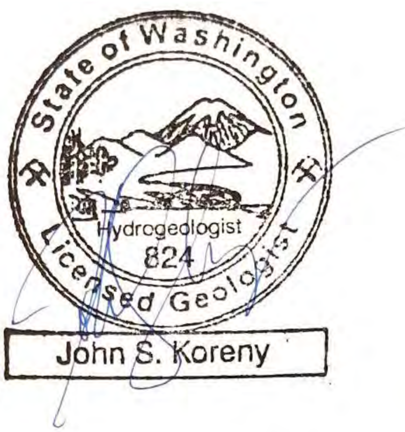
LOTT CLEAN WATER ALLIANCE
RECLAIMED WATER INFILTRATION STUDY

HYDROGEOLOGIC CHARACTERIZATION REPORT

ON-SITE WELLS AND LYSIMETER INSTALLATION (TASK 2.1.1.A) OFF-SITE MONITORING WELLS (TASK 2.1.2.C)
HAWKS PRAIRIE AREA



MARCH 26, 2018

Prepared by

HDR
606 Columbia St NW, Suite 200
Olympia, WA 98501

Prepared for

LOTT Clean Water Alliance
500 Adams St NE
Olympia, WA 98501

This page intentionally left blank.

Contents

List of Tables

List of Figures

List of Appendices

Acronyms and Abbreviations

bgs	Below Ground Surface
btoc	Below Top of Casing
Ca	Calcium
cm	Centimeter
d_{10}	10% Passing Soil Grain Size
d_{50}	50% Passing Soil Grain Size
d_{90}	90% Passing Soil Grain Size
DI	Deionized (DI water)
ft	Foot or Feet
g	Gram
gpd	Gallons per Day
gpm	Gallons per Minute
hr	Hour
ID	Inside Diameter
IEUA	Inland Empire Utilities Agency
LOTT	LOTT Clean Water Alliance
Ksat	Saturated Hydraulic Conductivity
meq/100g	Milliequivalents per 100 grams
mgd	Million Gallons per Day
mm	Millimeter
MSL	Mean Sea Level
MWRWP	Martin Way Reclaimed Water Plant
NaBr	Sodium Bromide
N/A	Not Applicable
OD	Outside Diameter
PVC	Polyvinyl Chloride
Qc	Pre-Vashon Coarse Deposits
Qf	Kitsap Formation
Qgof/Qgos	Late Vashon Sediments in Woodland Creek Valley
Qvr/Qgo	Alluvium Vashon Recessional Gravel Outwash
Qvt/Qgt	Vashon Till
Qva/Qga	Vashon Advance Outwash
RWIS	Reclaimed Water Infiltration Study
SF_6	Sulfur Hexafluoride
TQu	Tertiary Unconsolidated and Undifferentiated Sediments
USCS	Unified Soil Classification System
WAC	Washington Administrative Code

1.0 Introduction

1.1 Background

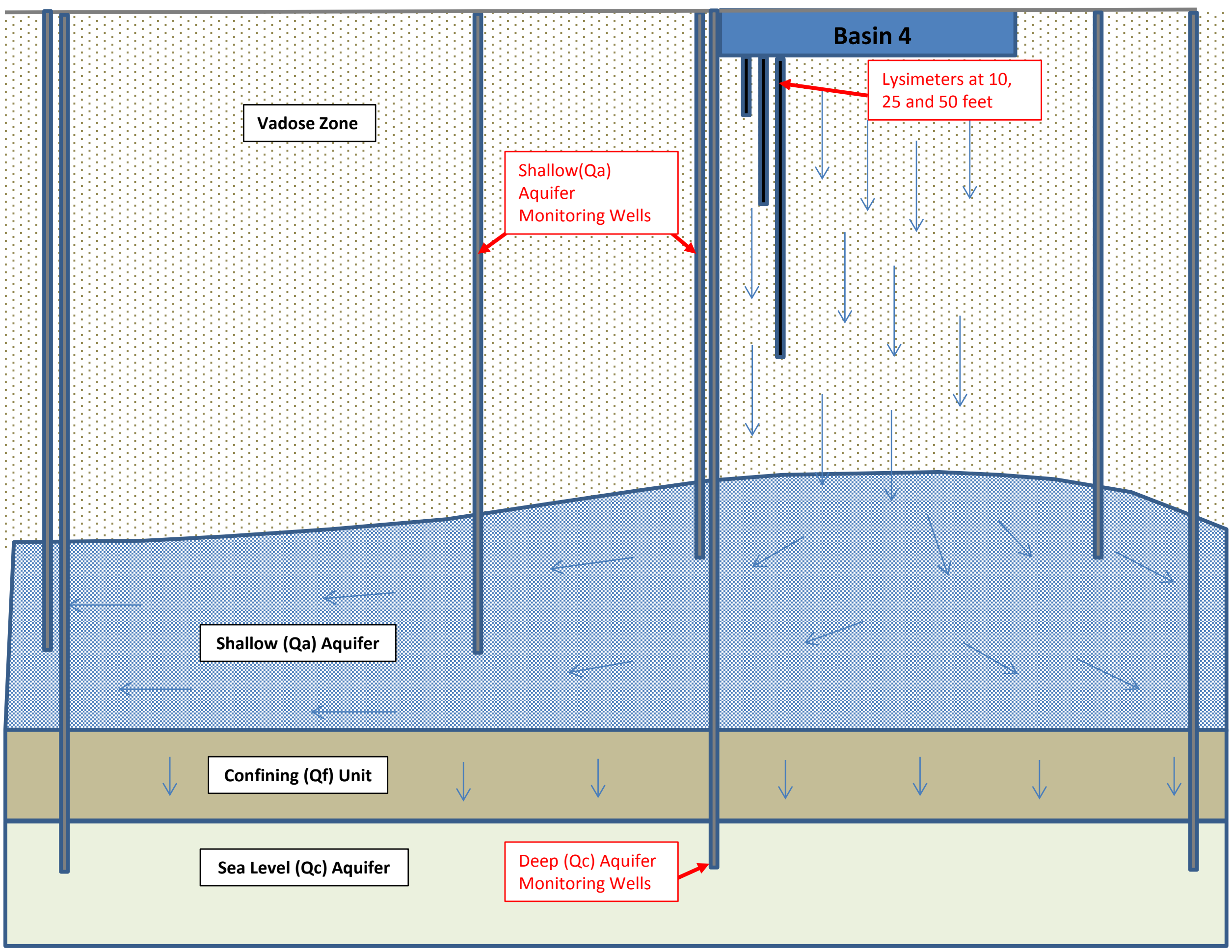
The LOTT Clean Water Alliance (LOTT) provides services to treat and manage wastewater for the urban areas of Lacey, Olympia, and Tumwater in Thurston County, Washington (at the southern end of Puget Sound). Since 2006, LOTT has also produced reclaimed water at the Martin Way Reclaimed Water Plant (MWRWP) that is used for irrigation and other non-drinking purposes. Some of the reclaimed water is used to recharge (replenish) groundwater using rapid-infiltration basins at the LOTT Hawks Prairie Ponds and Recharge Basins property (Hawks Prairie property). The long-range plan for meeting future wastewater needs includes expanding reclaimed water production and developing additional groundwater recharge facilities.

Some chemicals may remain in Class A reclaimed water in trace (residual) amounts even after going through advanced Class A required treatment. Residual chemicals may include pesticides/herbicides, pharmaceuticals, personal care products, cooking products, flame retardants, and other household chemicals not removed during treatment. In response to potential concerns regarding the residual chemicals in Class A reclaimed water, LOTT has initiated a study (Reclaimed Water Infiltration Study or RWIS) to quantify residual chemicals in reclaimed water and to assess their fate and transport through infiltration basins and into groundwater. Specifically, the study will quantify the loading of residual chemicals into the LOTT Hawks Prairie recharge basins and the attenuation of these chemicals as they pass through the shallow and deep soils under the basins. Next, the study will quantify any remaining residual chemicals in groundwater and the potential attenuation and transport of chemicals in the groundwater system to downgradient receptors (discharges to surface water creeks, lakes, springs, or drinking water wells). LOTT and the wider community will use study results to make the most appropriate choices for future reclaimed water management and to ensure protection of public health and the environment.

1.2 Purpose

In Task 1.0 of the RWIS, field investigations and water quality sampling were performed to identify the presence and concentration of residual chemicals in raw and treated wastewater, reclaimed water, groundwater, and surface water within the Hawks Prairie area and in the area around the City of Tumwater. The purpose of Task 2.0 of the RWIS (which includes this report) is to assess the treatment effectiveness (ability to remove residual chemicals) of the existing LOTT Hawks Prairie infiltration basins and groundwater system. Specifically, Task 2.0 is designed to evaluate the presence, potential degradation, attenuation, and transport of residual chemicals remaining after Class A treatment. Tracer testing (forthcoming) will determine groundwater travel time, and vadose (unsaturated) zone and groundwater quality sampling will be completed to evaluate water quality.

To accomplish Task 2.0, information is required on the depth, thickness, extent and hydraulic properties of the subsurface aquifers and confining units, and the groundwater flow directions and gradients. To collect this information, field investigations under Tasks 2.1.1.A and 2.1.2.C were completed which included drilling soil borings, collecting soil samples, and installing monitoring wells on and around the LOTT Hawks Prairie property. Lysimeters and other sensors measuring soil moisture, conductivity, temperature and oxygen were installed within recharge Basin 4, which has been designated as a test basin with two recharge cells. **Figure 1-1** shows a conceptual illustration of the monitoring approach for the vadose and saturated zones. Soil samples were collected and laboratory tested for a variety of hydraulic properties. *In-situ* aquifer testing was conducted including slug testing and aquifer pumping tests. This field work was completed from June 2017 through September 2017. The subsurface investigation work was performed in accordance with the procedures and specifications described in the work plan (HDR, 2017a). This report describes the results of the hydrogeologic field investigations, the collected data, and a summary of the major findings. This information will support development of the work plan for tracer testing and water quality monitoring, which will then be completed in the next step of the project in 2018.



(Not to scale, for illustration purposes only. All of the monitoring wells and lysimeters proposed are not shown.)

Figure 1-1. Conceptual illustration of monitoring test program at LOTT Hawks Prairie Property.

2.0 Physical Setting of Hawks Prairie Study Area

This section presents background information on the climate, topography, surface water drainage, and hydrogeology of the area surrounding the LOTT Hawks Prairie property.

2.1 Climate

The area is characterized by mild cool/wet winters and warm/dry summers. Precipitation and temperature data from the Olympia Airport USW00024227 gaging station (about 10 miles southwest of the Hawks Prairie Study Area) is shown in **Tables 2-1** and **2-2**. Over the 1948 to 2016 period of record, during the summer period from June to October, the average low/high temperature ranged from 46.8 to 77.2 degrees Fahrenheit (°F) and average total monthly precipitation ranged from 0.7 to 4.8 inches. During the winter period from December to February over the same period of record the low/high temperature ranged from 31.8 to 49.2 °F and average total monthly precipitation ranged from 5.3 to 8.2 inches. Total average annual precipitation was 51.0 inches and average annual temperature was 50.0 °F.

2.2 Topography and Surface Water Drainage

Figure 2-1 shows the land surface topography and the surface water drainage to the regional creeks, rivers, and Puget Sound. The Hawks Prairie Study Area is located on the east side of a broad plateau about eight miles wide (east to west) formed by deposition of sediments during multiple glaciations.

The Nisqually River and McAllister Creek are located on the east side of the Hawks Prairie Study Area in a valley deeply incised into the glacial deposits. There is a steep east-facing scarp on the western side of the Nisqually River valley. The western edge of the plateau is bound by Puget Sound (Budd Inlet) and the Deschutes River. Woodland Creek flows north through the plateau and drains the west side of the Hawks Prairie Study Area. Woodland Creek flows from Long Lake to the north into Puget Sound (Henderson Inlet). Large springs (e.g., Beatty Springs) are located mid-way in the Woodland Creek drainage. Several tributaries to Woodland Creek, including Eagle Creek and Fox Creek, drain the west side of the Hawks Prairie Study Area. The east side of the Hawks Prairie Study Area drains to the Nisqually River. Steep scarps and the Puget Sound bound the northern edge of the Hawks Prairie Study Area.

2.3 Hydrogeology

The Hawks Prairie Study Area was heavily glaciated, resulting in a sequence of stratified sediments that are regionally correlated based on their water-bearing properties. The hydrostratigraphic units present in the Hawks Prairie Study Area are discussed below from top to bottom. Unit nomenclature differs between two sources of data. In the unit descriptions below the abbreviations in parenthesis are first from Drost, et al (1999) and second from Logan et al (2003). For the purposes of this report, unit abbreviations follow Drost, et al (1999). Figures showing surface geology and regional geologic cross-sections are presented in the project work plan (HDR, 2017a).

<u>Late Vashon Sediments in Woodland Creek Valley (Qgof/Qgos).</u> Late Vashon sediments were deposited in the Woodland Creek valley during deglaciation. Sediments

consist of sand/silt up to 100 feet thick in the upper part of the drainage and less-thick silty/clay in the lower part of the drainage. This unit forms an unconfined aquifer within the Woodland Creek valley.

Alluvium and Vashon Recessional Gravel Outwash (Qvr, also known as Qgo). Alluvium and recessional glacial outwash sand and gravel form an unconfined aquifer where saturated. Throughout most areas the unit is unsaturated and forms the vadose zone. Approximate thickness of the unit ranges from being absent (eroded) to over 100 feet thick in places. This is the upper-most water bearing unit in the Hawks Prairie Study Area.

Vashon Till (Qvt, also known as Qgt). Deposits of dense (compacted) unsorted silt, clay, sand and gravel form a regional confining unit which impedes the vertical flow of groundwater. The till unit is not present underlying most of the LOTT Hawks Prairie property, but is present nearby to the south and north of the site. Approximate thickness of the unit ranges from being absent to over 50 feet thick, with appearances at the surface and at varying depths.

Vashon Advance Outwash (Qva, also known as Qga). The Vashon Advance Outwash is a regional aquifer composed of sand and gravel. This is the upper-most water bearing unit where Qvr is not saturated, as is the case throughout most of the study area. The Qvr and Qva units are sometimes grouped together and called the "Shallow (Qva) Aquifer" in previous studies. The depth to the bottom of the Shallow (Qva) Aquifer is generally less than 150 feet below ground surface (bgs), although may be deeper in places. In the vicinity of the LOTT Hawks Prairie property the Shallow (Qva) Aquifer is generally unconfined, although in places the groundwater level may rise into the glacial till and become confined. Well yields within the Hawks Prairie Study Area for the Shallow (Qva) Aquifer are reported up to 250 gallons per minute (gpm).

Kitsap Formation (Qf). The Kitsap Formation is a low-permeability silt, sand and clay formation that is a regional confining unit up to 150 feet thick between the Shallow (Qva) Aquifer and the Sea Level (Qc) Aquifer. Significant thicknesses of fine sand have been observed in some locations, which may cause the confining unit to behave as a leaky confining unit. The Kitsap Formation appears to be absent near the east side of the Thurston County Landfill.

Pre-Vashon Coarse Deposits (Qc). This thick (up to 150 feet) sequence of coarse, stratified sand and gravel forms a regional aquifer used in places for public supply wells. The aquifer is also sometimes called the "Sea Level (Qc) Aquifer" in previous studies. Well yields of up to 1,650 gpm have been reported for this aquifer on well logs (HDR, 2017b). The aquifer is confined because groundwater levels are well above the top of the formation. The coarse-grained deposits are usually found in beds overlain and underlain by finer-grained sediments that act as confining units or low-permeability units within the aquifer. The coarse-grained sediments are often correlated to be at or below current sea level, but are not necessarily uniform in depth or extent.

Tertiary Unconsolidated and Undifferentiated Sediments (TQu). Layers of clay, silt, sand and gravel of glacial and non-glacial origin above bedrock are characterized as Tertiary unconsolidated and undifferentiated sediments. Below the Sea Level (Qc) Aquifer this unit is known locally as the “Lower Confining Unit”. In some places, deep public supply wells have been completed in the coarse TQu sand and gravel units which form a deep confined aquifer. This is sometimes called the “Deep (TQu) Aquifer” in previous studies. Well yields of up to 860 gpm have been reported on logs for wells completed in the Deep (TQu) Aquifer within the Hawks Prairie area.

Table 2-1. Average precipitation for 2015 and for the 1948 to 2016 record from the Olympia Airport gaging station.

Date	Average Precipitation over the Period of Record (1948 - 2016) (in)	2015 Average Precipitation (in)
January	7.87	6.69
February	5.69	5.28
March	5.28	5.94
April	3.37	1.93
May	2.17	0.67
June	1.54	0.14
July	0.70	0.15
August	1.17	2.84
September	2.13	0.90
October	4.78	6.69
November	8.22	11.83
December	8.12	14.50
Total Annual	51.0	57.56

Note: Precipitation Data from GHCND Station USW00024227, Olympia Airport.

Table 2-2. Average temperature for 2015 and for the 1948 to 2016 record from the Olympia Airport gaging station.

Date	1948-2016 Average High (°F)	1948-2016 Average Low (°F)	1948-2016 Average Temperature (°F)	2015 Average High (°F)	2015 Average Low (°F)	2015 Average (°F)
January	44.7	31.8	38.3	49.3	36.0	42.6
February	49.2	32.5	40.8	55.0	37.0	46.0
March	53.3	33.9	43.6	59.2	36.7	47.8
April	58.8	36.6	47.7	60.3	36.7	48.6
May	65.7	41.7	53.7	68.4	44.8	56.7
June	70.9	46.8	58.8	79.9	50.2	65.1
July	77.2	49.6	63.4	83.3	52.9	68.0
August	77.2	49.7	63.4	80.4	52.0	66.2
September	71.6	45.4	58.5	70.2	45.5	57.9
October	60.5	40.0	50.2	64.2	44.8	54.5
November	50.4	35.5	43.0	48.9	33.8	41.4
December	44.8	32.6	38.7	46.0	35.1	40.6

Note: Temperature Data from GHNCD Station USW00024227, Olympia Airport

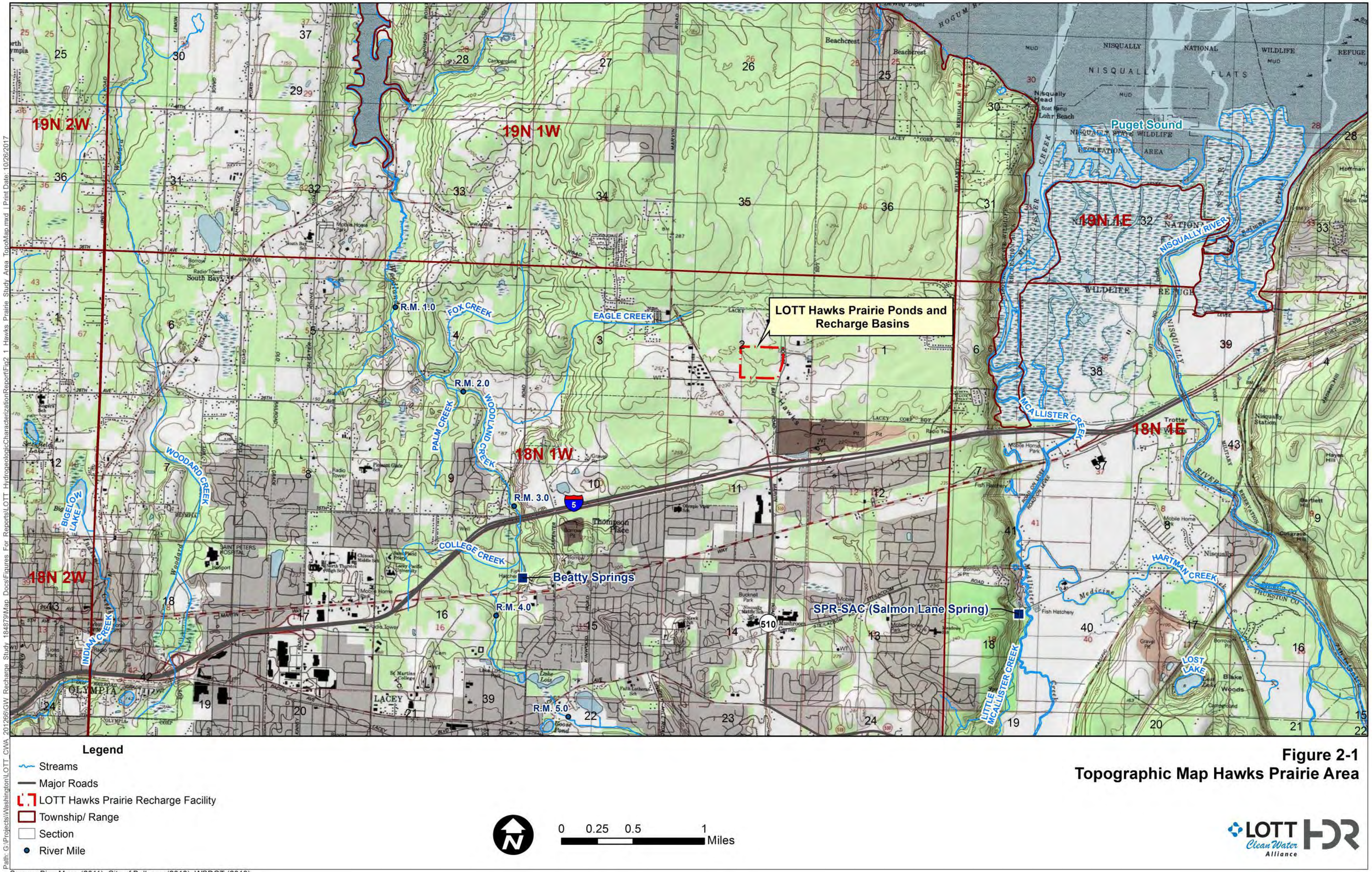


Figure 2-1
Topographic Map Hawks Prairie Area

This page intentionally left blank.

