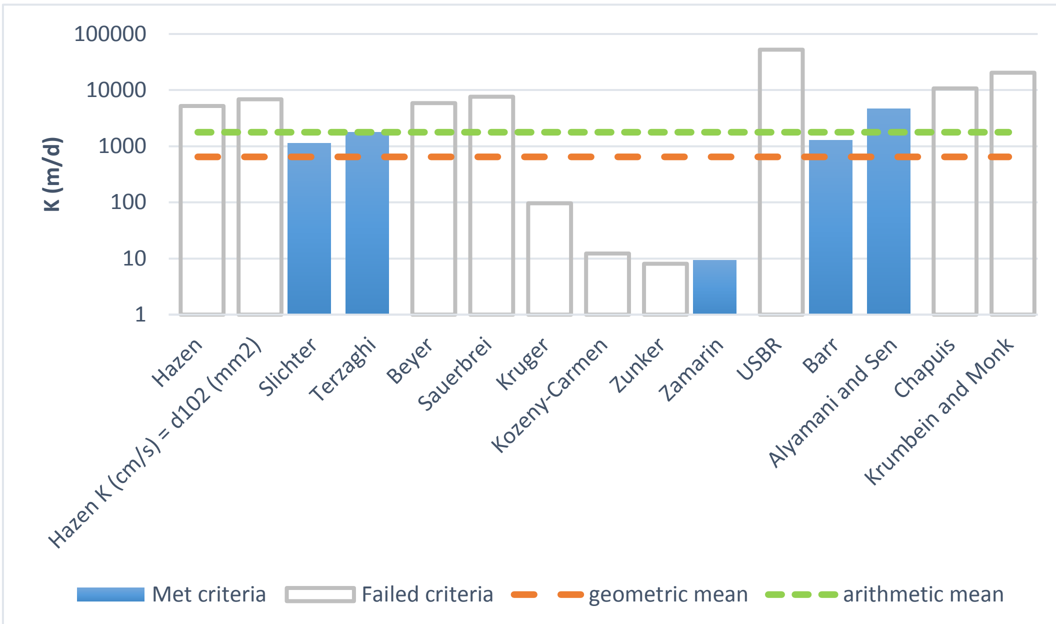
Grain Size Analysis Reports

K from Grain Size Analysis Report Date: 30-May-16

Sample Name: BH15-03 Sample #22

Mass Sample (g): 100 T (oC) 20

Poorly sorted gravel low in fines



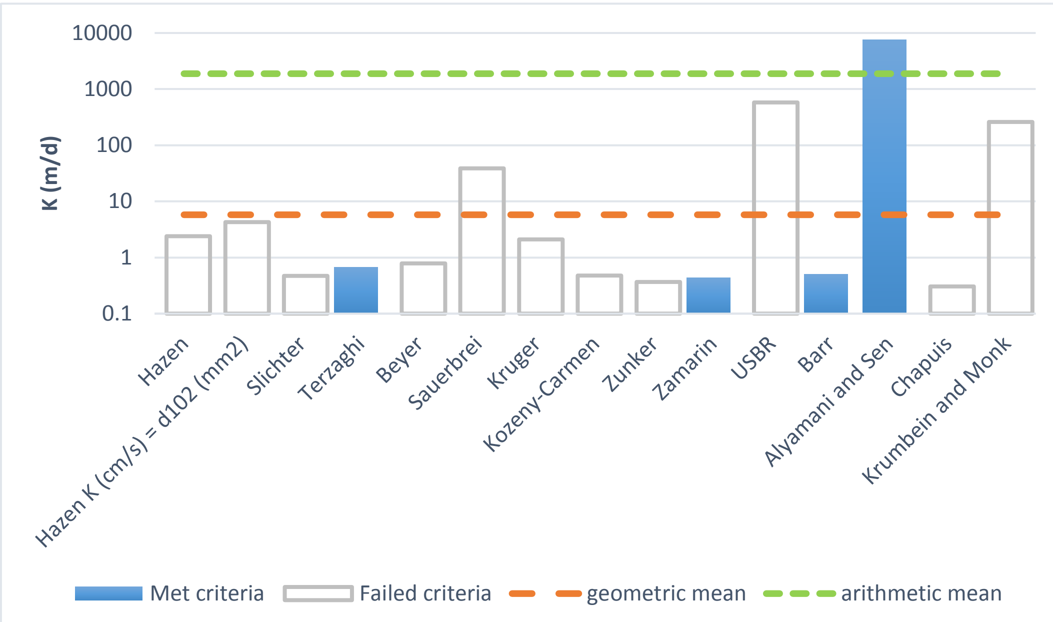
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.602E+01	.602E-01	5202.08
Hazen K (cm/s) = d_{10} (mm)	.792E+01	.792E-01	6843.06
Slichter	.131E+01	.131E-01	1130.18
Terzaghi	.206E+01	.206E-01	1776.83
Beyer	.677E+01	.677E-01	5852.18
Sauerbrei	.880E+01	.880E-01	7602.27
Kruger	.111E+00	.111E-02	96.02
Kozeny-Carmen	.141E-01	.141E-03	12.20
Zunker	.935E-02	.935E-04	8.08
Zamarin	.109E-01	.109E-03	9.41
USBR	.604E+02	.604E+00	52221.78
Barr	.148E+01	.148E-01	1280.03
Alyamani and Sen	.543E+01	.543E-01	4689.63
Chapuis	.124E+02	.124E+00	10684.67
Krumbein and Monk	.236E+02	.236E+00	20358.85
geometric mean	.749E+00	.749E-02	647.00
arithmetic mean	.206E+01	.206E-01	1777.22