3.0 Field and Laboratory Investigation Methods

This section describes the hydrogeologic field and laboratory investigation methods for the vadose (unsaturated) zone and the saturated zone. The locations of monitoring wells and lysimeters installed are shown on Figure 3-1 and **Figure 3-2**. All drilling was completed by Holt Services, Inc. using a Terra Sonic 150CC track-mounted sonic drilling rig. Lysimeter and monitoring well installation activities were conducted from June to August 2017. Aquifer testing was completed during September 2017. During monitoring well installation recharge rates at the LOTT Hawks Prairie recharge basins were approximately 0.1 to 0.5 million gallons per day (mgd) rotated through the eight basins and recharge was off the week prior to and during aquifer testing.

3.1 Vadose Zone

Monitoring of the vadose zone is included in the study scope because previous studies at other reclaimed water aquifer recharge sites indicate the majority of organic constituent degradation and sorption occurs in the vadose zone (Naranaswamy et al., 2001; IEUA, 2008; Quanrud et al, 2008). The vadose zone is the partially-saturated to un-saturated zone above the aquifer which is fully saturated with groundwater.

One set of stainless steel suction lysimeters and one set of vadose zone monitoring instruments (soil moisture, temperature, conductivity and oxygen) were installed in the east half and west half of Basin 4 (two sets total). The purpose of the suction lysimeters is to collect pore-water samples at discrete intervals above the groundwater table. The lysimeters are able to collect vadose zone samples under both fully unsaturated and perched water conditions. The purpose of the *in-situ* instrumentation is to collect data on vadose zone conditions in the subsurface soils directly under the recharge basin. Bulk soil samples were collected from the borings used to install the lysimeters, and were analyzed for hydraulic and physical properties.

The section below describes the installation procedures, the subsurface conditions encountered, and the results of the soils analysis.

3.1.1 Lysimeters

A set of three nested suction lysimeters were installed in the east and west halves of Basin 4 (two sets, six lysimeters total) at the locations shown on **Figure 3-2**. The setup of the lysimeters is similar to another reclaimed water/aquifer recharge vadose zone monitoring program by Inland Empire Utilities Agency (IEUA) in San Bernardino County, California (IEUA, 2003).

3.1.1.1 Lysimeter Soil Borings

The lysimeters were installed in individual 7-inch-diameter boreholes drilled inside Basin 4 about 15 feet south of the north edge of the basin (**Figure 3-2**). Each lysimeter set consists of three lysimeters installed about 5 feet apart at depths of 10, 25 and 50 feet. Each lysimeter was placed in an individual boring. Continuous soil samples were collected during drilling of the 50-foot boring using a 5-inch diameter, 10 foot long core sample barrel that was direct-pressed into the formation (not rotated). Upon removal of the sample barrel from the borehole, the soil was extruded into long plastic bags with minimal disturbance. An HDR geologist/engineer inspected the soil samples and described them in boring logs using the Unified Soil Classification System (USCS) in addition to other notes on density, consistency, color, moisture, and texture. Soil samples were observed but not logged for the 10 and 25 foot borings since they were adjacent to and similar to the logged 50-foot boring. Undisturbed soil samples were obtained using a 3-inch diameter and 5-foot long plastic tube that was placed into the barrel sampler and pressed into the soil from depths of 20 to 25 feet and 40 to 45 feet at the boring on the west side of the basin and from depths of 30 to 35 feet and 40 to 45 feet on the east side of the basin. Disturbed soil samples were obtained every five feet and placed into sealed 1-gallon plastic bags. The lysimeter borehole soil logs are presented in **Appendix A** and lysimeter construction diagrams are presented in **Appendix B**.

3.1.1.2 Lysimeter Installation Procedures

The lysimeters installed are 2-inch-diameter, 2-foot-long, dual chamber, stainless steel, suction lysimeter model SW-070-540 by Soil Measurement Systems, LLC. These lysimeters are designed for permanent installations. They operate using negative and positive pressure induced from the surface through polyethylene tubing. A negative suction is used to pull pore-water into a suction chamber (through thin, porous stainless steel walls) and then a positive pressure is used to force water from the suction chamber up to the surface. Check valves within the lysimeter enable suction and pressure to force water into the suction chamber and then up to the surface. The tubing used to operate the lysimeter consists of 1/8-inch inside diameter (ID), 1/4-inch outside diameter (OD) polyethylene tubing and the tubing is connected to the lysimeter ports using stainless-steel compression fittings. The black tube is the suction/pressure tube, the clear tube is the sample receiving tube and the green tube is used to pre-wet (prime) the lysimeter suction chamber with DI water if needed. A photo of the lysimeter setup prior to installation is shown on **Figure 3-3**.

Prior to installation the lysimeters were pressure tested and decontaminated using a 50 percent isopropyl alcohol, 50 percent deionized water rinse. Lysimeters were placed in 5 gallon stainless-steel containers filled with the alcohol rinse and a negative suction was applied using a dedicated laboratory grade vacuum pump for approximately 20 minutes to draw the rinse into the lysimeter. The rinse was then purged from the lysimeters by applying a positive pressure using a dedicated hand-operated pressure pump. The same procedure was then completed three times to purge the lysimeters using deionized water until there was no alcohol odor remaining in the deionized rinse water. The lysimeters and tubing were placed in plastic bags for transport to the site. In the field the lysimeters were again pressure tested in deionized water prior to installation.

The lysimeter polyethylene tubing was run up from the lysimeter body within 2-inch ID Schedule 40 PVC well casing material with threaded joints to the surface to protect the tubing from damage. The PVC casing was connected using stainless steel screws to a PVC fitting that screws into the upper portion of the steel lysimeter body. The PVC casing material is not sealed where it attaches to the lysimeter and water will seep and rise into the lysimeter casing. The PVC casing was intentionally designed without a bottom seal so that the perched water levels (described in **Section 4.1.1**) can be monitored at each of the 10-, 25-, and 50-foot deep lysimeter clusters. (The polyethylene tubing used to collect the lysimeter samples are fully sealed and water will not leak in from the casing into the polyethylene tubing.)

Fine silica sand was placed around the lysimeters and around the PVC casing in the borehole annulus to about 4 feet from the surface and a 2-foot-thick chip bentonite seal was placed at the top of the annulus from approximately 2 to 4 feet bgs. The work plan specified sieving out gravel from the native cuttings and backfilling the annulus with the remainder of the cuttings; however, a large percentage of the native soil is gravel, and sieving out the gravel would have resulted in insufficient backfill material. A field decision was made to use fine silica sand to backfill the borehole annulus instead of native cuttings (as specified in the work plan). This should have no impact on pore-water samples because the fine sand is inert silica, and the bentonite surface seal above the sand prevents water from leaking down the borehole from the surface, and pore-water will flow into the lysimeter from the adjacent formation.

The polyethylene lysimeter tubing was then run within a 2-foot-deep trench through 1–inch ID Schedule 40 PVC conduit to the north side of the basin into 12-inch-diameter steel monuments which house the outflow ports of the tubing. Black rubber fittings with stainless steel hose clamps were used to connect the conduit and to create a water tight seal to prevent basin water from leaking down the conduit.

3.1.1.3 Lysimeter Boring Soil Laboratory Analysis

Three of the 1-foot length, 3-inch diameter pressed tube soil samples collected from the 50-foot-deep lysimeter soil borings from within the east and west halves of Basin 4 (six 1-foot length samples total) were submitted to Daniel B. Stephens Laboratories, Inc. for soil laboratory testing. The purpose of submitting multiple samples was to provide extra samples in the event replicates were needed or a particular analysis needed to be repeated. The laboratory cut open the plastic tubes, examined the sample core and selected a representative sample from the 3-foot length as needed to complete their analysis. Analyses included grain-size by sieve and hydrometer method, organic carbon content by loss-on-ignition method, porosity, bulk density, permeability (saturated and unsaturated), soil moisture retention curves, and cation exchange capacity. A composite soil sample was also developed by compositing one sample from each of the 10-foot interval samples and analyzing the sample for mineralogy. The mineralogy analysis was by x-ray diffraction and performed by Technology of Materials, Inc. The laboratory soil analytical methods are cited in **Appendix D**.

3.1.2 Soil Moisture, Oxygen, Conductivity and Temperature Instruments

Two sets of dedicated instruments were installed to measure and record soil pore-water moisture, conductivity, temperature, and to measure soil oxygen in individual boreholes adjacent to the lysimeters. One set of instruments was installed in the east half and one set in the west half of Basin 4. The purpose of these instruments is to record soil parameters during recharge testing and to assist in accurate determination of the recharge wetting front through the vadose zone. The pore-water moisture, conductivity and temperature instruments are the ECH20/5TE sensor and the EM50 digital logger manufactured from Decagon Devices (also known as The Meter Group). The soil oxygen instruments are the SO-110 manufactured by Apogee Instruments. The instruments were installed together in a 50-foot-deep, 7-inch-diameter borehole at depths of 10, 25 and 50 feet. The instruments were tied to a 1-inch-diameter PVC guide pipe using plastic zip-ties and placed in the boring. A bentonite chip seal was placed in the top 2 feet of the borehole and inside the PVC guide pipe. Bentonite seals were not placed between the instruments (which is a deviation from the work plan); instead, the native cuttings were placed in the borehole annulus around the instruments. This was a field decision made because of the potential for the bentonite seal to settle or expand through the relatively loose soil into the instruments (which would invalidate the data). The construction diagrams for the soil instruments are presented in **Appendix B**.

3.2 Saturated Zone

This section describes the investigation of the saturated zone aquifers and confining units including drilling soil borings, collection of soil samples, and installation of monitoring wells. Existing wells on the LOTT Hawks Prairie property include 11 monitoring wells (MW-1 through MW-11) installed during the early 2000s, MW-3a which was drilled in 2013, and pumping test well P1 which was drilled in 2015. The prior hydrogeologic investigations and monitoring well installations are described in reports by Robinson and Noble (2002; 2000) and HDR (2014).

Fourteen new monitoring wells were installed including five monitoring wells on the LOTT Hawks Prairie property (MW-12, MW-13, MW-14, MW-15, and MW-16) and nine wells (MW-20, MW-21, MW-22, MW-23, MW-24, MW-25, MW-26, MW-27, and MW-28) installed off the property. Four of the new wells were completed in the Sea Level (Qc) Aquifer and ten of the wells were completed in the Shallow (Qva) Aquifer.

Figure 3-1 shows monitoring well locations, and **Tables 3-1** and **3-2** provide the details of the monitoring well installation and construction for existing and new wells, respectively. Monitoring well boring logs, construction diagrams, and surveying information for the new wells are presented in **Appendix A**, **B**, and **C**, respectively. Monitoring well boring logs and well construction diagrams for existing monitoring wells are presented in the original reports which are available upon request from LOTT.

3.2.1.1 Drilling Methods

All new monitoring well borings were drilled using a sonic drill rig. The outer drill casing diameter varied from 6 inches to 9 inches, and the sample barrel was 1 to 2 inches smaller in diameter than the outer casing (i.e., 4 inches to 7 inches). Soil borings for wells completed in the Shallow (Qva) Aquifer usually extended into the Kitsap Formation (Qf) upper confining unit in order to identify the depth to the top of the confining unit, with exception of MW-28, MW-15 and MW-16 which were terminated above the Qf. Soil borings for wells completed in the Sea Level (Qc) Aquifer extended through the Kitsap Formation (Qf) upper confining unit and into the top of the Qc aquifer. Two casing strings were installed in the deep well locations completed into the Sea Level (Qc) Aquifer. The outer (largest) casing was set in a bentonite seal in the upper portion of the Kitsap Formation (Qf) upper confining unit to provide a seal of the Shallow (Qva) Aquifer during drilling. Drilling then proceeded into the Sea Level (Qc) Aquifer using a second, smaller-diameter casing string inside of the outer casing.

Continuous soil samples were collected during drilling using the sample barrel. Upon removal of the sample barrel from the borehole, the soil was extruded into long plastic bags with minimal disturbance. An HDR geologist/engineer inspected the soil samples and described them in boring logs using the USCS in addition to other notes on density, consistency, color, moisture, and texture. For situations where a shallow monitoring well was placed adjacent to a deep monitoring well, soil sampling and logging was only conducted at the deep monitoring well boring. This is because the lithology at the shallow well was already recorded during drilling of the deep monitoring well.

3.2.1.2 Soil Laboratory Analysis

On average two soil samples were submitted for laboratory analysis to Materials Testing and Consulting (MTC), Inc. for each aquifer or confining unit encountered at each boring and were analyzed for grain-size using the sieve and hydrometer method, and for organic carbon using the loss-on-ignition method. The soil laboratory analytical methods are cited in **Appendix E**.

3.2.1.3 Monitoring Well Construction

Groundwater monitoring wells were constructed with well screens completed in specific aquifers after the depth to groundwater was estimated and the borehole termination depth had been reached. For borings that were over-drilled for purposes of exploring the depth of a formation, the bottom of the boring was backfilled with bentonite chips so that the well screen could be set at the desired depth. Monitoring wells were installed within the outer drill casing with the drill casing progressively removed as the well was constructed. Well construction followed the State of Washington requirements as stated in Chapter 173-160 WAC "Minimum Standards for Construction and Maintenance of Wells."

For wells completed in the Shallow (Qva) Aquifer the top portion of the well screens span across the groundwater table so that the fluctuating groundwater table is within the screened interval of the well. Well screen lengths were generally 20 to 40 feet. At the LOTT Hawks Prairie property and in the off-site upgradient and cross-gradient locations well screens extend approximately 20 feet below the groundwater level so that groundwater samples are collected from near the top of the aquifer in the same vertical zone where recharge water is mixing with native groundwater. Downgradient off-site wells have well screens spanning the groundwater table and extending down 40 feet or to the top of the Kitsap Formation (Qf) confining unit (whichever came first) so they can intersect deeper permeable zones within the aquifer that may be preferential flow paths.

The monitoring wells in the Shallow (Qva) Aquifer were constructed of 2-inch inside diameter Schedule 40 PVC and the deeper monitoring wells completed in the Sea Level (Qc) Aquifer were constructed of 2.5-inch inside diameter Schedule 80 PVC. Well screens were constructed of factory-slotted PVC with 0.020-inch-wide slots. A #10 by #20 gradation silica sand filter pack was placed around each well screen and extends five feet above the top of the well screen. The remaining annulus was sealed with bentonite chips. Flush-mount well protectors were placed at the top of the well with a concrete seal and a locking well cap. Wells MW-15 and MW-16 constructed within Basin 4 on the LOTT Hawks Prairie property were completed with above-ground well protectors. Monitoring wells were developed using a surge block and by air-lifting until the water discharged from the well was free of fine sand and silt.

The new monitoring wells were surveyed by Skillings Connolly, Inc. for horizontal and vertical control. Horizontal coordinates (northing and easting) were surveyed in feet within 10-foot accuracy, and the elevation of the top of the well casing was surveyed within 0.01-foot accuracy. The surveyor's report is presented in **Appendix C**.

3.2.1.4 Rationale for Well Locations and Depths

The purpose of installing new monitoring wells was to obtain a better understanding of the extent, depth and thickness of the vadose zone, aquifers and confining units, and to characterize groundwater flow directions and travel time. Specific rationale for each monitoring well is provided below.

Monitoring Wells on LOTT Hawks Prairie Property

Shallow (Qva) Aquifer

- MW-13: Located on the west end of the LOTT Hawks Prairie property and nested with deep well MW-12. The purpose for this well is to provide a western groundwater quality and water level monitoring point and to measure the vertical gradient between the deep and shallow aquifer. Total drilled depth was 150 feet and the well screen was constructed from 119 to 149 feet.
- MW-15: Located in the western half of Basin 4. The purpose for this well is to monitor groundwater quality and water levels under the basin and also to provide a potential point for the introduction of SF_6 tracer. Total drilled depth was 100 feet. The well screen was placed from 75 to 95 feet.
- MW-16: Located in the eastern half of Basin 4. The purpose for this well is to monitor groundwater quality and water levels under the basin and also to provide a potential point for the introduction of SF_6 tracer. Total drilled depth was 100 feet and the well screen was placed from 74.5 to 94.5 feet.

Sea Level (Qc) Aquifer

- MW-12: Located on the west end of the LOTT Hawks Prairie property and nested with shallow well MW-13. The purpose for this well is to provide an upgradient groundwater quality and water level monitoring point. Total drilled depth was 340 feet and the well screen was placed from 285 to 305 feet.
- MW-14: Located on the berm between Basin 4 and Basin 5. The purpose for this well is to monitor groundwater quality and provide information on the depth to groundwater in the Sea Level (Qc) Aquifer. Total drilled depth was 390 feet and the well screen was placed from 310 to 330 feet.

Upgradient from LOTT Hawks Prairie Property

Shallow (Qva) Aquifer

- MW-26: Located approximately 2,400 feet northeast of the LOTT Hawks Prairie property. The purpose for this well is to monitor groundwater level and water quality upgradient of the LOTT Hawks Prairie property. Total drilled depth was 150 feet and the well screen was placed from 75 to 105 feet.

Cross-Gradient from LOTT Hawks Prairie Property

Shallow (Qva) Aquifer

- MW-24: Located approximately 1,200 feet east of the LOTT Hawks Prairie property and paired with deep well MW-23. The purpose for this well is to provide further definition of the groundwater flow path to the east of the LOTT Hawks Prairie property. Total drilled depth was 90 feet and the well screen was placed from 65 to 90 feet.