K from Grain Size Analysis Report Date: 30-May-16

Sample Name: BH15-03 Sample #24

Mass Sample (g): 100 T (oC) 20

Poorly sorted sandy gravel low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.278E-02	.278E-04	2.40
Hazen K (cm/s) = d_{10} (mm)	.491E-02	.491E-04	4.25
Slichter	.547E-03	.547E-05	0.47
Terzaghi	.779E-03	.779E-05	0.67
Beyer	.910E-03	.910E-05	0.79
Sauerbrei	.451E-01	.451E-03	39.00
Kruger	.244E-02	.244E-04	2.11
Kozeny-Carmen	.555E-03	.555E-05	0.48
Zunker	.424E-03	.424E-05	0.37
Zamarin	.501E-03	.501E-05	0.43
USBR	.669E+00	.669E-02	577.95
Barr	.586E-03	.586E-05	0.51
Alyamani and Sen	.872E+01	.872E-01	7533.04
Chapuis	.352E-03	.352E-05	0.30
Krumbein and Monk	.299E+00	.299E-02	258.72
geometric mean	.669E-02	.669E-04	5.78
arithmetic mean	.218E+01	.218E-01	1883.66

K from Grain Size Analysis Report

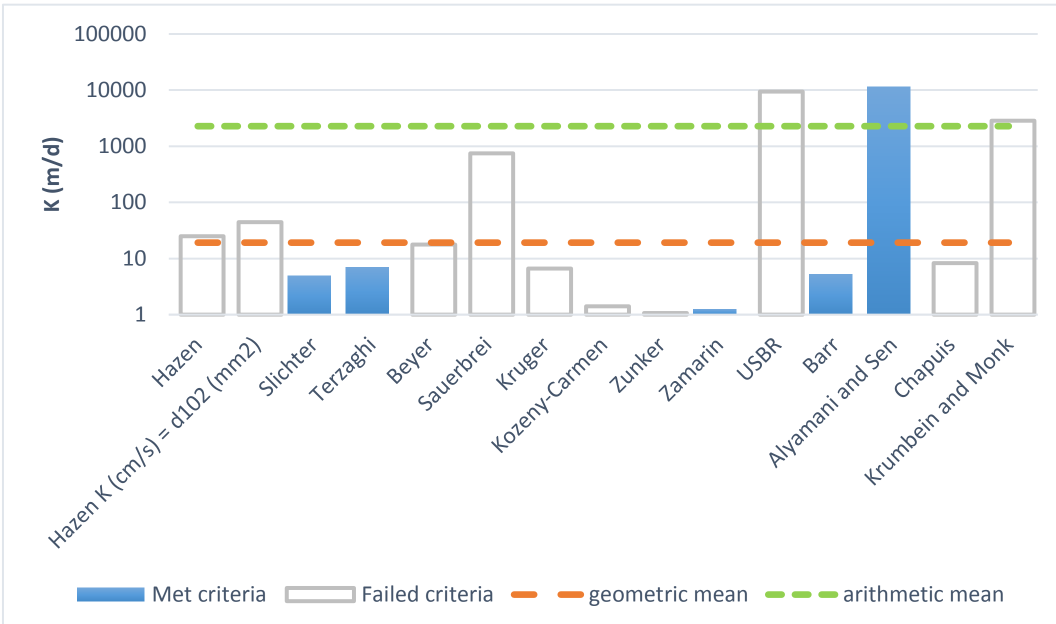
Date: 30-May-16

Sample Name: BH15-03 Sample #26

Mass Sample (g): 100

T (oC) 20

Poorly sorted gravel low in fines



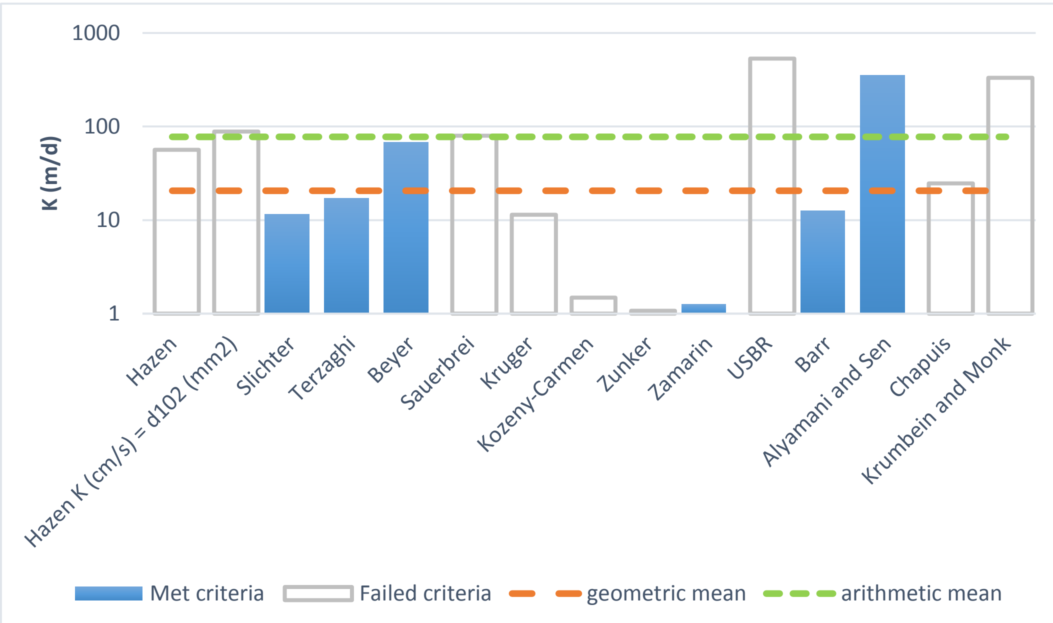
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.290E-01	.290E-03	25.04
Hazen K (cm/s) = d_{10} (mm)	.512E-01	.512E-03	44.22
Slichter	.569E-02	.569E-04	4.92
Terzaghi	.812E-02	.812E-04	7.01
Beyer	.204E-01	.204E-03	17.64
Sauerbrei	.860E+00	.860E-02	742.69
Kruger	.768E-02	.768E-04	6.64
Kozeny-Carmen	.162E-02	.162E-04	1.40
Zunker	.123E-02	.123E-04	1.06
Zamarin	.145E-02	.145E-04	1.25
USBR	.110E+02	.110E+00	9473.10
Barr	.611E-02	.611E-04	5.28
Alyamani and Sen	.132E+02	.132E+00	11372.88
Chapuis	.955E-02	.955E-04	8.25
Krumbein and Monk	.329E+01	.329E-01	2841.04
geometric mean	.222E-01	.222E-03	19.17
arithmetic mean	.264E+01	.264E-01	2278.27

K from Grain Size Analysis Report | Date: 30-May-16

Sample Name: BH15-03 Sample #28

Mass Sample (g): 100 | T (oC) 20