Sea Level (Qc) Aquifer

- MW-21: Located approximately 3,000 feet southwest of the LOTT Hawks Prairie property and nested with shallow well MW-22. The purpose for this well is to monitor cross-gradient groundwater quality and provide information on the depth to groundwater in the Sea Level (Qc) Aquifer. Total drilled depth was 310 feet and the well screen was placed from 220 to 240 feet.

Downgradient from LOTT Hawks Prairie Property

The purpose of the new off-site and downgradient monitoring wells is to provide monitoring points at the groundwater table for tracer testing and water quality monitoring.

Shallow (Qva) Aquifer

- MW-20: Located approximately 1,700 feet southwest of the LOTT Hawks Prairie property. Total drilled depth was 225 feet and the well screen was placed from 120 to 150 feet.
- MW-22: Located approximately 3,000 feet southwest of the LOTT Hawks Prairie property and nested with deep well MW-21. Total drilled depth was 142 feet and the well screen was placed from 110 to 140 feet.
- MW-25: Located approximately 1,200 feet south of the LOTT Hawks Prairie property. Total drilled depth was 190 feet and the well screen was placed from 118 to 168 feet. A 50 foot screen was used as it was difficult to determine where the water table was due to frequent clay lenses throughout the aquifer, and to ensure that the water table was not higher than the top of the screen. The well was screened to the bottom of the aquifer.
- MW-27: Located approximately 900 feet south of the LOTT Hawks Prairie property. Total drilled depth was 150 feet and the well screen was placed from 95 to 120 feet.
- MW-28: Located approximately 2,100 feet southwest of the LOTT Hawks Prairie property. Total drilled depth was 170 feet and the well screen was placed from 130 to 170 feet.

Sea Level (Qc) Aquifer

- MW-23: Located approximately 1,200 feet east of the LOTT Hawks Prairie property and nested with shallow well MW-24. The purpose for this well is to monitor downgradient groundwater quality and provide information on the depth to groundwater in the Sea Level (Qc) Aquifer. Total drilled depth was 320 feet and the well screen was placed from 260 to 290 feet.

3.2.1.5 Soil Sampling and Analysis

Approximately two representative soil samples were collected for laboratory analysis from each hydrogeologic unit encountered, including the Qva, Qf, and Qc units. Soil samples were submitted to MTC in Olympia for grain size analysis and representative samples were analyzed for organic content. Soil samples were analyzed for hydraulic conductivity using the Hazen formula (Fetter, 2001; Hazen, 1911) which is:

$$k = C * d_{10}^2$$

where

k = hydraulic conductivity (cm/sec)

C = a dimensionless coefficient ranging from 40 to 150 depending on grain-size

d_{10} = the grain diameter for which 10 percent of the distribution is finer (mm)

3.2.2 Groundwater Level Monitoring

Depth to groundwater was measured by hand using an electric water level sounder at the existing and newly-installed monitoring wells. Continuous groundwater levels were recorded at select paired monitoring wells to understand the relationship between shallow and deep aquifer groundwater levels. The electronic recording pressure transducers are the HOBO model manufactured by Onset Instruments, Inc. and they were suspended in the well between 5 to 20 feet below the water table using braided nylon fishing line. Groundwater levels were adjusted to account for barometric pressure shifts which were measured on-site using a pressure transducer exposed to atmospheric pressure.

Table 3-1. Existing LOTT Wells

Well ID	Location	Date Constructed	Depth Drilled (feet bgs)	Type	Screen Interval (feet bgs)	Screen Construction	Northing[1] (feet)	Easting[1] (feet)	Top of Casing Elevation (NAVD 88) (feet)	Screened Geologic Unit[2]
P-1	On-site, near basins	12/7/2015	235	Test Well	156-211	8-in. dia. PS 304 SS w/ 0.080-in. wire-wrap slot (casing is 12-in.-dia. steel)	NA	NA	NA	Qf
MW-1	On-site, near basins	12/7/2001	155	Monitoring Well	87-97	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,684	1,076,316	219.46	Qva
MW-2	On-site, near basins	12/8/2001	125	Monitoring Well	97-107	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,770	1,076,140	218.27	Qva
MW-3	On-site, near basins	12/10/2001	135	Monitoring Well	117-127	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,566	1,075,924	218.15	Qf
MW-3a	On-site, near basins	12/17/2013	127	Monitoring Well	77-127	2-in.-dia. Sch. 40 PVC w/ 0.010-in. factory slot	642,566	1,075,924	219.17	Qva, Qf
MW-5	On-site, near basins	12/12/2001	124	Monitoring Well	76-96	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,379	1,076,096	219.09	Qva
MW-6	On-site, near basins	6/29/2005	115	Monitoring Well	83-103	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	643,157	1,076,201	218.97	Qva
MW-7	On-site, near basins	5/19/2005	145	Monitoring Well	100-120	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,881	1,075,959	218.91	Qva, Qf

Well ID	Location	Date Constructed	Depth Drilled (feet bgs)	Type	Screen Interval (feet bgs)	Screen Construction	Northing[1] (feet)	Easting[1] (feet)	Top of Casing Elevation (NAVD 88) (feet)	Screened Geologic Unit[2]
MW-8	On-site, near basins	6/23/2005	138	Monitoring Well	105-125	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,506	1,075,400	218.70	Qva, Qf
MW-9	On-site, near basins	5/23/2005	135	Monitoring Well	89-109	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,394	1,075,575	218.69	Qva
MW-10	On-site, near basins	6/16/2005	140	Monitoring Well	112-132	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	643,502	1,074,903	224.89	Qva, Qf
MW-11	On-site, near basins	11/18/2011	160	Monitoring Well	150-160	4-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,391	1,074,897	228.00	Qva, Qf

Notes:
[1] Northing and Easting are given in the projected coordinate system NAD 1983 Washington State Plane South
[2] Qva = Shallow (Qva) Aquifer, Qf = Upper Confining Unit (Kitsap Formation), Qc = Sea Level (Qc) Aquifer.

Table 3-2. New Monitoring Wells

Well ID	Location	Date Constructed	Depth Drilled (feet bgs)	Completion	Screen Interval (feet bgs)	Screen Construction	Northing[1] (feet)	Easting[1] (feet)	Top of Casing Elevation (NAVD 88) (feet)	Screened Geologic Unit[2]
MW-12	On-site, west side	6/13/2017	340	Monitoring Well	284.7-304.7	2.5-in.-dia. Sch. 80 PVC w/ 0.020-in. factory slot	642,690	1,074,893	227.00	Qc
MW-13	On-site, west side	6/15/2017	150	Monitoring Well	118.7-148.7	2-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,684	1,074,897	226.80	Qva
MW-14	On-site, near basins	7/5/2017	390	Monitoring Well	310-330	2.5-in.-dia. Sch. 80 PVC w/ 0.020-in. factory slot	642,641	1,075,991	218.04	Qc
MW-15	On-site, near basins	8/2/2017	100	Monitoring Well	75-95	4-in.-dia. Sch. 80 PVC w/ 0.040-in. factory slot	642,742	1,076,002	219.20	Qva
MW-16	On-site, near basins	8/4/2017	100	Monitoring Well	74.5-94.5	4-in.-dia. Sch. 80 PVC w/ 0.040-in. factory slot	642,738	1,076,203	219.34	Qva
MW-20	Off-site, southwest	1/13/2017	225	Monitoring Well	120-150	2-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	641,507	1,074,874	219.22	Qva
MW-21	Off-site, southwest	7/19/2017	310	Monitoring Well	220-240	2.5-in.-dia. Sch. 80 PVC w/ 0.020-in. factory slot	641,077	1,073,574	227.16	Qc
MW-22	Off-site, southwest	7/21/2017	142	Monitoring Well	110-140	2-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	641,051	1,073,575	227.23	Qva

Well ID	Location	Date Constructed	Depth Drilled (feet bgs)	Completion	Screen Interval (feet bgs)	Screen Construction	Northing[1] (feet)	Easting[1] (feet)	Top of Casing Elevation (NAVD 88) (feet)	Screened Geologic Unit[2]
MW-23	Off-site, east	7/17/2017	320	Monitoring Well	259.8-289.8	2.5-in.-dia. Sch. 80 PVC w/ 0.020-in. factory slot	643,061	1,077,296	204.54	Qc
MW-24	Off-site, east	7/28/2017	90	Monitoring Well	65-90	2-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	643,021	1,077,296	204.90	Qva
MW-25	Off-site, south	7/20/2017	190	Monitoring Well	118-168	2-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	641,496	1,075,647	228.95	Qva
MW-26	Off-site, northeast	7/26/2017	150	Monitoring Well	75-105	2-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	644,799	1,077,568	233.18	Qva
MW-27	Off-site, south	7/28/2017	150	Monitoring Well	95-120	2-in.-dia. Sch. 40 PVC w/ 0.020-in. factory slot	642,077	1,075,465	220.16	Qva
MW-28	Off-site, southwest	8/5/2017	170	Monitoring Well	130-170	2.5-in.-dia. Sch. 80 PVC w/ 0.020-in. factory slot	641,129	1,074,790	224.85	Qva

Notes:
[1] Northing and Easting are given in the projected coordinate system NAD 1983 Washington State Plane South.
[2] Qva = Shallow (Qva) Aquifer, Qf = Upper Confining Unit (Kitsap Formation), Qc = Sea Level (Qc) Aquifer.

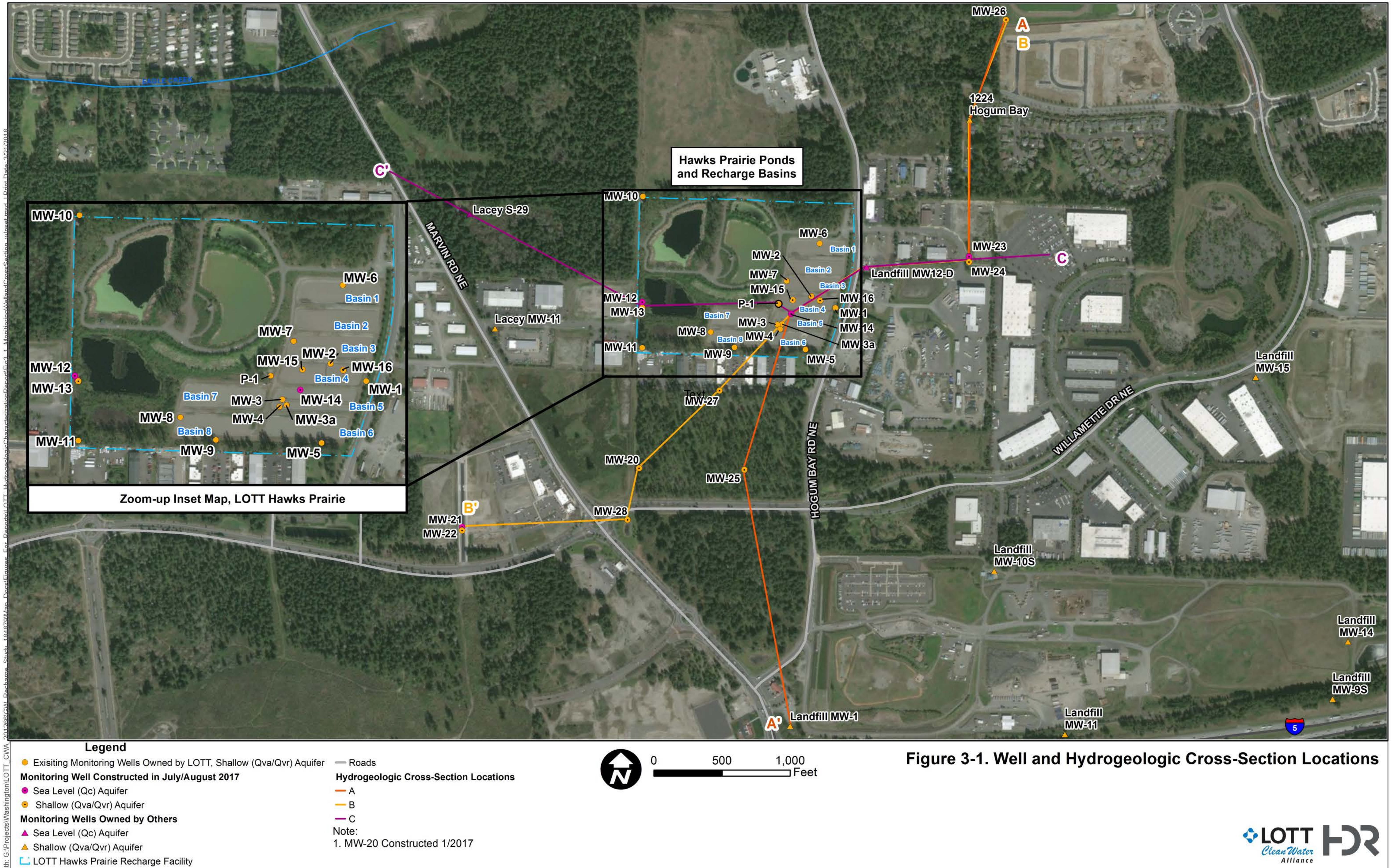


Figure 3-1. Well and Hydrogeologic Cross-Section Locations

Source: Bing Maps (2011), City of Lacey (2014), WSDOT (2013).

This page intentionally left blank.

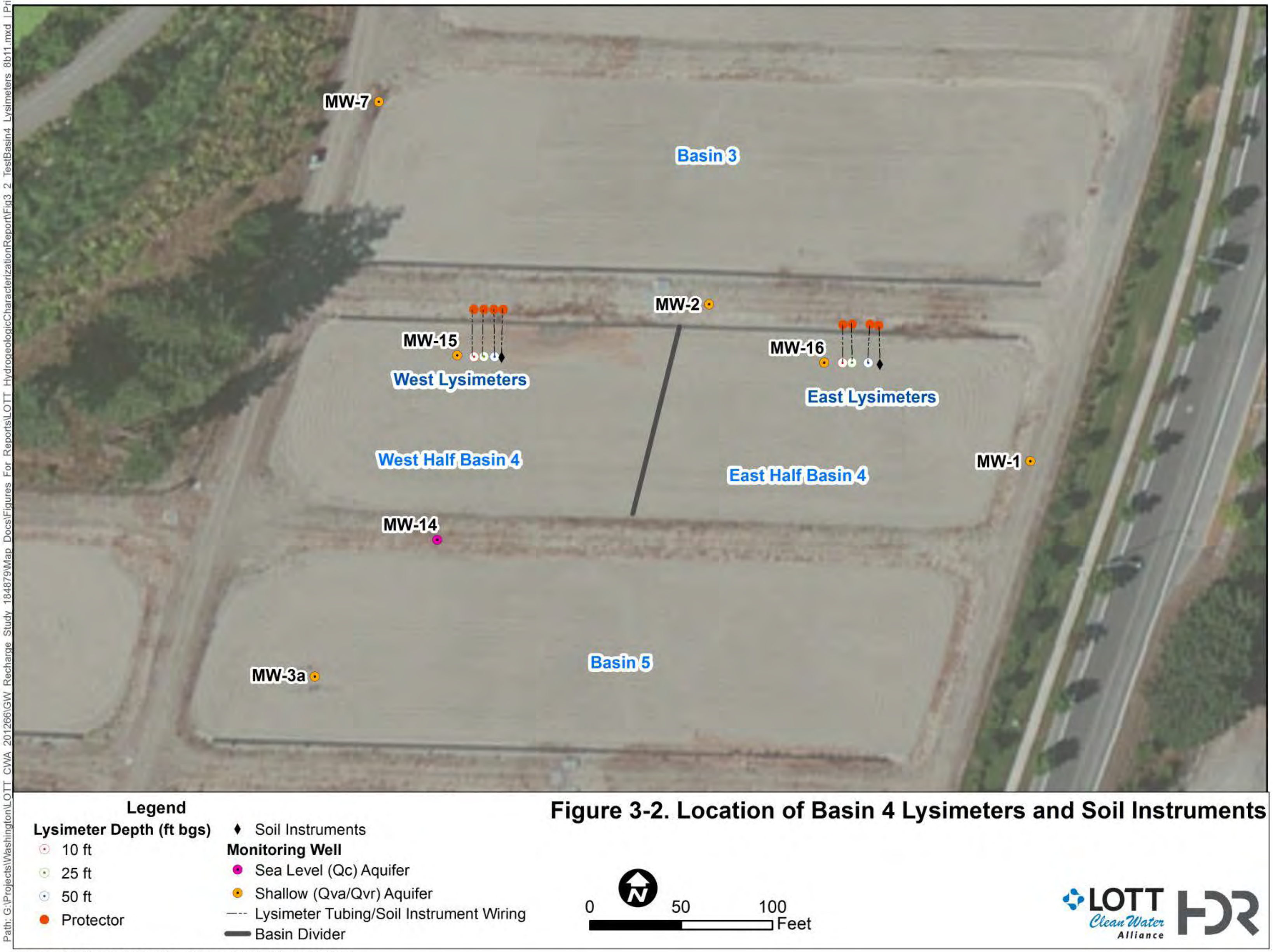


Figure 3-2. Location of Basin 4 Lysimeters and Soil Instruments

Source: Bing Maps (2011), City of Lacey (2014), WSDOT (2013).

Figure 3-3. Photograph of Lysimeter Prior to Installation.

3.3 Aquifer Hydraulic Testing

Aquifer hydraulic tests were performed on certain monitoring wells screened in the Shallow (Qva) Aquifer and Sea Level (Qc) Aquifer in order to obtain estimates of aquifer hydraulic properties (e.g., transmissivity, hydraulic conductivity, and storativity) for those formations. These hydraulic properties measure the ability of groundwater to flow through an aquifer and to be held or released from storage. They are used to evaluate changes in groundwater levels and flow rates in response to changes in recharge or well pumping. To measure these aquifer hydraulic properties, slug tests and pumping tests were completed using onsite and offsite monitoring wells.

3.3.1 Slug Testing

Slug tests were performed on the following monitoring wells:

- Shallow (Qva) Aquifer: MW-24
- Sea Level (Qc) Aquifer: MW-12, MW-14, MW-21, and MW-23

Slug testing was performed on September 20 through 22, 2017. Slug tests involve placing a known volume of water into the well and recording the change in water levels. Aquifer hydraulic parameters are calculated from the change in groundwater levels observed during the test. Well construction information and static water levels at the tested wells are presented in **Table 3-3**.

Table 3-3. Slug Test Summary

Well ID	Formation[1]	Well Diameter (inches)	Screened Interval (feet bgs)	Static Groundwater Level (feet btoc[2])	Range of Water Level Rise during Test (feet)
MW-24	Qva	2	65-90	64.66	2.79-3.68
MW-12	Qc	2.5	284.7-304.7	138.79	1.09-1.48
MW-14	Qc	2.5	310-330	156.65	6.74-11.65
MW-21	Qc	2.5	220-240	140.53	0.52-1.43
MW-23	Qc	2.5	259.8-289.8	151.53	2.14-2.89

Note:
[1] Qva = Shallow (Qva) Aquifer, Qf = Upper Confining Unit (Kitsap Formation), Qc = Sea Level (Qc) Aquifer.
[2] btoc = below top of casing

Water level measurements were recorded using an electronic water level recorder. All slug tests were conducted as “slug-in” tests, or falling head tests. Tests involved adding 2-5 gallons of potable water to the well and observing the water level response using the pressure transducer. The water was added to the well as instantaneously as possible, generally taking 5-10 seconds to complete. Multiple slug-in tests were performed on each well, with the water level allowed to reach equilibrium before each test. The slug test data were analyzed using the program AQTESOLV following the Bouwer and Rice (1976) method for unconfined aquifers and confined aquifers. This method involves manually fitting a straight line through the displacement vs. time data from early in the test when the formation is taking in the water added to the well.

3.3.2 Aquifer Pumping Tests

Pumping tests were conducted on select monitoring wells in order to obtain a more reliable and accurate estimate of aquifer hydraulic properties than those provided by slug testing.

3.3.2.1 Single-Well Pumping Tests – Specific Capacity Tests

Single-well pumping tests were performed between September 13 and September 25, 2017 on the following monitoring wells (used as pumping wells):

- Shallow (Qva) Aquifer: MW-2, MW-13, and MW-16
- Sea Level (Qc) Aquifer: MW-12 and MW-14

Single-well pumping tests involved installing a 2-inch- or 4-inch-diameter submersible pump in the monitoring well and pumping at a constant rate until water level drawdown stabilized. Pumping rates were limited by the size of the pump. The pumping rate was then divided by the maximum drawdown (in feet) to calculate specific capacity (in gpm/ft), which describes the productivity of a well. Test details and specific capacity calculations are provided in **Table 3-4**.

Table 3-4. Single-Well Pumping Test Summary – Specific Capacity

Well ID	Formation[1]	Test Duration	Starting Ground-water Level (feet btoc)	Ending Ground-water Level (feet btoc)	Ground-water Level Drawdown (feet)	Pumping Rate (gpm)	Specific Capacity (gpm/foot)
MW-2	Qva	2 hr	87.52	90.37	2.85	30	10.5
MW-13	Qva	0.5 hr	127.35	127.87	0.52	3.2	6.2
MW-16	Qva	16 hr	86.16	87.38	1.22	17	13.9
MW-12	Qc	1 hr	139.11	139.35	0.24	2.9	12.1
MW-14	Qc	1.5 hr	157.26	160.41	3.15	3.0	1.0

Note:
[1] Qva = Shallow (Qva) Aquifer, Qc = Sea Level (Qc) Aquifer.

The calculated specific capacity was used to estimate aquifer transmissivity (results are presented in **Section 4.2.3**) using equations by Driscoll (1986):

For confined aquifers:

$$\frac{Q}{s} = \frac{T}{2{,}000}$$

For unconfined aquifers:

$$\frac{Q}{s} = \frac{T}{1{,}500}$$

Where

Q = Well pumping rate (gpm)
s = Drawdown (ft)
T = Transmissivity (gpd/ft)

3.3.3 Multiple-well Pumping Tests

A multiple-well pumping test was performed on pumping wells MW-16 and MW-2 and groundwater level drawdown was recorded in multiple observation wells on the site. This method of aquifer testing provides a more reliable approximation of aquifer properties than single-well pumping tests or slug tests. A 4-inch-diameter submersible pump was used for both tests. Pumping test water discharge was routed to the northeast LOTT Hawks Prairie pond located approximately 500 feet northwest of the pumping wells. The pumping rate was measured periodically during the tests. **Table 3-5** presents the well construction details for wells used during the pumping tests. The data from the drawdown and recovery phase of the constant-rate tests were analyzed using the program AQTESOLV following the Cooper-Jacob (1946) solution for a pumping test in an unconfined aquifer. The Agarwal (1980) method of transforming the time variable for recovery data was applied to the recovery data.

Table 3-5. Multiple-Well Pumping Test Summary

Well ID	Formation[1]	Well Diameter (inches)	Screened Interval (feet bgs)	Static Groundwater Level (feet bgs)	Distance from Pumping Well (feet)	Test Use
MW-16 Pumping Test						
MW-16	Qva	4	74.5-94.5	86.16	0	Pumping Well
MW-1	Qva	4	87-97	87.03	125	Observation Well
MW-2	Qva	4	97-107	84.96	71	Observation Well
MW-3a	Qva	2	117-127	91.76	328	Observation Well
MW-15	Qva	4	75-95	84.03	201	Observation Well
MW-2 Pumping Test						
MW-2	Qva	4	97-107	87.52	0	Pumping Well
MW-1	Qva	4	87-97	88.36	196	Observation Well
MW-6	Qva	4	83-103	83.80	392	Observation Well
MW-7	Qva	4	100-120	86.25	212	Observation Well
MW-15	Qva	4	75-95	85.81	140	Observation Well
MW-16	Qva	4	74.5-94.5	85.75	71	Observation Well

Note:
[1] Qva = Shallow (Qva) Aquifer.

3.3.3.1 MW-16 Pumping Test

The MW-16 pumping test was performed starting on September 13, 2017 pumping at a rate of 17 gpm for a total pumping duration of about 17 hours. At the end of the constant-rate test, a maximum drawdown of 0.54 feet was measured at observation well MW-2, which is the observation well nearest the pumping well. All other observation wells indicated less than 0.2 feet of drawdown which is too little drawdown for the analysis of aquifer properties.

3.3.3.2 MW-2 Pumping Test

The MW-2 pumping test was performed on September 19, 2017 at 30 to 35 gpm and continued until September 22 over a duration of approximately four days. Issues were encountered with the pump tripping off three times during the test causing pumping to be off for several hours and then restarted. A maximum drawdown of 0.47 feet was measured at observation well MW-16, which is the observation well nearest the pumping well. All other observation wells indicated less than 0.2 feet of drawdown and were not used in the analysis of aquifer properties.

4.0 Results of Hydrogeologic Investigation

This section presents the results of the hydrogeologic investigation.

4.1 Aquifer Hydrostratigraphy and Soil Properties

The regional geology is shown on **Figures 4-1** and **4-2**. Hydrogeologic cross-sections are presented on **Figures 4-3, 4-4** and **4-5** which depict the extent and vertical distribution of aquifers and confining units. The results of laboratory analysis of soil properties from the lysimeter soil samples are presented in **Tables 4-1** and **4-2** and the results from the monitoring well soil samples are presented in **Table 4-3**. Soil laboratory reports are presented in Appendix D for soil samples collected from the lysimeter borings and in Appendix E for soil samples collected from the monitoring well borings

4.1.1 Vadose Zone

The vadose zone is primarily of interest in the vicinity of the Hawks Prairie property recharge basins, so the discussion will focus on this area. Locally, the vadose zone is composed of an upper unit of Vashon recessional outwash silty sand and gravel transitioning into a lower unit of Vashon advance outwash sand and gravel that forms the upper regional aquifer. In places to the south and north of the Hawks Prairie property thin layers of Vashon till are also present at varying depths (the till is largely absent at the Hawks Prairie property).

The soil borings drilled in the vicinity of recharge Basin 4 (MW-14, MW-15, MW-16 and the lysimeter borings) indicate the vadose zone is composed of a brown silty sand and gravel layer from the ground surface to approximately 10 feet deep. Below 10 feet the vadose zone is composed of silty fine to coarse sand and gravel with beds of finer-grained material consisting of fine to medium sand, silt and clay. Coloration was brown at 10 feet transitioning to a darker grey with depth. Perched groundwater (i.e., groundwater present above the upper aquifer) was observed in in the vadose zone in all lysimeter borings and in monitoring wells MW-15 and MW-16 drilled in Basin 4, likely as a result of low-permeability lenses of silt and silty sand. Perched groundwater was observed in the 50-foot-depth east basin lysimeter PVC casing at a depth of 20 feet, and sediments appeared wet from 30 feet bgs to the bottom of the boring (50 feet bgs). In the 50-foot-depth west basin lysimeter, perched groundwater was observed at 38 feet bgs and sediments appeared wet from 25 feet bgs to the bottom of the boring at 50 feet. The depth to the groundwater table in the Shallow (Qva) Aquifer (which underlies the vadose zone) is approximately 80 feet. Perched groundwater and low-permeability soils were an unexpected finding, as the soils underlying the basins are described as sand and gravel in the prior hydrogeologic reports for the site (Robinson and Noble, 2002; 2000).

The organic content of the upper ten feet of the soil is low (less than 1 percent) and the cation exchange capacity is also low, ranging from 3 to 7 meq/100g. The low organic content and cation exchange capacity suggest a lower potential to bind cations (such as sodium, calcium, potassium) to the soil. The mineralogy of the vadose zone soil as indicated from composite soil samples from the entire length of the lysimeter soil borings is composed primarily of quartz and feldspar with lesser percentages of kaolin, smectite, mica and chlorite. The low total organic content, low cation exchange capacity, and quartz/feldspar-dominated mineralogy is typical of relatively recent glacial deposits. However, prior studies have shown that given the relatively low level of trace organic compounds, minerals, and nutrients in reclaimed water, there usually is more than adequate soil capacity to attenuate contaminants, and the primary factors governing attenuation rates are vadose zone and groundwater residence time (or travel time), oxygen concentrations, and bioavailable carbon in soil and water (AWWARF, 2001; Gunthe and Jenkel, 2005; Makam and Fox, 2009; Naranaswamy et al., 2001; Rittman and McCarty, 2001; Stuyfzand et al., 2007).

The laboratory permeameter analysis of the four soil samples from the 50-foot-depth lysimeter borings (two each from two borings) indicate a relatively low saturated vertical permeability ranging from 0.0023 to 0.15 feet/day. Total porosity was measured in the lab at 15 to 24 percent. The relatively low vertical permeability is caused by the presence of finer-grained deposits within the vadose zone which impedes the downward migration of water and causes perched groundwater conditions during recharge operations. Additional unsaturated hydraulic testing data on the four soil samples collected from the 50-foot-depth lysimeter boring is presented in Appendix D.

4.1.2 Shallow (Qva) Aquifer

The Shallow (Qva) Aquifer is composed of Vashon recessional outwash (where saturated) and Vashon advance outwash sand, sand and gravel, and silty sand and gravel. The upper portion of the aquifer is coarser-grained (cleaner) with fine to coarse sand and less silt. The unit transitions into the finer-grained Kitsap Formation of fine sand and silt which forms a confining unit. The aquifer is generally unconfined but also may act as a semi-confined aquifer where it is overlain by lower-permeability, silty fine sand units. Organic content in the aquifer is low, less than 1 percent.

The depth to groundwater in the Shallow (Qva) Aquifer near Basin 4 is approximately 80 feet, but increases to the south, southwest and west to a maximum of approximately 135 feet at MW-11 and MW-25. The saturated thickness of the aquifer is approximately 25 feet at MW-14 in the vicinity of Basin 4 and approximately 15 feet at MW-12. This is consistent with the lithologic data from the existing monitoring wells on the property which show a saturated thickness of 10 to 30 feet.

4.1.3 Vashon Till (Qvt) and the Kitsap Formation (Qf) Upper Confining Unit

Vashon Till (Qvt) consisting of compacted unsorted silt, clay, sand and gravel is a discontinuous confining unit impeding the vertical flow of groundwater. Till is derived from erosion and entrainment of material by glaciers and is identified as a heterogeneous mixture of soil textures and often has a clayey matrix. The Qvt till unit is mostly absent at the LOTT Hawks Prairie property, but is present nearby to the south and north of the site. Where present, the Qvt till unit is either exposed at the land surface or is buried under Vashon recessional outwash. Till was observed at the following monitoring wells: MW-12 (onsite – from 10-20 feet below ground surface), MW-15 (onsite - from 80-83 feet bgs), MW-20 (offsite – from 5-16 and 30-40 feet bgs), MW-21 (offsite from 10-21 feet bgs), MW-23 (offsite from 32-40 feet bgs), MW-25 (offsite, from 10-18 feet bgs), MW-26 (offsite – from 70-73 feet bgs), and MW-27 (offsite, from 17-34 feet bgs). No till was observed in the borings of MW-16 (onsite) and MW-28 (offsite).

The Kitsap Formation (Qf) upper confining unit is composed of fine sand and silt that is grey or black in color. The unit contains a higher percentage of sand in the upper portions where it transitions from the Shallow (Qva) Aquifer, and a higher percentage of silt in the lower portions. In places there are silty clay beds. In some of the monitoring well borings higher-permeability sand/gravel zones were observed within the Kitsap Formation that are varying and discontinuous in depth and extent. The organic content of the soil samples from the Kitsap Formation ranges from less than 1 to 2 percent. The thickness of the formation ranges from less than 80 to over 190 feet at the Hawks Prairie property. To the southwest and south of the Hawks Prairie property the top of the confining unit decreases in elevation and the unit thins or is absent.

The Kitsap Formation (Qf) upper confining unit is expected to be leaky, allowing water to slowly penetrate through the more permeable sand lenses. One to two soil samples were collected from each boring that penetrated the Kitsap Formation and were analyzed for grain-size distribution (data in Table 4-3). Borings at MW-12, MW-21, MW-25 and MW-27 each produced a Kitsap Formation sample with more than 85% sand. However, the Kitsap Formation does form a low-permeability barrier that is evidenced by the difference in groundwater levels measured in nested monitoring wells completed in the Shallow (Qva) Aquifer and the deeper Sea Level (Qc) Aquifer (discussed in more detail in a subsequent section below).

4.1.4 Sea Level (Qc) Aquifer

The Sea Level (Qc) Aquifer is a deeper confined aquifer that is used as a water supply aquifer by the City of Lacey and other water purveyors. Well yields of up to 1,650 gpm have been reported for this aquifer (HDR, 2017b). Locally, the formation is up to 150 feet thick and transitions from the fine-grained silty clay of the Kitsap Formation into alternating sequences of coarser-grained sand and gravel and fine-grained sandy silt. One of the defining characteristics of the Sea Level (Qc) Aquifer deposits is reddish-brown staining whereas the overlying Kitsap Formation and the underlying Undifferentiated Tertiary Deposits (TQu) are grey to black.

Three soil borings penetrated to the Sea Level (Qc) Aquifer on or near the Hawks Prairie property, including MW-12 and MW-14 on the Hawks Prairie property and MW-23 about 800 feet to the east of the property. At these borings the coarse-grained, brown-red-stained sand and gravel deposits began from 280 to 290 feet below ground surface with a thickness of about 30 to 50 feet, and were underlain by 10 to 35 feet of fine sand. Organic content is less than 1 percent, indicating low sorbtive (retardation) capacity. At MW-14, the boring extended to a depth of 390 feet and the bottom 20 feet was a black clay that is likely the Undifferentiated Tertiary Deposits (TQu). The 30- to 50-foot thickness of the coarse-grained Sea Level (Qc) Aquifer deposits at the monitoring wells on the Hawks Prairie property is similar to the 56-foot thickness of sand and gravel encountered at the Lacey S29 (Betti) well and the depths of the units at all the wells are also similar (Robinson and Noble, 2005).

The Sea Level (Qc) Aquifer was also penetrated at MW-21, located approximately 1,500 feet to the southwest of the Hawks Prairie property. At this location the coarse-grained, reddish-brown deposits of the Sea Level (Qc) Aquifer were much shallower, from approximately 220 to 250 feet. Below 250 feet, fine-grained silt and fine sand deposits are present.

Table 4-1. Soil Properties from Lysimeter Boring Soil Samples

Sample Number	Effective Grain Size[1]			Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Porosity (%)	Saturated Hydraulic Conductivity K_{sat} [2] (feet/day)	Soil Classification	Grain-Size Fractions[3]				Organic Matter (%)	Cation Exchange Capacity (meq/100g)
	d_{10} (mm)	d_{50} (mm)	d_{90} (mm)						Gravel (%)	Sand (%)	Silt (%)	Clay (%)		
West Lysimeter (Upper 10')	0.30	6.9	25	NA	NA	NA	NA	Fine to medium sand and gravel, trace silt and clay.	59.0	35.1	4.7	1.1	0.7	3.43
West Lysimeter (22'-25')	0.036	0.47	2	2.04	2.27	23.8	0.15	Fine sand, some silt, trace clay and gravel.	6.0	79.6	11.3	3.2	0.6	4.86
West Lysimeter (42'-45')	0.023	0.63	28	2.16	2.32	19.3	0.035	Fine sand and gravel, some silt, trace clay	28.8	55.8	10.4	5.1	0.6	5.61
East Lysimeter (Upper 10')	0.30	2.4	21	NA	NA	NA	NA	Fine to medium sand and gravel, trace silt and clay.	32.7	61.2	4.6	1.5	0.7	3.04
East Lysimeter (32'-35')	0.078	7.1	16	2.27	2.42	15.2	0.0064	Fine to medium sand and gravel, trace silt and clay.	63.3	26.8	7.0	2.9	0.7	6.84
East Lysimeter (42'-45')	0.0038	1.2	20	2.19	2.36	18.2	0.0023	Fine to medium sand and gravel, some silt, trace clay.	36.8	37.3	18.5	7.4	1.0	7.10

Notes:
[1] Effective Grain Sizes:
- d_{10} = 10% passing grain size
- d_{50} = 50% passing grain size
- d_{90} = 90% passing grain size

[2] K_{sat} = Saturated Hydraulic Conductivity
[3] Size Fractions based on the following:
- Gravel = material between 4.75 mm and 760 mm
- Sand = material between 0.075 mm and 4.75 mm
- Silt = material between 0.002 mm and 0.075 mm
- Clay = material less than 0.002 mm

Table 4-2. Mineralogical Composition of Lysimeter Boring Soil Samples

Sample ID	Smectite (%)	Chlorite (%)	Mica/Illite (%)	Kaolin (%)	Quartz (%)	Ca-Na Feldspars (%)
West Lysimeter, 50-Foot Boring Composite Soil Sample	2	3	2	5	68	20
East Lysimeter, 50-Foot Boring Composite Soil Sample	3	4	3	5	65	20