Poorly sorted sandy gravel low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.656E-01	.656E-03	56.64
Hazen K (cm/s) = d_{10} (mm)	.102E+00	.102E-02	88.35
Slichter	.133E-01	.133E-03	11.51
Terzaghi	.199E-01	.199E-03	17.17
Beyer	.787E-01	.787E-03	68.02
Sauerbrei	.923E-01	.923E-03	79.76
Kruger	.132E-01	.132E-03	11.39
Kozeny-Carmen	.172E-02	.172E-04	1.49
Zunker	.124E-02	.124E-04	1.07
Zamarin	.147E-02	.147E-04	1.27
USBR	.618E+00	.618E-02	534.35
Barr	.146E-01	.146E-03	12.60
Alyamani and Sen	.411E+00	.411E-02	354.85
Chapuis	.285E-01	.285E-03	24.61
Krumbein and Monk	.384E+00	.384E-02	331.50
geometric mean	.238E-01	.238E-03	20.59
arithmetic mean	.898E-01	.898E-03	77.57

ATTACHMENT 3

AGAT Laboratories Reports

AGAT Laboratories
3700 21st Street NE
Calgary, AB T2E 6V6
403.299.2000

Reservoir Characterization

Single Stage Flash

Reporting Date: 11-Jan-17
Sampling Date: 21-Dec-16 - 23-Dec-16
Well Name: -
Well Location: -
Surface Location: -
Sampling Point: -
Sample Type: Water
Cylinder ID: -
Res. Eng. WO#: 17P6098
Analytical WO#: 17C175581

Golder Associates Ltd.
Suite 200 - 2920 Virtual Way
Vancouver, BC V5M 0C4
Phone: 604.296.4200
Fax: 604.298.5253

Sample Control Number	Sample Location	Date Sampled	Gas in Solution (m^3/m^3)(A)(B)
03190-01	SH16-01S	21-Dec-16	0.179
03190-02	SH16-07S	22-Dec-16	0.125
03190-03	SH16-07M	22-Dec-16	0.125
03190-04	SH16-05S	22-Dec-16	0.119
03190-05	SH16-05M	22-Dec-16	0.148
03190-06	SH16-01M	23-Dec-16	0.183

(A) Cubic meters of gas per cubic meter of water at standard conditions (101.325 kPaa, 15.0 °C)
(B) The detailed description of Gas In Solution (GIS) can be found in AER Directive 17

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)299-2000
FAX (403)299-2010
http://www.agatlabs.com

CLIENT NAME: GOLDER ASSOCIATES LTD.
102, 2535 - 3 AVENUE SE
CALGARY, AB T2A7W5
(403) 299-5600

ATTENTION TO: Matt Zeppetelli / JOrdan Wilson

PROJECT:

AGAT WORK ORDER: 17C175581

OCCUPATIONAL HYGIENE REVIEWED BY: Rong Jin, Condensate Technician

DATE REPORTED: Jan 10, 2017

PAGES (INCLUDING COVER): 8

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (403) 299-2000

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories
2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)299-2000
FAX (403)299-2010
http://www.agatlabs.com

Certificate of Analysis

CLIENT NAME: GOLDER ASSOCIATES LTD.
AGAT WORK ORDER: 17C175581
PROJECT:
ATTENTION TO: Matt Zeppetelli / JOrdan Wilson
SAMPLING SITE:
SAMPLED BY:

Trace Hydrogen Sulphide Analysis (GC/SCD) - Gas

SAMPLE TYPE: Gas **SAMPLE ID: SYRINGE1** **DATE RECEIVED: Jan 10, 2017**
DATE SAMPLED: **DATE REPORTED: Jan 10, 2017**
SAMPLE DESCRIPTION: NOT AVAILABLE; SCN 03190-02; SH16-07S; 17P6098; WET

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Hydrogen Sulphide	ppm (v/v)	<0.1		0.1	Jan 05, 2017	RJ	Jan 05, 2017

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard
Field Hydrogen Sulphide : Not Available.
Identification based on retention time relative to standard.
Hydrogen sulphide quantified using its standard response factor.

Certified By: 金誉

AGAT Laboratories

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CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)299-2000
FAX (403)299-2010
http://www.agatlabs.com

Certificate of Analysis

CLIENT NAME: GOLDER ASSOCIATES LTD.
AGAT WORK ORDER: 17C175581
PROJECT:
ATTENTION TO: Matt Zeppetelli / JOrdan Wilson
SAMPLING SITE:
SAMPLED BY:

Trace Hydrogen Sulphide Analysis (GC/SCD) - Gas

SAMPLE TYPE: Gas **SAMPLE ID: SYRINGE2** **DATE RECEIVED: Jan 10, 2017**
DATE SAMPLED: **DATE REPORTED: Jan 10, 2017**
SAMPLE DESCRIPTION: NOT AVAILABLE; SCN 03190-03; SH16-07M; 17P6098

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Hydrogen Sulphide	ppm (v/v)	<0.1		0.1	Jan 05, 2017	RJ	Jan 05, 2017

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard
Field Hydrogen Sulphide : Not Available.
Identification based on retention time relative to standard.
Hydrogen sulphide quantified using its standard response factor.

Certified By:

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)299-2000
FAX (403)299-2010
http://www.agatlabs.com

Certificate of Analysis

CLIENT NAME: GOLDER ASSOCIATES LTD.
AGAT WORK ORDER: 17C175581
PROJECT:
ATTENTION TO: Matt Zeppetelli / JOrdan Wilson
SAMPLING SITE:
SAMPLED BY:

Trace Hydrogen Sulphide Analysis (GC/SCD) - Gas

SAMPLE TYPE: Gas **SAMPLE ID: SYRINGE3** **DATE RECEIVED: Jan 10, 2017**
DATE SAMPLED: Dec 06, 2016 **DATE REPORTED: Jan 10, 2017**
SAMPLE DESCRIPTION: NOT AVAILABLE; SCN 03190-01; SH16-01S; 17P6098; WET Rec'd Jan 6

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Hydrogen Sulphide	ppm (v/v)	<0.1		0.1	Jan 06, 2017	RJ	Jan 06, 2017

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard
Field Hydrogen Sulphide : Not Available.
Identification based on retention time relative to standard.
Hydrogen sulphide quantified using its standard response factor.

Certified By: 金蓉

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)299-2000
FAX (403)299-2010
http://www.agatlabs.com

Certificate of Analysis

CLIENT NAME: GOLDER ASSOCIATES LTD. **AGAT WORK ORDER: 17C175581**
PROJECT: **ATTENTION TO: Matt Zeppetelli / JOrdan Wilson**
SAMPLING SITE: **SAMPLED BY:**

Trace Hydrogen Sulphide Analysis (GC/SCD) - Gas

SAMPLE TYPE: Gas **SAMPLE ID: SYRINGE5** **DATE RECEIVED: Jan 10, 2017**
DATE SAMPLED: Dec 06, 2016 **DATE REPORTED: Jan 10, 2017**
SAMPLE DESCRIPTION: NOT AVAILABLE; SCN 03190-06; SH16-01M; 17P6098; WET Rec'd Jan 6

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Hydrogen Sulphide	ppm (v/v)	<0.1		0.1	Jan 06, 2017	RJ	Jan 06, 2017

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard
Field Hydrogen Sulphide : Not Available.
Identification based on retention time relative to standard.
Hydrogen sulphide quantified using its standard response factor.