Table 4-3. Soil Properties from Samples Collected from Monitoring Well Borings

Well ID	Depth Interval (feet bgs)	Formation[1]	Gravel[2] (%)	Sand[2] (%)	Silt/Clay[2] (%)	Organic Content (%)	Grain-Size d_{10}[3] (mm)	Grain Size d_{50}[3] (mm)	Grain Size d_{90}[3] (mm)	Calculated Hydraulic Conductivity[4] (feet/day)	Geometric Mean Hydraulic Conductivity[4] (feet/day)
MW-12	56-58	Qva	45.0	52.5	2.5		0.47	3.30	17.00	501	384 (Qva)
	88-90	Qva	57.4	38.2	4.4		0.36	7.20	31.00	294	
	148-150	Qf	0.0	56.6	43.4		0.01	0.09	0.24		
	185-187	Qf	0.0	89.8	10.2		0.08	0.21	0.36		
	234-236	Qf	0.0	25.9	74.1		0.00	0.03	0.18		
	295-297	Qc	60.1	34.7	4.6		0.71	6.90	21.00	1,429	1,429 (Qc)
	335-337	Qc	1.8	87.8	10.4		0.06	0.51	1.20		
MW-14	48-50	Qva	27.3	67.7	5.0	0.2	0.23	0.70	23.00	120	209 (Qva)
	86-88	Qva	51.9	44.8	3.3	0.3	0.40	5.10	21.00	363	
	130-132	Qf	0.0	3.6	96.4	0.6	0.01	0.02	0.06		
	308-310	Qc	7.1	84.7	8.2	0.2	0.11	0.92	3.10	34	34 (Qc)
	338-340	Qc	0.0	84.3	15.7	0.5	0.02	0.31	0.58		
	378-380	TQu	0.0	7.6	92.4	0.4	0.00	0.02	0.07		
MW-15	18-20	Qva	0.2	45.7	54.1		0.01	0.07	0.30		150 (Qva)
	28-30	Qva	39.5	56.1	4.4		0.40	2.70	19.00	363	
	38-40	Qva	40.3	56.9	2.8		0.34	3.00	41.00	262	
	48-50	Qva	33.3	60.6	6.1		0.21	0.83	24.00	100	
	58-60	Qva	75.8	17.0	7.2		0.23	18.00	40.00	120	
	68-70	Qva	62.1	30.6	7.3		0.17	8.80	29.00	66	
	78-80	Qva	50.6	46.5	2.9		0.01	2.10	19.00		
MW-16	18-20	Qva	49.4	43.7	6.9		0.16	4.10	31.00	58	160 (Qva)
	28-30	Qva	0.0	88.7	11.3		0.03	0.43	1.00		
	38-40	Qva	56.9	36.5	6.6		0.21	7.50	28.00	100	
	48-50	Qva	47.0	49.4	3.6		0.48	4.00	21.00	523	
	58-60	Qva	69.3	24.7	6.0		0.31	11.00	40.00	218	
	68-70	Qva	67.2	27.4	5.4		0.41	10.00	35.00	381	
	78-80	Qva	53.1	40.1	6.8		0.17	5.90	24.00	66	
MW-21	54-56	Qva	53.1	38.8	8.1		0.42	7.90	21.00	400	400 (Qva)
	136-138	Qva	1.6	88.8	9.6	0.5	0.08	0.50	0.82		
	148-150	Qf	0.0	48.6	51.4	0.7	0.01	0.07	0.19		
	186-188	Qf	1.2	88.8	10.0		0.08	0.22	0.60		
	228-230	Qc	41.1	56.4	2.5	0.4	0.42	3.10	25.00	400	400 (Qc)
	256-258	Qc	0.0	92.3	7.7		0.10	0.27	0.49		
MW-23	72-74	Qva	5.1	91.3	3.6	0.2	0.22	0.51	1.10	110	112 (Qva)
	95-97	Qva	19.8	74.4	5.8	0.2	0.20	0.60	8.40	113	
	107-109	Qf	0.0	20.7	79.3	1.5	0.00	0.02	0.30		
	160-162	Qf	0.0	10.8	89.2	0.6	0.00	0.03	0.08		
	247-249	Qc	31.4	46.6	22.0	0.3	0.01	1.70	20.00		137 (Qc)
	273-275	Qc	43.8	50.6	5.6	0.2	0.22	2.30	30.00	137	
	305-307	Qc	6.8	84.1	9.1		0.10	0.81	2.80		
	314-316	Qc	0.0	33.1	66.9		0.01	0.05	0.12		
MW-25	148-150	Qva	52.5	44.6	2.9		0.41	5.20	31.00	381	218 (Qva)
	166-168	Qva	23.5	72.0	4.5	0.4	0.21	1.70	9.50	125	
	171-172	Qf	0.0	92.4	7.6		0.09	0.23	0.41		
	179-180	Qf	47.5	34.8	17.7	0.4	0.02	3.90	19.00		
MW-26	73-75	Qva	31.4	55.5	13.1		0.03	0.57	10.60		
	96-98	Qva	23.3	59.1	17.6	0.4	0.01	0.90	11.00		
	138-140	Qf	0.0	9.8	91.2		0.00	0.03	0.08		
	143-145	Qf	0.0	17.2	82.8	2.1	0.00	0.04	0.10		
MW-27	70-72	Qva	47.2	50.1	2.7		0.36	4.10	14.00	294	351 (Qva)
	106-108	Qva	50.6	45.8	3.6	0.3	0.43	4.90	29.00	419	
	138-140	Qf	0.0	93.1	6.9	0.4	0.10	0.21	0.33		
	143-145	Qf	0.2	87.5	12.3		0.04	0.28	0.51		
MW-28	153-155	Qva	54.6	25.1	20.3		0.01	7.10	22.00		91 (Qva)
	168-170	Qva	57.6	35.5	6.9	0.4	0.20	8.00	30.00	91	

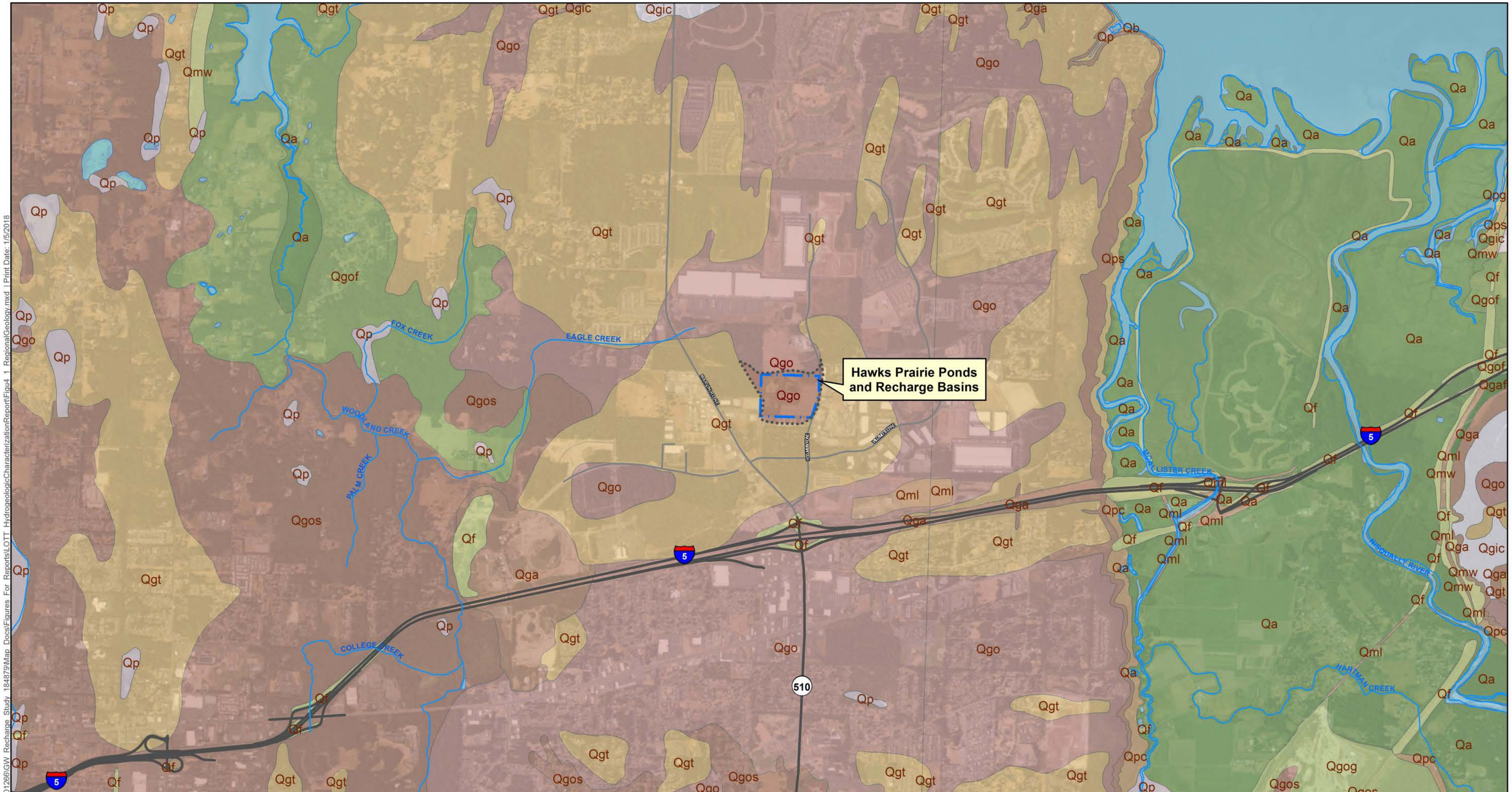
Notes:

[1] Qva = Shallow (Qva) Aquifer, Qf = Upper Confining Unit (Kitsap Formation), Qc = Sea Level (Qc) Aquifer.

[2] Size Fractions based on the following:
- Gravel = material between 4.75 mm and 760 mm
- Sand = material between 0.075 mm and 4.75 mm
- Silt and or Clay = material less than 0.075 mm

[3] Effective Grain Sizes:
- d_{10} = 10% passing grain size
- d_{50} = 50% passing grain size
- d_{90} = 90% passing grain size

[4] Calculated using the Hazen formula which is applicable for materials with d_{10} grain size >0.1mm and < 3mm.



Legend

Geologic Units

- Qa - Alluvium
- Qb - Beach deposits
- Qf - Fill
- Qga - Vashon advance outwash
- Qgaf - Vahon advance outwash
- Qgas - Vashon advance outwash
- Qge - Eskers
- Qgic - Ice-contact deposits
- Qgo - Vashon recessional outwash
- Qgof - Latest Vashon fine-grained sediments
- Qgog - Vashon recessional outwash gravel
- Qgos - Latest Vashon recessional sand and minor silt
- Qgt - Vashon Till
- Qml - Modified land
- Qmw - Colluvium
- Qp - Peat
- Qpc - Pre-Vashon seiment of Cascade Range source, undifferentiated
- Qpg - Pre-Vashon gravel
- Qps - Pre-Vashon sand-size or finer deposits
- Water Body
- LOTT Hawks Prairie Recharge Facility
- Roads

N

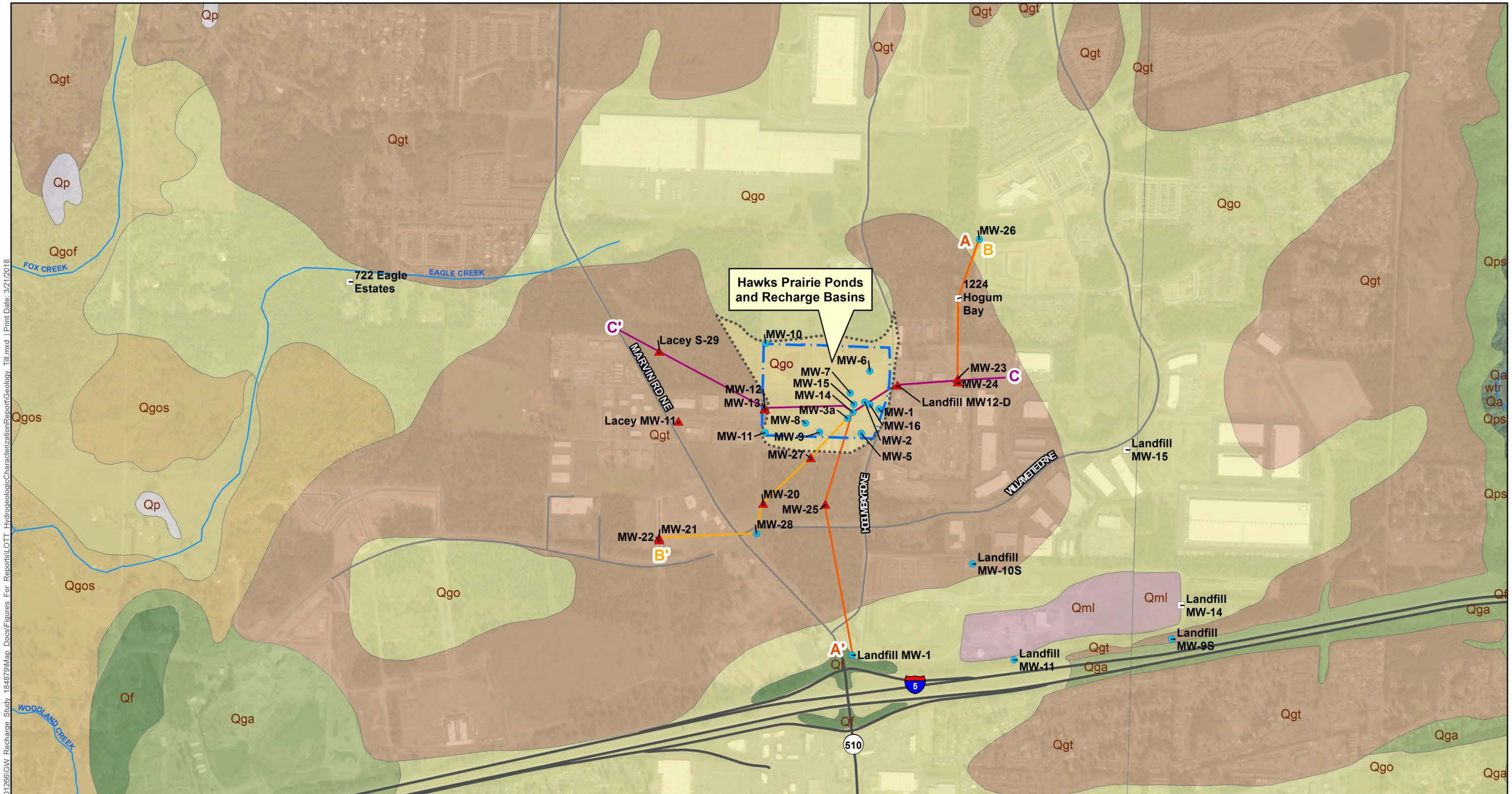
0 0.25 0.5 Miles

Figure 4-1
Surface Geologic Units

LOTT Clean Water Alliance HDR

Washington Geological Survey, 2017,
Surface geology, 1:24,000--GIS data, September 2017:
Washington Geological Survey Digital Data Series DS-10, version 3.0, previously released November 2016
https://www.dnr.wa.gov/programs-and-services/geology/publications-and-data/gis-data-and-databases
Source: Bing Maps (2011), City of Lacey (2014), WSDOT (2013).

Path: G:\Projects\Washington\LOTT_CWA_201266\GW_Recharge_Study_184879\Map_Docs\Figures_For_Reports\LOTT_HydrogeologicCharacterizationReport\Figu4_1_RegionalGeology.mxd | Print Date: 1/5/2018



Legend

Well Locations and Information on Presence of Vashon Glacial Till (Qgt) Unit
- Well Location
- Less than 10 ft. of till present
- 10 ft. or more of till present

Hydrogeologic Cross-Section Locations
- A
- B
- C
- LOTT Hawks Prairie Recharge Facility
- Roads

Geologic Units
- Qf - Fill
- Qga - Vashon advance outwash
- Qgo - Vashon recessional outwash
- Qgof - Latest Vashon fine-grained sediments
- Qgos - Latest Vashon recessional sand and minor silt
- Qgt - Vashon till
- Qml - Modified land
- Qp - Peat

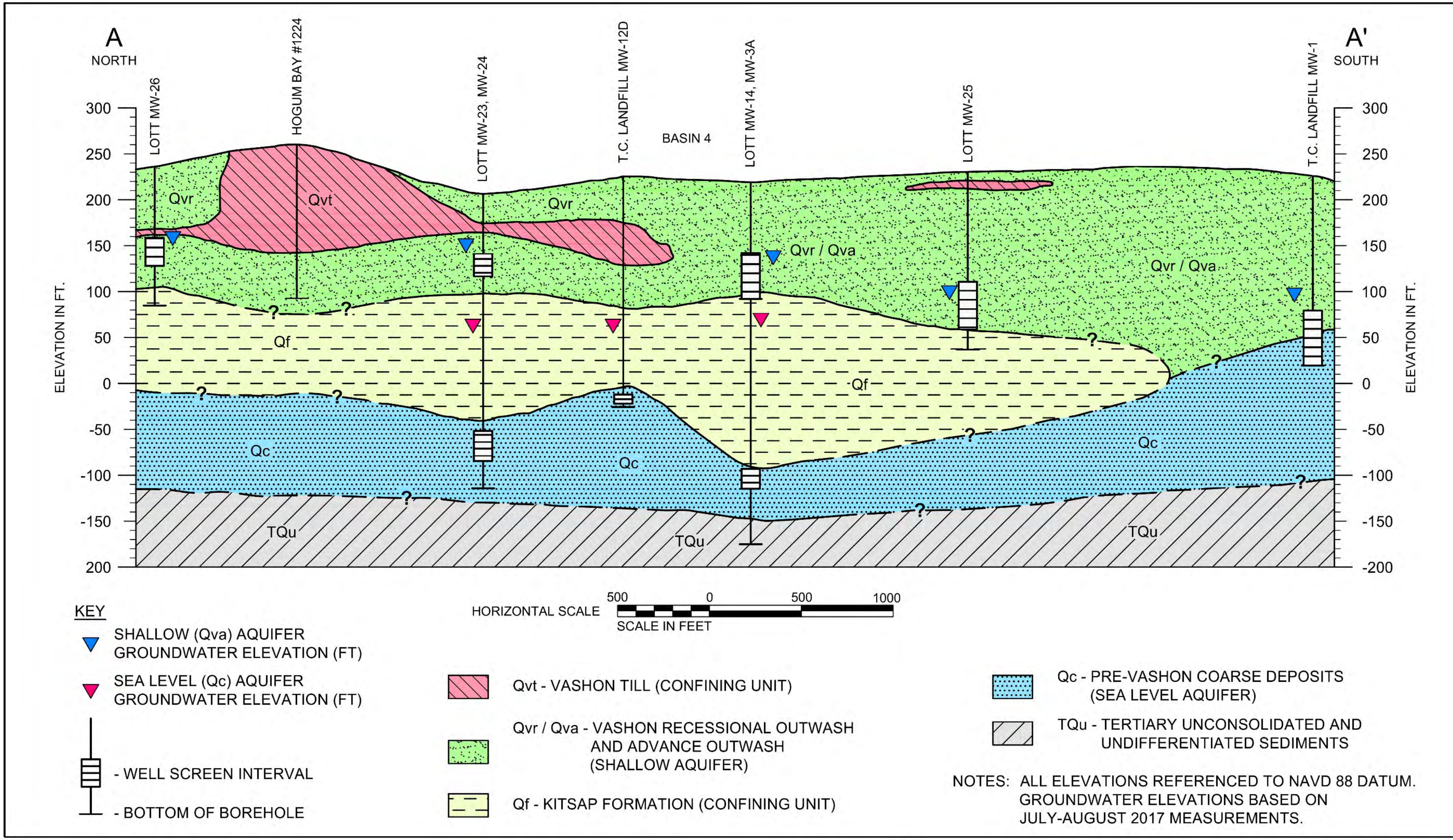
Washington Geological Survey, 2017,
Surface geology, 1:24,000--GIS data, September 2017:
Washington Geological Survey Digital Data Series DS-10, version 3.0, previously released November 2016
https://www.dnr.wa.gov/programs-and-services/geology/publications-and-data/gis-data-and-databases

0 500 1,000 Feet

Figure 4-2
Surface Geologic Units and Locations Where Vashon (Qvt) Till Was Encountered in Monitoring Wells

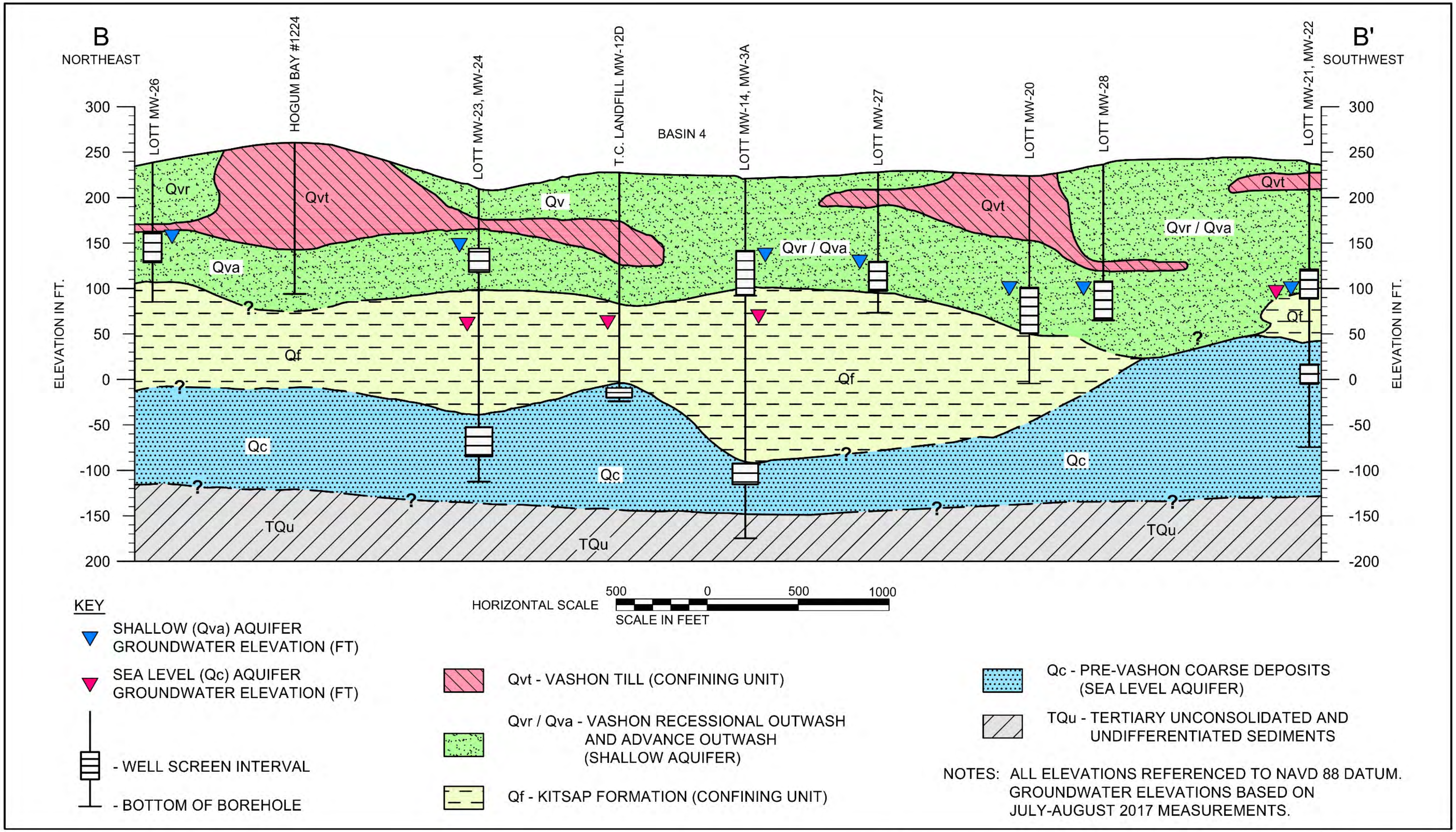
LOTT Clean Water Alliance HDR

Source: Bing Maps (2011), City of Lacey (2014), WSDOT (2013).



DATE
01/08/2018

FIGURE 4-3, CROSS-SECTION A-A'



HDR

FIGURE 4-4, CROSS-SECTION B-B'

DATE 01/08/2018

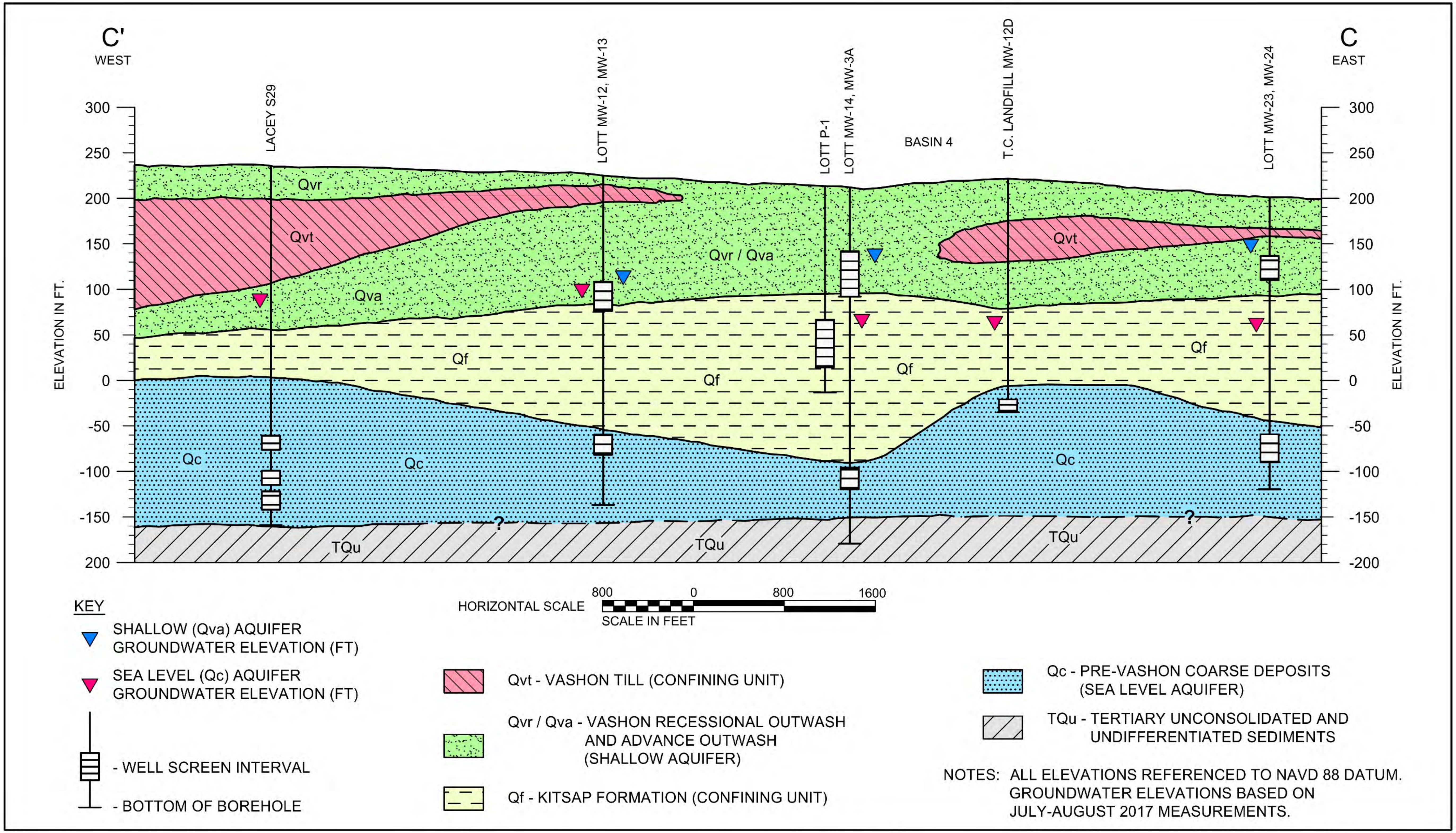


FIGURE 4-5, CROSS-SECTION C'-C

DATE
01/08/2018

4.2 Aquifer Hydraulic Testing Results

Aquifer hydraulic testing consisted of falling-head slug tests, single-well pumping tests, and multiple-well pumping tests focused on identifying the hydraulic parameters of the Shallow (Qva) Aquifer and the Sea Level (Qc) Aquifer, as discussed in **Section 4.2.4**.

4.2.1 Slug Test Results

Estimates of aquifer hydraulic conductivity from slug tests are presented in **Table 4-4**. The geometric mean of the horizontal hydraulic conductivity estimates for the Shallow (Qva) Aquifer is 9 feet/day. The geometric mean of the horizontal hydraulic conductivity estimates for the Sea Level (Qc) Aquifer ranges from 2 feet/day to 38 feet/day with an average of 21 feet/day. Plots of the slug test analyses are contained in **Appendix F**.

Table 4-4. Slug Testing Hydraulic Conductivity Estimates

Well ID	Slug Test Replicate ID	Test Date	Maximum Water Displacement (feet)	Hydraulic Conductivity (feet/day)	Geometric Mean Hydraulic Conductivity (feet/day)
Shallow (Qva) Aquifer					
MW-24	1	9/22/2017	3.5	11	9
	2	9/22/2017	2.8	9	
	3	9/22/2017	3.7	8	
Sea Level (Qc) Aquifer					
MW-12	1	9/21/2017	1.5	55	38
	2	9/21/2017	1.1	26	
MW-14	1	9/20/2017	6.7	3	2
	2	9/20/2017	8.5	2	
	3	9/20/2017	10.1	2	
	4	9/20/2017	11.7	2	
	5	9/20/2017	7.1	2	
	6	9/20/2017	7.1	2	
MW-21	1	9/22/2017	1.4	38	24
	2	9/22/2017	0.5	17	
	3	9/22/2017	0.8	22	
MW-23	1	9/21/2017	2.3	23	21
	2	9/21/2017	2.1	17	
	3	9/21/2017	2.9	25	

4.2.2 Multiple-Well Pumping Test Results

The MW-2 and MW-16 multiple-well pumping test results are shown below in **Tables 4-5** and **4-6**. The hydraulic conductivity estimate from the MW-2 pumping test is 229 feet/day at observation well MW-16. The hydraulic conductivity estimate from the MW-16 pumping test is 110 feet/day at observation well MW-2. The storativity value estimates ranged from 6.2 x 10^{-5} to 0.012. Plots of the pumping test analyses are contained in **Appendix G**.

Table 4-5. MW-2 Pumping Test Hydraulic Conductivity Estimates for the Shallow Aquifer (Qva)

Observation Well	Test Type	Analytical Method	Storativity (unitless)	Transmissivity (feet^2/day)	Hydraulic Conductivity (feet/day)	Average Hydraulic Conductivity (feet/day)
MW-16	Drawdown	Cooper-Jacob	1.8E-4	6,935	224	229
	Recovery	Cooper-Jacob w/ Agarwal	6.2E-5	7,298	235	

Table 4-6. MW-16 Pumping Test Hydraulic Conductivity Estimates for the Shallow Aquifer (Qva)

Observation Well	Test Type	Analytical Method	Storativity (unitless)	Transmissivity (feet^2/day)	Hydraulic Conductivity (feet/day)	Average Hydraulic Conductivity (feet/day)
MW-2	Drawdown	Cooper-Jacob	1.2E-2	2,118	68	110
	Recovery	Cooper-Jacob w/ Agarwal	1.4E-4	4,670	151	

4.2.3 Single-Well Pumping Test Results

Estimates of aquifer transmissivity and hydraulic conductivity from single-well pumping tests are provided in **Table 4-7**. The geometric mean hydraulic conductivity for the Shallow (Qva) Aquifer is 79 feet/day. The geometric mean hydraulic conductivity for the Sea Level (Qc) aquifer is 11 feet/day.

Table 4-7. Estimated Aquifer Properties from Single-Well Pumping Tests

Well ID	Specific Capacity (gpm/foot)	Transmissivity (feet^2/day)	Saturated Thickness (feet)	Hydraulic Conductivity (feet/day)	Geometric Mean Hydraulic Conductivity (feet/day)
Shallow (Qva) Aquifer					
MW-2	10.5	2,111	31	68	79
MW-13	6.2	1,234	15	82	
MW-16	13.9	2,794	32	87	
Sea Level (Qc) Aquifer					
MW-12	12.1	3,231	110	29	11
MW-14	1.0	255	60	4	

4.2.4 Discussion of Aquifer Hydraulic Parameters

The Shallow (Qva) Aquifer hydraulic conductivity from multiple-well aquifer tests ranges from 110 to 229 feet/day. The hydraulic conductivity from single-well pumping tests in the Shallow (Qva) Aquifer ranges from 68 to 87 feet/day. These are all reasonable values for an unconfined sand and gravel aquifer, and are similar to the values suggested by Brown and Caldwell (2009) of 36 to 320 feet/day for the Shallow (Qva) Aquifer at the property. The calculated hydraulic conductivity from slug tests was 9 feet/day. This value is lower than hydraulic conductivity values calculated from the pumping tests. This is likely because slug tests do not stress the aquifer as much as a pumping test and may consequently underestimate hydraulic conductivity. The storativity value estimates ranging from 6.2×10^{-5} to 1.2×10^{-2} are likely biased low. Fetter (2001) estimates storativity in an unconfined aquifer should range from 0.02 to 0.30, with the upper end limited by the specific yield of the formation. The likely reason for the low estimates of storage is because the MW-2 and MW-16 pumping tests were limited to pumping rates of 30 and 17 gpm, respectively, which were insufficient to create enough drawdown to stress the deeper, coarse-grained portion of the aquifer and not enough to cause water to be released from storage. Based on experience with other similar unconfined sand/gravel aquifers, the storativity of the coarse-grained portion of the unconfined Shallow (Qva) Aquifer is likely to be in the range of 0.05 to 0.20.

The Sea Level (Qc) Aquifer hydraulic conductivity values from slug testing and single-well aquifer pumping tests ranged from 2 to 38 feet/day. This is lower than the estimated hydraulic conductivity value derived from the pumping test on the City of Lacey S29 well, which is the closest test well with pumping test data available (Robinson and Noble, 2005). The City of Lacey S29 well pumping test data indicates a transmissivity of 6,550 to 8,021 feet^2/day, which is equivalent to a hydraulic conductivity value of 80 to 100 feet per day assuming the aquifer thickness is the same as the screened interval of 80 feet. The reason for the difference may be that the City of Lacey test well was pumped at a high rate for a longer time which stressed more of the coarse-grained portions of the Sea Level (Qc) Aquifer, or that there are fewer fine-grained sediments in that area of the aquifer.

Hydraulic conductivity values from aquifer testing data were used in preference over hydraulic conductivity values from grain-size analysis because aquifer testing stresses a larger portion of the aquifer and is considered to be more reliable. However, the grain-size analysis data does provide an indication of the variability in aquifer hydraulic properties and shows that hydraulic conductivity may in places be significantly higher or lower than the values presented above.

4.3 Groundwater Levels and Flow Directions

Groundwater levels were measured from July to September 2017 in new and existing monitoring wells located in the vicinity of the LOTT Hawks Prairie property. **Table 4-8** presents the measured groundwater levels and corresponding elevations. **Figures 4-6** and **4-7** show the groundwater potentiometric elevations and estimated groundwater flow directions for the Shallow (Qva) Aquifer and the Sea Level (Qc) Aquifer, respectively, in August 2017. **Figures 4-8** to **4-12** present hydrographs showing groundwater levels monitored during the July to September 2017 period in monitoring wells completed in the Shallow (Qva) and Sea Level (Qc) aquifers.

4.3.1 Shallow (Qva) Aquifer Groundwater Levels and Flow Direction

Groundwater in the Shallow (Qva) Aquifer flows from the northeast to the southwest below the LOTT Hawks Prairie property (see **Figure 4-6**). Groundwater ultimately flows towards and discharges into the Woodland Creek valley. The Shallow (Qva) Aquifer groundwater gradient is steeper at the LOTT Hawks Prairie property and then flattens to the southwest of the property. This may be partially due to the influence of recharge operations which raise the groundwater levels about 5 to 10 feet. From the middle of recharge Basin 4 on the LOTT Hawks Prairie property to MW-20 (referred to as Zone 1 in **Tables 4-9** through **4-10**), the horizontal hydraulic gradient is approximately 0.023-foot of hydraulic head per foot of distance, and from MW-20 to MW-22 (Zone 2), the hydraulic gradient decreases to 0.00241-foot per foot. The reason for the change in hydraulic gradient to the southwest of the LOTT Hawks Prairie property appears to be due to the structural control of the Kitsap Formation (Qf) upper confining unit which dips downward to the south and southwest and then flattens in the area around MW-21/MW-22. The hydrographs in **Figures 4-8** to **4-12** indicate that the groundwater levels during July through August of 2017 were on a declining trend which is normal during hot and dry summer periods.

4.3.2 Sea Level (Qc) Aquifer Groundwater Levels and Flow Direction

Groundwater in the Sea Level (Qc) aquifer flows from the west to the east below the LOTT Hawks Prairie property (see **Figure 4-7**), likely ultimately discharging to the Nisqually River valley. The overall horizontal hydraulic gradient from west to east is 0.01-foot of hydraulic head per foot of distance. Groundwater hydrographs presented in **Figures 4-8** to **4-11** indicate that groundwater levels in the Sea Level (Qc) Aquifer are lower but follow the same declining summer trend as the Shallow (Qva) Aquifer.

4.3.3 Vertical Gradient Between Shallow (Qva) and Sea Level (Qc) Aquifers

The groundwater levels in paired monitoring wells located adjacent to each other and completed in Shallow (Qva)/Sea Level (Qc) aquifers indicate a downward vertical flow direction. The range of vertical head difference between monitoring wells MW-12/13, MW-23/24 and MW-3a/14 is 15 feet at MW-12/13 to 89 feet at MW-23/24 (the gradient could not be calculated for the MW-21/22 pair since MW-22 was dry). Accounting for the vertical distance between the center of the monitoring well screens, the vertical gradient across the Kitsap Formation (Qf) upper confining unit ranges from 0.09 to 0.45 or roughly 9 to 45 percent. This is a large vertical gradient and, combined with the fine-grained lithology observed in the soil borings, indicates that the Kitsap Formation is a significant barrier to downward vertical flow; therefore, the majority of groundwater flow will likely occur laterally within the aquifer sediments rather than vertically through the Kitsap Formation.

4.3.4 Groundwater Travel Times - Shallow (Qva) Aquifer

Tables 4-9 and **4-10** show the estimated groundwater velocity, travel time and travel distance for the Shallow (Qva) Aquifer. The advective travel distance was estimated for 30-, 60-, 90-, 120-, and 150-day periods, as shown on **Figure 4-13**. Groundwater travel times were estimated using the groundwater velocity from the Darcy equation (Fetter, 2001), below.

$V = (k * i)/n_e$

where:

V = velocity (feet/day)

k = hydraulic conductivity (feet/day)

i = hydraulic gradient (feet/feet)

n_e = effective porosity (percent)

Hydraulic conductivity in the Shallow (Qva) Aquifer was assumed to be between 100 to 200 feet/day based on the results of aquifer testing. A hydraulic gradient of 0.023 and 0.0024 was selected based on the measured groundwater elevations. Effective porosity was assumed at 20 to 25 percent. The resulting groundwater velocity ranges from a low of 0.96 feet/day to a high of 23.0 feet/day. As a point of comparison, the startup monitoring investigation completed by HDR in 2014 indicated a groundwater velocity at the LOTT Hawks Prairie property between 13 and 43 feet/day (HDR, 2014). These estimated groundwater velocities were based on observations of groundwater temperature and salinity changes at observation wells during restart of infiltration at Basin 4.

Using the groundwater velocities calculated above, travel time and distance downgradient from the LOTT Hawks Prairie property was then estimated over two zones:

- Zone 1: Center of Recharge Basin 4 southwest to MW-20 with a measured gradient of 0.023 feet/feet.
- Zone 2: MW-20 to the southwest with a measured gradient of 0.0024 feet/feet.