Certified By: 金 蓉

2910 12TH STREET NE
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CANADA T2E 7P7
TEL (403)299-2000
FAX (403)299-2010
http://www.agatlabs.com

Certificate of Analysis

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 17C175581
ATTENTION TO: Matt Zeppetelli / JOrdan Wilson
SAMPLED BY:

Trace Hydrogen Sulphide Analysis (GC/SCD) - Gas

SAMPLE TYPE: Gas **SAMPLE ID: SYRINGE8** **DATE RECEIVED: Jan 10, 2017**

DATE SAMPLED: Dec 09, 2016 **DATE REPORTED: Jan 10, 2017**

SAMPLE DESCRIPTION: NOT AVAILABLE; SCN 03190-04; SH16-05S; 17P6098; WET Rec'd Jan 9

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Hydrogen Sulphide	ppm (v/v)	<0.1		0.1	Jan 09, 2017	RJ	Jan 09, 2017

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard
Field Hydrogen Sulphide : Not Available.
Identification based on retention time relative to standard.
Hydrogen sulphide quantified using its standard response factor.

Certified By: 金蓉

AGAT Laboratories
2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)299-2000
FAX (403)299-2010
http://www.agatlabs.com

Certificate of Analysis

CLIENT NAME: GOLDER ASSOCIATES LTD.
AGAT WORK ORDER: 17C175581
PROJECT:
ATTENTION TO: Matt Zeppetelli / JOrdan Wilson
SAMPLING SITE:
SAMPLED BY:

Trace Hydrogen Sulphide Analysis (GC/SCD) - Gas

SAMPLE TYPE: Gas **SAMPLE ID: SYRINGE9** **DATE RECEIVED: Jan 10, 2017**
DATE SAMPLED: Dec 10, 2016 **DATE REPORTED: Jan 10, 2017**
SAMPLE DESCRIPTION: NOT AVAILABLE; SCN 03190-05; SH16-05M; 17P6098; WET Rec'd Jan 10

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Hydrogen Sulphide	ppm (v/v)	0.2		0.1	Jan 10, 2017	RJ	Jan 10, 2017

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard
Field Hydrogen Sulphide : Not Available.
Identification based on retention time relative to standard.
Hydrogen sulphide quantified using its standard response factor.

Certified By: 金蓉

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)299-2000
FAX (403)299-2010
http://www.agatlabs.com

Method Summary

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 17C175581
ATTENTION TO: Matt Zeppetelli / JOrdan Wilson
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Occupational Hygiene Analysis			
Hydrogen Sulphide	HC-0160, HC-801	GPA 2286-95, ASTM D5504-12	GC/SCD/TCD

AGAT Laboratories

GAS ANALYSIS

Container Identification	Sample Point Code	Meter Code	AGAT WDMS Number	Previous Number	Laboratory Number
SYRINGE4C					17G175581C

Operator Name	Sampling Point	Unique Well Identifier
GOLDER ASSOCIATES LTD.	NOT AVAILABLE	NOT AVAILABLE

Well Name	Well License	Well Status	Well Fluid Status	LSD
NOT AVAILABLE				

Field or Area	Pool or Zone	Sampler's Company	Name of Sampler
NOT AVAILABLE	NOT AVAILABLE	GOLDER ASSOCIATES LTD.	NOT AVAILABLE

Test Interval (mKB) From :	Test Interval (mKB) To:	Test Type	Test No.	Elevation (m) KB	Elevation (m) GRD	Pressure (kPa) Source	Pressure (kPa) Received	Temperature (°C) Source	Temperature (°C) Received

Date Sampled	Date Received	Date Analyzed	Date Reported	Location - Approved By - Title
Dec 21, 2016	Jan 06, 2017	Jan 06, 2017	Jan 06, 2017	Calgary - Liming Zhao - Reporter

Other Information : H2S: FIELD = NA/LAB BY SCD <0.1 ppm, SCN 03190-01; SH16-01S; 17P6098; Rec'd Jan 6

COMPOSITION

Component	Mole Fraction: Air Free As Received	Mole Fraction: Air & Acid Gas Free As Received	Liquid Volume mL / m³	Mole Fraction of Previous Analysis
H_2	0.0000	0.0000		
He	0.0000	0.0000		
N_2	0.1255	0.4512		
CO_2	0.7218	0.0000		
H_2S	TRACE	0.0000		
C_1	0.0493	0.1772		
C_2	0.0055	0.0198	19.5	
C_3	0.0063	0.0226	23.2	
iC_4	0.0041	0.0147	17.9	
nC_4	0.0195	0.0701	82.0	
iC_5	0.0135	0.0485	65.9	
nC_5	0.0202	0.0726	97.7	
C_6	0.0206	0.0740	113.1	
C_7+	0.0137	0.0493	85.8	
TOTAL	1.0000	1.0000	505.1	

WDMS Data Verification Check

Exceeds normal limits :CO2, IC5, NC5, C6, C7, N2

PROPERTIES

Calculated Heating Value @15 °C & 101.325 kPa *(MJ/m³)*

Gross: Air Free as Received	Gross: Moisture & Acid Gas Free	Gross: C_7+ Moisture Free	Net: Air Free as Received	Net: Moisture & Acid Gas Free
17.35	62.33	2.87	**15.91**	57.18

Calculated Density

Relative: Moisture Free As Received	Relative: Moisture & Acid Gas Free	Relative: C_7+ Moisture Free	Absolute: C_7+ Density (kg/m³)	Absolute: Total Sample Density (kg/m³)
1.502	1.456	3.530	691.0	1.839

Calculated Pseudo Critical Properties

As Sampled: pPc (kPa)	As Sampled: pTc (K)	Acid Gas Free: pPc (kPa)	Acid Gas Free: pTc (K)
6332.8	292.3	3623.7	261.7

Hydrogen Sulfide (H_2S) (ppm)

Field Value: Stain Tube	Field Value: Tutweiler	Laboratory Value: Other	Laboratory Value: GC-SCD	g/m³
		0.1		0.00

Calculated Molecular Weight (Moisture Free as Received) (g/mol)

Total Sample	C_7+ Fraction
43.5	102.2

Calculated Vapour Pressure

72.28

C_5+ (kPa)

Gas Compressibility

0.9744

@15 °C & 101.325 kPa

Results relate to only items tested. Analysis and associated calculations are based on GPA 2261, GPA 2286, GPA 2145, AGA #5, and TP-17.

View or download your data online at webfluids.agatlabs.com

AGAT Laboratories

GAS ANALYSIS

Container Identification	Sample Point Code	Meter Code	AGAT WDMS Number	Previous Number	Laboratory Number
SYRINGE6D					17G175581D

Operator Name	Sampling Point	Unique Well Identifier
GOLDER ASSOCIATES LTD.	NOT AVAILABLE	NOT AVAILABLE

Well Name	Well License	Well Status	Well Fluid Status	LSD
NOT AVAILABLE				

Field or Area	Pool or Zone	Sampler's Company	Name of Sampler
NOT AVAILABLE	NOT AVAILABLE	GOLDER ASSOCIATES LTD.	NOT AVAILABLE

Test Interval (mKB) From :	To:	Test Type	Test No.	Elevation (m) KB	GRD	Pressure (kPa) Source	Received	Temperature (°C) Source	Received

Date Sampled	Date Received	Date Analyzed	Date Reported	Location - Approved By - Title
Dec 23, 2016	Jan 06, 2017	Jan 06, 2017	Jan 06, 2017	Calgary - Liming Zhao - Reporter

Other Information : H2S: FIELD = NA/LAB BY SCD <0.1 ppm, SCN 03190-06; SH16-01M; 17P6098; WET Rec'd Jan 6

COMPOSITION

Component	Mole Fraction: Air Free As Received	Mole Fraction: Air & Acid Gas Free As Received	Liquid Volume mL / m³	Mole Fraction of Previous Analysis
H_2	TRACE	TRACE		
He	0.0000	0.0000		
N_2	0.0415	0.1759		
CO_2	0.7641	0.0000		
H_2S	TRACE	0.0000		
C_1	0.0959	0.4066		
C_2	0.0156	0.0661	55.4	
C_3	0.0053	0.0225	19.5	
iC_4	0.0021	0.0089	9.2	
nC_4	0.0116	0.0492	48.8	
iC_5	0.0069	0.0292	33.7	
nC_5	0.0152	0.0644	73.5	
C_6	0.0205	0.0869	112.5	
C_7+	0.0213	0.0903	133.8	
TOTAL	1.0000	1.0000	486.4	

WDMS Data Verification Check

Exceeds normal limits :CO2, NC5, C6, C7

PROPERTIES

Calculated Heating Value @15 °C & 101.325 kPa *(MJ/m³)*

Gross: Air Free as Received	Gross: Moisture & Acid Gas Free	Gross: C_7+ Moisture Free	Net: Air Free as Received	Net: Moisture & Acid Gas Free
18.34	77.70	4.48	**16.78**	71.11

Calculated Density

Relative: Moisture Free As Received	Relative: Moisture & Acid Gas Free	Relative: C_7+ Moisture Free	Absolute: C_7+ Density (kg/m³)	Absolute: Total Sample Density (kg/m³)
1.498	1.427	3.546	691.6	1.834

Calculated Pseudo Critical Properties

As Sampled: pPc (kPa)	As Sampled: pTc (K)	Acid Gas Free: pPc (kPa)	Acid Gas Free: pTc (K)
6562.5	300.7	3924.5	289.8

Hydrogen Sulfide (H_2S) (ppm)

Field Value: Stain Tube	Field Value: Tutweiler	Laboratory Value: Other	Laboratory Value: GC-SCD	g/m³
		0.1		0.00

Calculated Molecular Weight (Moisture Free as Received) (g/mol)

Total Sample	C_7+ Fraction
43.4	102.7

Calculated Vapour Pressure

55.02

C_5+ (kPa)

Gas Compressibility

0.9686

@15 °C & 101.325 kPa

Results relate to only items tested. Analysis and associated calculations are based on GPA 2261, GPA 2286, GPA 2145, AGA #5, and TP-17.