The 30-, 60-, 90-, 120-, and 150-day travel distances were estimated to be 276 to 690, 552 to 1380, 828 to 1851, 1104 to 1923, and 1380 to 1995 feet, respectively. Prior groundwater modeling by Brown and Caldwell (2009) estimated travel distances of 4,000 feet over 1 year (or about 11 feet/day groundwater velocity) in the west to southwest direction assuming a recharge rate of 5 mgd and an effective porosity of 30 percent. Assuming no recharge, Brown and

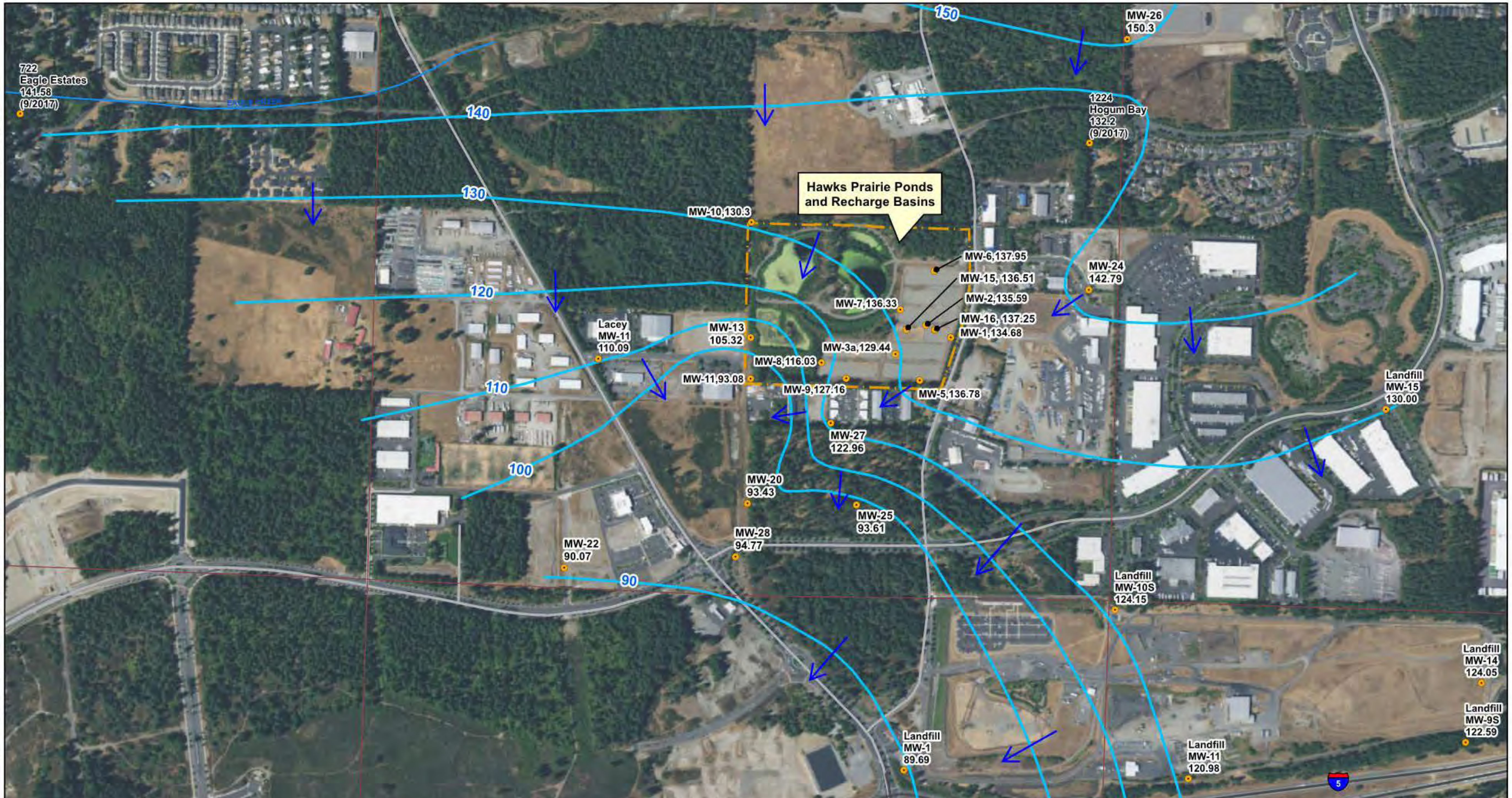
Caldwell (2009) estimated travel distances of 1,600 ft over 1 year (or about 4 feet/day groundwater velocity). However, Brown and Caldwell (2009) estimates did not incorporate the flatter hydraulic gradient that has been observed to the southwest of MW-20.

Table 4-8. Groundwater Level Measurements

Groundwater Level Measurements, Shallow (Qva) Aquifer											
Well Name	Top of Casing Elevation (NAVD88) (feet)	Screen Interval (feet bgs)	July 2017			August 2017			September 2017		
			Measurement Date	Depth to Groundwater (feet btoc)	Groundwater Elevation (NAVD88) (feet)	Measurement Date	Depth to Groundwater (feet btoc)	Groundwater Elevation (NAVD88) (feet)	Measurement Date	Depth to Groundwater (feet btoc)	Groundwater Elevation (NAVD88) (feet)
LOTT Hawks Prairie MW-1	219.46	87-97	7/24/2017	83.30	136.16	8/15/2017	84.78	134.68	9/12/2017	86.83	132.63
LOTT Hawks Prairie MW-2	218.27	97-107	7/24/2017	81.20	137.07	8/15/2017	82.68	135.59	9/12/2017	84.72	133.55
LOTT Hawks Prairie MW-3	218.15	117-127	7/24/2017	89.00	129.15	8/15/2017	89.74	128.41			
LOTT Hawks Prairie MW-3a	219.17	77-127	7/24/2017	88.95	130.22	8/16/2017	89.73	129.44	9/12/2017	91.4	127.77
LOTT Hawks Prairie Mw-5	219.09	76-96	7/24/2017	79.20	139.89	8/15/2017	82.31	136.78	9/12/2017	84.98	134.11
LOTT Hawks Prairie MW-6	218.97	83-103	7/24/2017	79.30	139.67	8/15/2017	81.02	137.95	9/12/2017	82.88	136.09
LOTT Hawks Prairie MW-7	218.91	100-120	7/24/2017	81.00	137.91	8/15/2017	82.58	136.33	9/12/2017	84.6	134.31
LOTT Hawks Prairie MW-8	218.70	105-125	7/24/2017	101.50	117.20	8/15/2017	102.67	116.03	9/12/2017	103.85	114.85
LOTT Hawks Prairie MW-9	218.69	89-109	7/24/2017	90.70	127.99	8/15/2017	91.53	127.16	9/12/2017	92.66	126.03
LOTT Hawks Prairie MW-10	224.89	112-132	7/25/2017	93.10	131.79	8/16/2017	94.59	130.3	9/12/2017	96.23	128.66
LOTT Hawks Prairie MW-11	228.00	150-160	7/25/2017	133.30	94.70	8/16/2017	134.92	93.08	9/12/2017	136.61	91.39
LOTT Hawks Prairie MW-13	226.80	118.7-148.7	7/25/2017	120.10	106.70	8/11/2017	121.48	105.32	9/12/2017	124.4	102.4
LOTT Hawks Prairie MW-15	219.20	75-95				8/18/2017	82.69	136.51	9/12/2017	83.76	135.44
LOTT Hawks Prairie MW-16	219.34	74.5-94.5				8/18/2017	82.09	137.25	9/12/2017	85.27	134.07
LOTT Hawks Prairie MW-20	219.22	120-150	7/31/217	124.81	94.41	8/11/2017	125.79	93.43	9/12/2017	125.52	93.7
LOTT Hawks Prairie MW-22	227.23	110-140	7/25/2017	135.20	92.03	8/15/2017	137.16	90.07	9/13/2017	dry	
LOTT Hawks Prairie MW-24	204.90	65-90				8/16/2017	62.11	142.79	9/13/2017	63.99	140.91
LOTT Hawks Prairie MW-25	228.95	118-168	7/24/2017	133.70	95.25	8/18/2017	135.34	93.61	9/14/2017	137.07	91.88
LOTT Hawks Prairie MW-26	233.18	75-105				8/11/2017	82.88	150.3	9/13/2017	80.38	152.8
LOTT Hawks Prairie MW-27	220.16	95-120				8/15/2017	97.2	122.96	9/13/2017	98.08	122.08
LOTT Hawks Prairie MW-28	224.85	130-170				8/18/2017	130.08	94.77	9/14/2017	132.7	92.15
Thurston Cty Landfill MW-1	220.58		7/25/2017	130.89	89.69						
Thurston Cty Landfill MW-9S	253.24	130-145	7/25/2017	130.65	122.59						
Thurston Cty Landfill MW-10S	228.09	125-135	7/25/2017	103.94	124.15						
Thurston Cty Landfill MW-11	225.07	90-105	7/25/2017	104.09	120.98						
Thurston Cty Landfill MW-12S	220.18	158-168	7/25/2017	120.50	99.68						
Thurston Cty Landfill MW-13S	213.97	110-120	7/25/2017	112.00	101.97						
Thurston Cty Landfill MW-14	226.35	222.9[2]	7/25/2017	102.30	124.05						
Thurston Cty Landfill MW-15	226.41	222.74[2]	7/25/2017	96.41	130.00						
Eagle Estates 722	198.30	141.75-153.75							9/13/2017	109.76	88.54
Hogum Bay 1224	251.34	-							9/13/2017	99.92	151.42
Lacey MW-11	232.12[1]	119.3-129.3	7/26/2017	121.80		8/16/2017	122.03	110.09	9/13/2017	122.3	109.822
Lacey MW-12	181.52[1]	71.5-81.5	6/22/2017	37.37							

Groundwater Level Measurements, Sea Level (Qc) Aquifer											
Well Name	Top of Casing Elevation (NAVD88) (feet)	Screen Interval (feet bgs)	July 2017			August 2017			September 2017		
			Measurement Date	Depth to Groundwater (feet btoc)	Groundwater Elevation (NAVD88) (feet)	Measurement Date	Depth to Groundwater (feet btoc)	Groundwater Elevation (NAVD88) (feet)	Measurement Date	Depth to Groundwater (feet btoc)	Groundwater Elevation (NAVD88) (feet)
Lacey S29 (Betti)[1]	230.62	294-394	7/31/2017	148.40	82.22						
Hill-Betti Well	234.20	-									
Thurston Cty Landfill MW-6R	227.87	224.34[2]	7/25/2017	192.55	35.32						
Thurston Cty Landfill MW-9D	252.53	248-258	7/25/2017	222.92	29.61						
Thurston Cty Landfill MW-10D	227.51	253-258	7/25/2017	188.67	38.84						
Thurston Cty Landfill MW-12D	220.18	238-248	7/25/2017	164.97	55.21						
Thurston Cty Landfill MW-13D	214.04	218-228	7/25/2017	181.78	32.26						
LOTT Hawks Prairie MW-12	227.00	284.7-304.7	7/25/2017	135.10	91.90	8/11/2017	136.27	90.73	9/12/2017	138.22	88.78
LOTT Hawks Prairie MW-14	218.04	310-330	7/25/2017	155.50	62.54	8/9/2017	156.45	61.59	9/13/2017	156.99	61.05
LOTT Hawks Prairie MW-21	227.16	220-240	7/25/2017	135.50	91.66	8/15/2017	137.37	89.79	9/13/2017	139.81	87.35
LOTT Hawks Prairie MW-23	204.54	259.8-289.8	7/24/2017	151.20	53.34	8/10/2017	151.16	53.38	9/13/2017	152.02	52.52

Notes:
Elevation datum is NAVD88 ft.
[1] City of Lacey well top of casing elevation is reported as NGVD 29 datum and has been converted to NAVD 88 datum.
[2] Screened interval is not available, total depth of the well is given.



Legend

- Well ID, Groundwater Elevation (ft)
- Groundwater Potentiometeric Surface Contour, Shallow Aquifer (ft)
- Groundwater Flow Direction
- Roads

Notes:
Groundwater elevations from July and August 2017.
Wells Hogum Bay and Eagle Estates were measured 9/13/2017.
Vertical datum for groundwater elevations is NAVD 88.

0 500 1,000 Feet

Figure 4-6
Observed Groundwater Elevations, July/August 2017
Shallow Aquifer, Qva/Qvr

LOTT Clean Water Alliance HDR

Path: G:\Projects\Washington\LOTT_CWA_201266\GW_Recharge_Study_184879\Map_Docs\Figures_For_Reports\LOTT_HydrogeologicCharacterizationReport\Fig4_1_Aug2017_GW_Elev_ShallowAquiferQva_noarrows.mxd | Print Date: 10/19/2017

Source: Bing Maps (2011), City of Lacey (2014), WSDOT (2013).

Legend

- Well ID, Ground Water Elevation (ft)
- Groundwater Potentiometeric Surface Contour, Sea Level Aquifer (ft)
- Groundwater Flow Direction
- Roads
- Section

0 500 1,000 Feet

Notes:
Groundwater elevations at wells Classic H, White Fir and Thompson are from summer 2015
Vertical datum for groundwater elevations is NAVD 88.

Source: Bing Maps (2011), City of Lacey (2014), WSDOT (2013).

Figure 4-7
Observed Groundwater Elevations, July/August 2017
Sea Level Aquifer, Qc

Figure 4-8. Groundwater Elevations MW-23 and MW-24

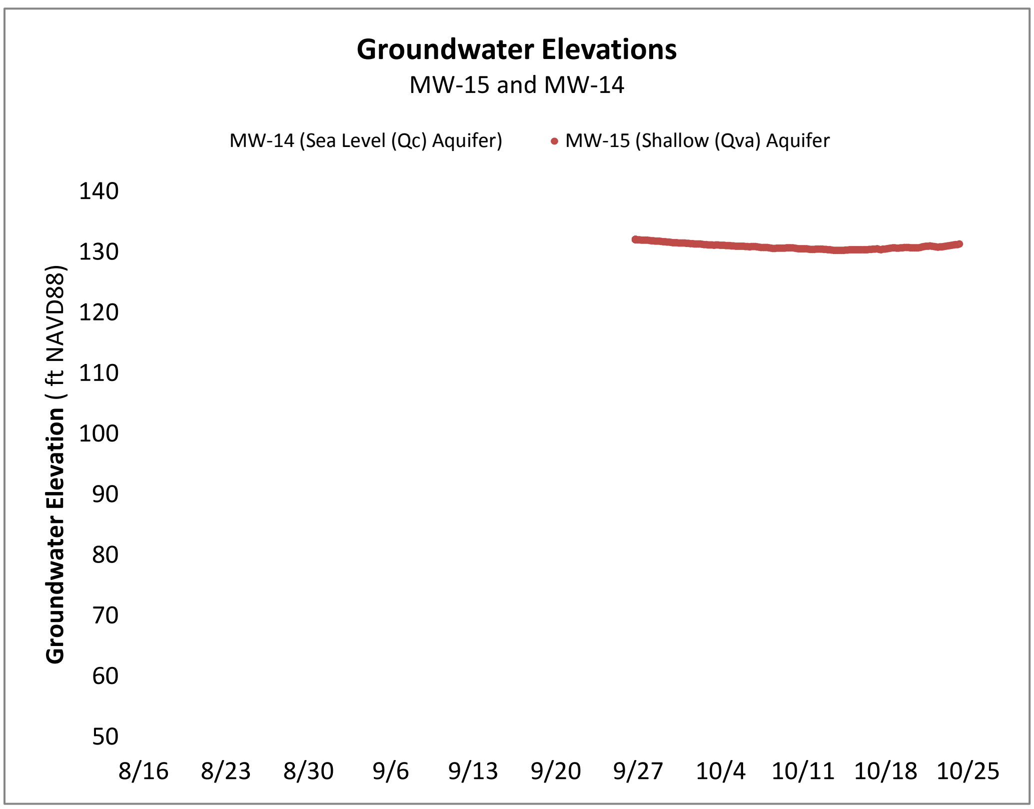


Figure 4-9. Groundwater Elevation MW-14 and MW-15

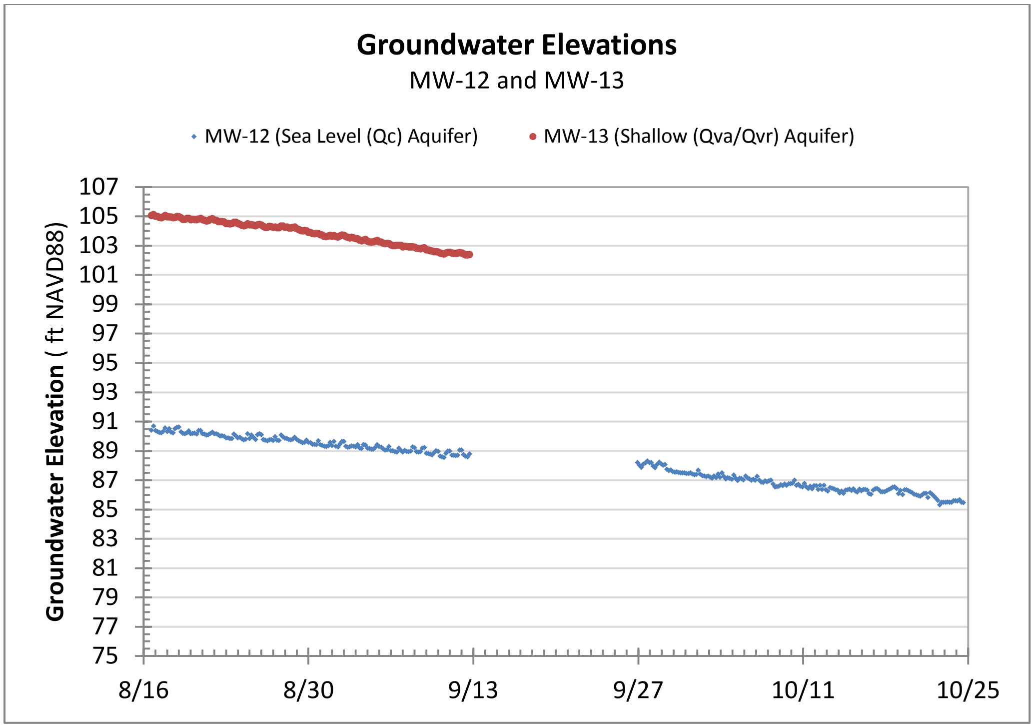
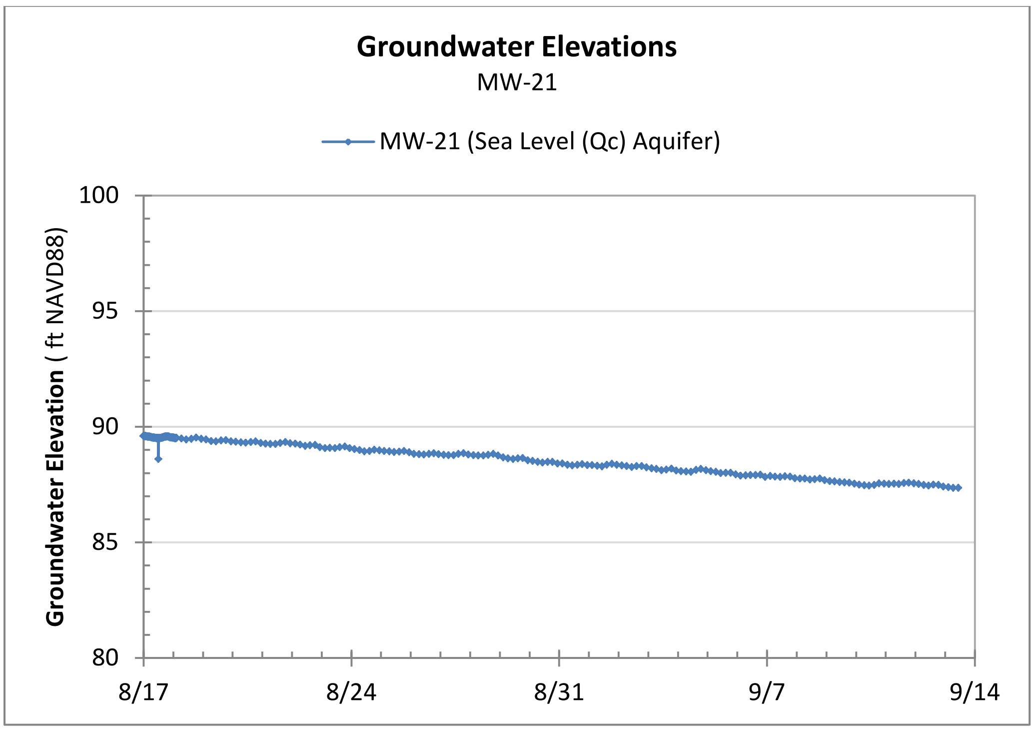


Figure 4-10. Groundwater Elevations MW-12 and MW-13



Note: MW-22 the shallow well in the pair was dry.