View or download your data online at webfluids.agatlabs.com

AGAT Laboratories

GAS ANALYSIS

SYRINGE7E					17G175581E
Container Identification	*Sample Point Code*	*Meter Code*	*AGAT WDMS Number*	*Previous Number*	*Laboratory Number*

GOLDER ASSOCIATES LTD.	NOT AVAILABLE	NOT AVAILABLE
Operator Name	*Sampling Point*	*Unique Well Identifier*

NOT AVAILABLE				
Well Name	*Well License*	*Well Status*	*Well Fluid Status*	*LSD*

NOT AVAILABLE	NOT AVAILABLE	GOLDER ASSOCIATES LTD.	NOT AVAILABLE
Field or Area	*Pool or Zone*	*Sampler's Company*	*Name of Sampler*

Test Interval (mKB)				*Elevation (m)*		*Pressure (kPa)*		*Temperature (°C)*	
									21
From :	*To:*	*Test Type*	*Test No.*	*KB*	*GRD*	*Source*	*Received*	*Source*	*Received*

Dec 22, 2016	Jan 09, 2017	Jan 09, 2017	Jan 09, 2017	Calgary - Vera Scherban - Reporter
Date Sampled	*Date Received*	*Date Analyzed*	*Date Reported*	*Location - Approved By - Title*

Other Information : SCN 03190-04; SH16-05S; 17P6098; WET Rec'd Jan 9; LAB H2S BY SCD = <0.1ppm

COMPOSITION

Component	Mole Fraction		Liquid Volume mL / m³	Mole Fraction of Previous Analysis
	Air Free As Received	Air & Acid Gas Free As Received		
H_2	TRACE	TRACE		
He	0.0000	0.0000		
N_2	0.0891	0.4819		
CO_2	0.8151	0.0000		
H_2S	0.0000	0.0000		
C_1	0.0107	0.0579		
C_2	0.0023	0.0124	8.2	
C_3	0.0049	0.0265	18.0	
iC_4	0.0028	0.0151	12.2	
nC_4	0.0093	0.0503	39.1	
iC_5	0.0079	0.0427	38.6	
nC_5	0.0151	0.0817	73.1	
C_6	0.0230	0.1244	126.3	
C_7+	0.0198	0.1071	123.9	
TOTAL	1.0000	1.0000	439.4	

WDMS Data Verification Check

Exceeds normal limits :CO2, NC5, C6, C7, N2

PROPERTIES

Calculated Heating Value @15 °C & 101.325 kPa *(MJ/m³)*

Gross			***Net***	
14.24	77.15	4.15	**13.09**	70.80
Air Free as Received	*Moisture & Acid Gas Free*	*C_7+ Moisture Free*	*Air Free as Received*	*Moisture & Acid Gas Free*

Calculated Density

Relative			***Absolute***	
1.560	1.741	3.530	691.0	1.911
Moisture Free As Received	*Moisture & Acid Gas Free*	*C_7+ Moisture Free*	*C_7+ Density (kg/m³)*	*Total Sample Density (kg/m³)*

Calculated Pseudo Critical Properties

As Sampled		***Acid Gas Free***	
6642.6	301.9	3405.0	292.4
pPc (kPa)	*pTc (K)*	*pPc (kPa)*	*pTc (K)*

Hydrogen Sulfide (H_2S) (ppm)

Field Value		***Laboratory Value***		***g/m³***
			0	0.00
Stain Tube	*Tutweiler*	*Other*	*GC-SCD*	

Calculated Molecular Weight (Moisture Free as Received) (g/mol)

45.2	102.3
Total Sample	*C_7+ Fraction*

Calculated Vapour Pressure

56.55

C_5+ (kPa)

Gas Compressibility

0.9617

@15 °C & 101.325 kPa

Results relate to only items tested. Analysis and associated calculations are based on GPA 2261, GPA 2286, GPA 2145, AGA #5, and TP-17.

View or download your data online at webfluids.agatlabs.com

AGAT Laboratories

GAS ANALYSIS

Container Identification	Sample Point Code	Meter Code	AGAT WDMS Number	Previous Number	Laboratory Number
SYRINGE10F					17G175581F

Operator Name	Sampling Point	Unique Well Identifier
GOLDER ASSOCIATES LTD.	NOT AVAILABLE	NOT AVAILABLE

Well Name	Well License	Well Status	Well Fluid Status	LSD
NOT AVAILABLE				

Field or Area	Pool or Zone	Sampler's Company	Name of Sampler
NOT AVAILABLE	NOT AVAILABLE	GOLDER ASSOCIATES LTD.	NOT AVAILABLE

Test Interval (mKB) From :	To:	Test Type	Test No.	Elevation (m) KB	GRD	Pressure (kPa) Source	Received	Temperature (°C) Source	Received
									21

Date Sampled	Date Received	Date Analyzed	Date Reported	Location - Approved By - Title
Dec 22, 2016	Jan 10, 2017	Jan 10, 2017	Jan 10, 2017	Calgary - Vera Scherban - Reporter

Other Information : SCN 03190-05; SH16-05M; 17P6098; WET Rec'd Jan 10; LAB H2S BY SCD = 0.2ppm

COMPOSITION

Component	Mole Fraction: Air Free As Received	Mole Fraction: Air & Acid Gas Free As Received	Liquid Volume mL / m³	Mole Fraction of Previous Analysis
H_2	0.0000	0.0000		
He	TRACE	TRACE		
N_2	0.0616	0.2721		
CO_2	0.7737	0.0000		
H_2S	TRACE	0.0000		
C_1	0.0194	0.0857		
C_2	0.0007	0.0031	2.5	
C_3	0.0050	0.0221	18.4	
iC_4	0.0050	0.0221	21.8	
nC_4	0.0242	0.1069	101.8	
iC_5	0.0202	0.0893	98.6	
nC_5	0.0295	0.1304	142.7	
C_6	0.0332	0.1467	182.2	
C_7+	0.0275	0.1216	175.1	
TOTAL	1.0000	1.0000	743.1	

WDMS Data Verification Check

Exceeds normal limits :CO2, IC5, NC5, C6, C7, N2

PROPERTIES

Calculated Heating Value @15 °C & 101.325 kPa *(MJ/m³)*

Gross: Air Free as Received	Gross: Moisture & Acid Gas Free	Gross: C_7+ Moisture Free	Net: Air Free as Received	Net: Moisture & Acid Gas Free
24.18	107.29	5.88	**22.20**	98.11

Calculated Density

Relative: Moisture Free As Received	Relative: Moisture & Acid Gas Free	Relative: C_7+ Moisture Free	Absolute: C_7+ Density (kg/m³)	Absolute: Total Sample Density (kg/m³)
1.635	2.029	3.607	694.1	2.002

Calculated Pseudo Critical Properties

As Sampled: pPc (kPa)	As Sampled: pTc (K)	Acid Gas Free: pPc (kPa)	Acid Gas Free: pTc (K)
6481.5	316.2	3419.7	357.8

Hydrogen Sulfide (H_2S) (ppm)

Field Value: Stain Tube	Field Value: Tutweiler	Laboratory Value: Other	Laboratory Value: GC-SCD	g/m³
			0.2	0.00

Calculated Molecular Weight (Moisture Free as Received) (g/mol)

Total Sample	C_7+ Fraction
47.3	104.5

Calculated Vapour Pressure

67.00
C_5+ (kPa)

Gas Compressibility

0.9475
@15 °C & 101.325 kPa

Results relate to only items tested. Analysis and associated calculations are based on GPA 2261, GPA 2286, GPA 2145, AGA #5, and TP-17.

View or download your data online at webfluids.agatlabs.com

Golder Associates
200 – 2920 Virtual Way
Vancouver, British Columbia, Canada V5M 0C4
Telephone (604) 296-4200 Fax (604) 298-5253

CHAIN OF CUSTODY RECORD/ANALYSIS REQUEST

No. 03190 page 1 of 1

Project Number:	1525010/3100/3100.5
Short Title:	Annacis Island
Golder Contact:	Don Chorley
Golder E-mail Address 1:	dchorley@golder.com
Golder E-mail Address 2:	nfretz@golder.com
Laboratory Name:	AGAT
Address:	3650 21st St. NE, Calgary, AB
Telephone/Fax:	403-975-1657
Contact:	Jordan Wilson

Office Name: Vancouver- Virtual Way

EQuIS Facility Code: ______
EQuIS upload: ☐

Turnaround Time: ☐ 24 hr ☐ 48 hr ☐ 72 hr ☐ Regular (5 Days)

Criteria: ☐ CSR ☐ CCME ☐ BC Water Quality ☐ Other

Note: Final Reports to be issued by e-mail

Quote No.:

DEC 29 AM 9:51

Analyses Required

Sample Control Number (SCN)	Sample Location	Sa. #	Sample Depth (m)	Sample Matrix (over)	Date Sampled (D / M / Y)	Time Sampled (HH:MM)	Sample Type (over)	QAQC Code (over)	Related SCN (over)	Number of Containers	Air free flash from snap sampler	C7+ gas	Trace H_2S							RUSH (Select TAT above)	Remarks (over)
03190 - 01	SH16-01S			WG	21/12/16					15	X	X	X							X	please rush
- 02	SH16-07S				22/12/16					15	X	X	X							X	through lab
- 03	SH16-07M									15	X	X	X							X	on arrival
- 04	SH16-05S									15	X	X	X							X	
- 05	SH16-05M									15	X	X	X							X	
- 06	SH16-01M				23/12/16					15	X	X	X							X	
- 07																					
- 08																					
- 09																					
- 10																					
- 11																					
- 12																					

Sampler's Signature: [signature]	Relinquished by: Signature [signature]	Company: Golder	Date: 29/Dec/2016	Time:	Received by: Signature / Company:
Comments: • ON ICE • please send to Jordan Wilson (Calgary) ASAP	Method of Shipment: AGAT to ship	Waybill No.:	Received for Lab by: [signature]	Date:	Time: 9:54 AM
	Shipped by:	Shipment Condition: Seal Intact:	Temp (°C): 3	Cooler opened by: Date:	Time:

• RUSH

WHITE: Golder Copy YELLOW: Lab Copy

ESED

CDM Smith

cdmsmith.com