Figure 4-11. Groundwater Elevation MW-21

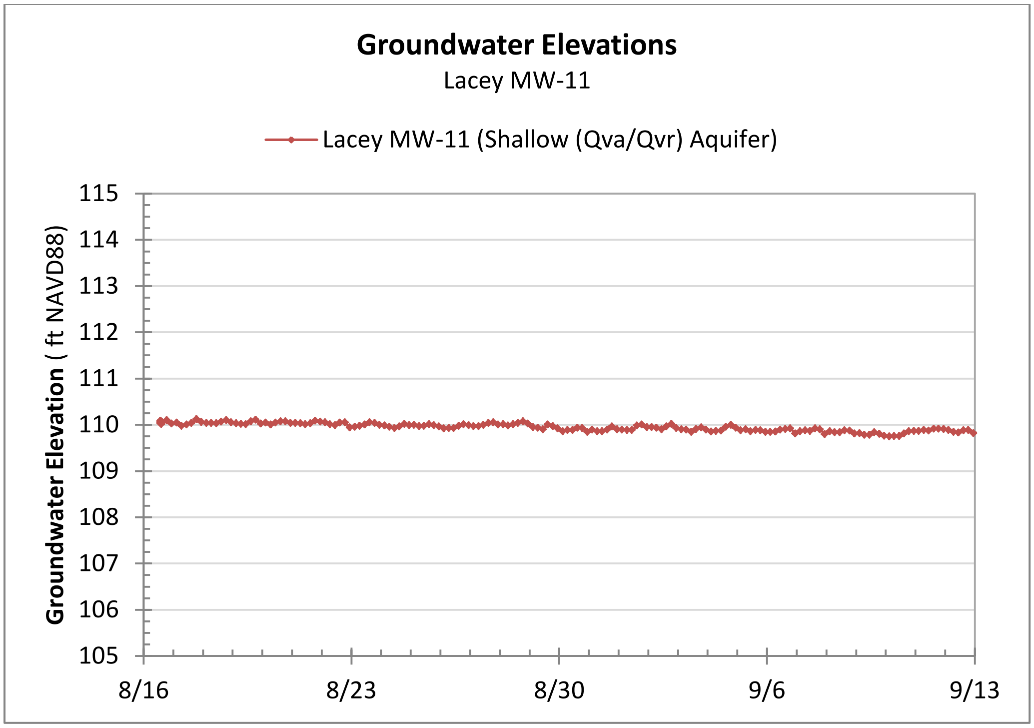
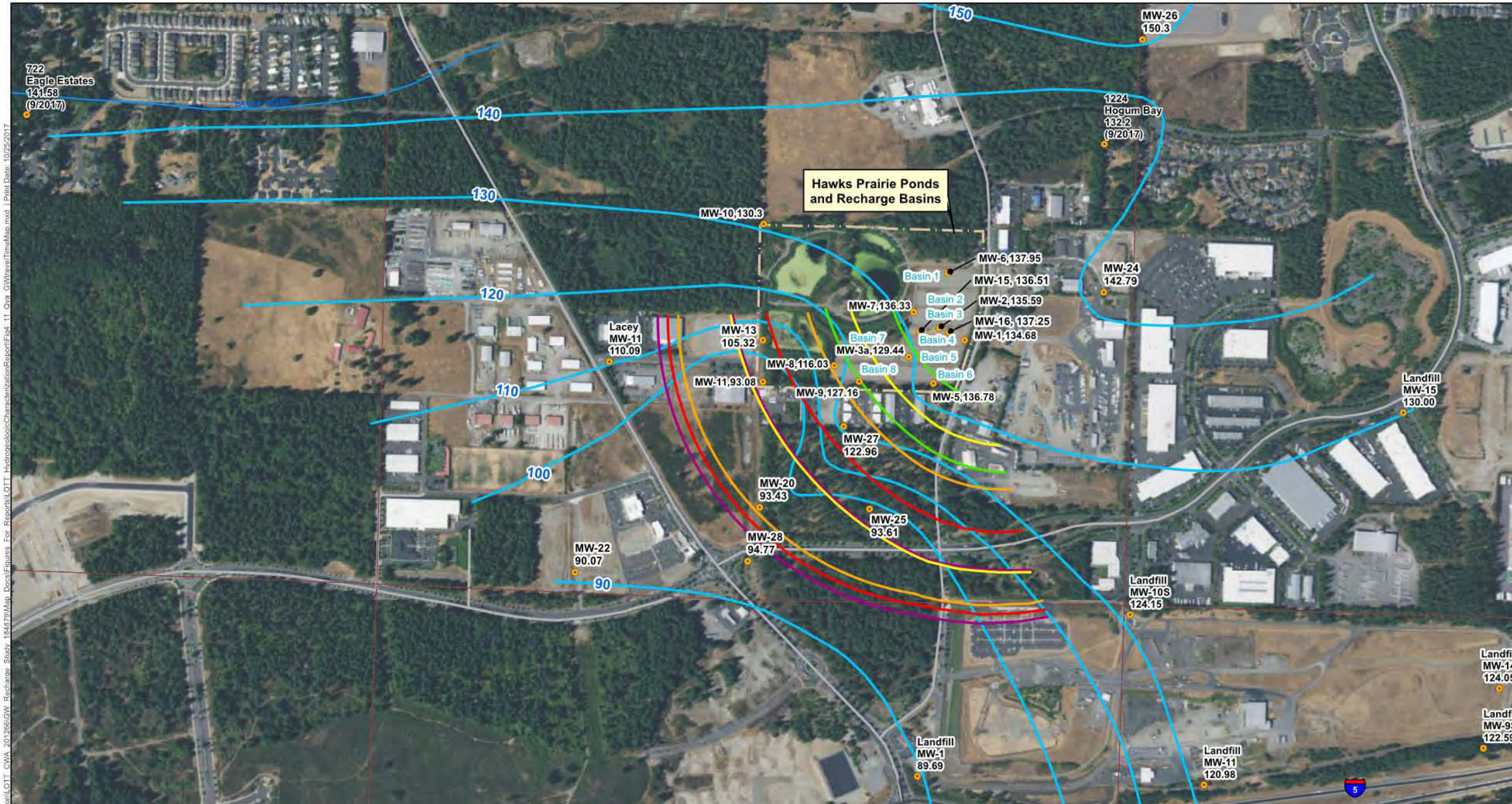


Figure 4-12. Groundwater Elevation Lacey MW-11

This page intentionally left blank.



Legend

- Well ID, Groundwater Elevation (ft)
- Groundwater Potentiometeric Surface Contour, Shallow Aquifer (ft)

Estimated Time of Travel from Middle of Basin 4

- 30 Day Travel Time Zone
- 60 Day Travel Time Zone
- 90 Day Travel Time Zone
- 120 Day Travel Time Zone
- 150 Day Travel Time Zone

0 500 1,000 Feet

Notes:

Groundwater elevations from July and August 2017.
Wells Hogum Bay and Eagle Estates were measured 9/13/2017.
Vertical datum for groundwater elevations is NAVD 88.

Source: Bing Maps (2011), City of Lacey (2014), WSDOT (2013).

Figure 4-13
Groundwater Elevation and Estimated Time of Travel
Shallow Aquifer, Qva/Qvr
July/August 2017

This page intentionally left blank.

Table 4-9. Calculated Groundwater Velocity – Shallow (Qva) Aquifer

Calculated Groundwater Velocity - Shallow (Qva) Aquifer					
Zone 1[1] Gradient (feet/feet)	Zone 2[2] Gradient (feet/feet)	Hydraulic Conductivity (feet/day)	Effective Porosity (%)	Zone 1 Groundwater Flow Velocity (feet/day)	Zone 2 Groundwater Flow Velocity (feet/day)
0.023	0.00241	100	20	11.5	1.2
0.023	0.00241	100	25	9.2	0.9
0.023	0.00241	200	20	23.0	2.4
0.023	0.00241	200	25	18.4	1.9
			Min.	9.2	0.9
			Max.	23.0	2.4

Notes:
[1] Zone 1 is from center of Recharge Basin 4 on LOTT Hawks Prairie property southwest to MW-20.
[2] Zone 2 is from MW-20 southwest to MW-22.

Table 4-10. Estimated Travel Distance over Time – Shallow (Qva) Aquifer

Estimated Travel Distance Over Time - Shallow (Qva) Aquifer					
Distance between Basin 4 and MW-20 (Zone1-2 Boundary)	1825	feet			
Min. Days until transition from Zone 1 to Zone 2	79	days			
Max. Days until transition from Zone 1 to Zone 2	198	days			
Travel Time (months)	1	2	3	4	5
Travel Time (days)	30	60	90	120	150
Travel Time in Zone 1 (days)	30	60	79-90	79-120	79-150
Travel Time in Zone 2 (days)	0	0	0-11	0-41	0-71
Min. Estimated Travel Distance (feet)	276	552	828	1,104	1,380
Max. Estimated Travel Distance (feet)	690	1,380	1,851	1,923	1,995

5.0 Summary

LOTT is conducting the Reclaimed Water Infiltration Study (RWIS) to provide local scientific data and community perspectives to help policymakers make informed decisions about future reclaimed water treatment and use. Task 2.0 of the RWIS project (which includes this report) is a treatment effectiveness evaluation to evaluate the presence, potential degradation, attenuation and transport of residual chemicals remaining after Class A reclaimed water treatment. Tracer testing (forthcoming) will determine groundwater travel time, and vadose zone (unsaturated) and groundwater quality sampling will be completed to evaluate water quality while reclaimed water is infiltrated into Basin 4 at the LOTT Hawks Prairie property. This basin is divided in half, and the tracer test will involve reclaimed water alternating between the two halves of the basin on 7-day wetting/drying cycles. Groundwater and vadose zone monitoring points are needed to complete the proposed monitoring. Information is required on the depth, thickness, extent, and hydraulic properties of the subsurface aquifers and confining units, and the groundwater flow directions and gradients in the vicinity of the LOTT Hawks Prairie property.

5.1 Scope of Field Investigations

Field investigations under Tasks 2.1.1.A and 2.1.2.C were completed including drilling soil borings, collecting and analyzing soil samples, and installing monitoring wells on and around the LOTT Hawks Prairie property. Three lysimeters were installed in each half of Basin 4 (six total lysimeters) at depths of 10, 25 and 50 feet. Instruments measuring soil moisture, conductivity, temperature and oxygen were also installed at the same depths adjacent to the lysimeters. Fourteen monitoring wells were installed; four wells were completed within the Sea Level (Qc) Aquifer and ten wells were completed in the Shallow (Qva) Aquifer, and groundwater levels were measured in all wells. Soil samples were collected and laboratory tested for a variety of hydraulic properties. *In-situ* aquifer testing was conducted including slug testing and aquifer pumping tests. This field work was completed from June 2017 through September 2017.

5.2 Findings from Subsurface Drilling and Monitoring Well and Lysimeter Installation

Vadose zone borings indicate the vadose zone is composed of a brown upper silty sand and gravel layer from the ground surface to approximately 10 feet deep. Below a depth of 10 feet the vadose zone is composed of silty fine to coarse sand and gravel with beds of finer-grained material consisting of fine to medium sand, silt and clay. Perched groundwater was observed in the vadose zone in the monitoring well and lysimeter borings drilled on the LOTT Hawks Prairie property. The organic content of the upper ten feet of soil is low (less than 1 percent) and the cation exchange capacity is also low (ranging from 3 to 7 meq/100g), and the soil minerals are composed primarily of quartz and feldspar, conditions typical of recently glaciated landscapes. The low total organic content, low cation exchange capacity, and quartz/feldspar-dominated mineralogy is typical of relatively recent glacial deposits. However, prior studies have shown that given the relatively low level of trace organic compounds, minerals and nutrients in reclaimed water, there usually is more than adequate soil capacity to attenuate contaminants, and the primary factors governing attenuation rates are vadose zone and groundwater residence time (or travel time), oxygen concentrations, and bioavailable carbon in soil and water (AWWARF, 2001; Gunthe and Jenkel, 2005; Makam and Fox, 2009; Naranaswamy et al., 2001; Rittman and McCarty, 2001; Stuyfzand et al., 2007).

The laboratory permeameter analyses indicate relatively low saturated vertical permeability ranging from 0.0023 to 0.15 feet/day with total porosity of 15 to 24 percent. The relatively low vertical permeability is caused by the presence of finer-grained deposits within the vadose zone which impedes the downward migration of water and causes perched groundwater conditions during recharge operations. Depth to groundwater is approximately 80 feet at Basin 4.

The Shallow (Qva) Aquifer is composed of Vashon recessional outwash (where saturated) and Vashon advance outwash sand, sand and gravel and silty sand and gravel. The upper portion of the aquifer is coarser-grained (cleaner) with fine to coarse sand and less silt. The lower portion of the aquifer transitions into the finer-grained Kitsap Formation (Qf) consisting of fine sand and silt which forms a confining unit. The aquifer is generally unconfined but also may act as a semi-confined aquifer where it is overlain by lower-permeability, fine-grained silty fine sand units. Organic content in the aquifer is low, less than 1 percent, indicating low sorbtive (retardation) capacity. The depth to groundwater in the Shallow (Qva) Aquifer near Basin 4 is approximately 80 feet, but increases to the south, southwest and west to a maximum of approximately 135 feet at MW-11 and MW-25. The saturated thickness of the aquifer is approximately 10 to 30 feet.

The Kitsap Formation (Qf) upper confining unit is composed of fine sand and silt that is grey or black in color. In some of the monitoring well borings there are higher-permeability sand/gravel zones within the Kitsap Formation that are varying and discontinuous in depth and extent. The organic content of the soil samples from the Kitsap Formation ranged from less than 1 to 2 percent. The thickness of the Kitsap Formation ranges from less than 80 feet to over 190 feet on the LOTT Hawks Prairie property. To the southwest and south of the LOTT Hawks Prairie property the top of the confining unit decreases in elevation and the unit thins or is absent.

5.3 Results from Aquifer Hydraulic Testing

The Shallow (Qva) Aquifer hydraulic conductivity estimated from multiple-well aquifer pumping tests ranges from 110 to 229 feet/day. The single-well pumping test results for the Shallow (Qva) Aquifer range from 68 to 87 feet/day. The storage value estimates ranging from 6.2×10^{-5} to 1.2×10^{-2} and are likely biased low. Actual storativity of the unconfined Qva aquifer is likely to be in the range of 0.05 to 0.20 with the upper end being the actual specific yield. The Sea Level (Qc) Aquifer hydraulic conductivity values from slug testing and single-well aquifer pumping tests range from 2 to 38 feet/day.

5.4 Groundwater Flow Directions and Travel Time and Distance

Groundwater in the Shallow (Qva) Aquifer flows from the northeast to the southwest below the LOTT Hawks Prairie property. Groundwater ultimately flows towards and discharges into the Woodland Creek valley. The Shallow (Qva) Aquifer groundwater gradient is steeper at the

LOTT Hawks Prairie property and then flattens to the southwest. The reason for the change in hydraulic gradient to the southwest appears to be due to the structural control of the Kitsap Formation (Qf) upper confining unit which dips down to the south and southwest and then flattens in the area around MW-21/MW-22. The estimated groundwater travel distances for the Shallow (Qva) Aquifer for 30-, 60-, 90-, 120-, and 150-day periods are approximately 276-690, 552-1380, 828-1851, 1104-1923, and 1380-1995 feet, respectively, from Basin 4 to the southwest.

Groundwater in the Sea Level (Qc) Aquifer flows from the west to the east below the LOTT Hawks Prairie property, likely ultimately discharging to the Nisqually River valley. The paired monitoring wells completed in the Shallow (Qva) and Sea Level (Qc) aquifers indicate a downward vertical flow direction, and the vertical gradient across the Kitsap Formation (Qf) upper confining unit ranges from 0.09 to 0.45, or roughly 9 to 45 percent. This is a large vertical gradient and, combined with the fine-grained lithology observed in the soil borings, indicates that the Kitsap Formation (Qf) upper confining unit is a significant barrier to downward vertical flow.

6.0 References

Agarwal, R.G., 1980. A new method to account for producing time effects when drawdown type curves are used to analyze pressure buildup and other test data, SPE Paper 9289 presented at the 55th SPE Annual Technical Conference and Exhibition, Dallas, Texas, Sept. 21-24, 1980.

American Water Works Association Research Foundation (AWWARF), 2001. Soil Aquifer Treatment for Sustainable Water Reuse, AWWARF, Denver, CO.

Bouwer, H., 1989. The Bouwer and Rice slug test – an update, Groundwater, vol. 27, no. 3, pp. 304-309.

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.

Brown and Caldwell, 2009. LOTT Hawks Prairie Groundwater Modeling Update. Prepared for LOTT Clean Water Alliance, Olympia, Washington.

Cooper, H.H. and C.E. Jacob, 1946. A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys. Union Trans., vol. 27, pp. 526-534.

Driscoll, F.G., 1986. Groundwater and Wells (2nd ed.), Johnson Filtration Systems, Inc., St. Paul, Minnesota, 1089p.

Drost, B., D. Ely and W. Lum, 1999. Conceptual Model and Numerical Simulation of the Ground-water Flow System in the Unconsolidated Sediments of Thurston County, Washington. U.S. Geological Survey Water Resources Investigations Report, 99-4165.

Fetter, C.W. 2001. Applied Hydrogeology, Fourth Edition. Prentice Hall, New Jersey.

Günthe, S., Amy, G., Jekel, M., 2005. Removal of bulk dissolved organic carbon (DOC) and trace organic compounds by bank filtration and artificial recharge. Water Research 39, 3219–3228.

Hazen, A., 1911. Discussion: Dams on sand foundations. Transactions, American Society of Civil Engineers, 73:199.

HDR, 2017a. Reclaimed Water Infiltration Study Work Plan On-Site Wells and Lysimeter Installation (Task 2.1.1.A) and Off-Site Monitoring Wells (Task 2.1.2.C). Prepared for LOTT Clean Water Alliance. April 25, 2017.

HDR, 2017b. Reclaimed Water Infiltration Study Task 1.1 Groundwater Quality Characterization. Prepared for LOTT Clean Water Alliance, Olympia, Washington. February 7, 2017.

HDR, 2014. Reclaimed Water Infiltration Study Startup Water Quality Monitoring Report Hawks Prairie Reclaimed Water Ponds and Recharge Basins, November 20, 2014. Prepared for LOTT Clean Water Alliance, Olympia, Washington.

HDR, 2013. Reclaimed Water Infiltration Study Phase 1 (Technical Data Review), Technical Memorandum – "State of the Science", May 31, 2013. Prepared for LOTT Clean Water Alliance, Olympia, Washington.

Inland Empire Utilities Agency (IEUA). 2008. Chino Basin Recycled Water Groundwater Recharge Program, Start-up Period Report for Turner Basin.

Inland Empire Utilities Agency (IEUA). 2003. Ely Basin No. 3 Lysimeter Installation and Sampling, Draft Work Plan.

Logan, R., T. Walsh, H. Schasse, and M. Polenz, 2003. Geologic Map of the Lacey 7.5-minute Quadrangle, Thurston County, Open File Report 2003-9. Washington Division of Geology and Earth Resources, Olympia, Washington

Makam, R. and P. Fox, 2009. Surface Area and Travel Time Relationships in Aquifer Treatment Systems, Water Environment Research 81:11, 2337-2443.

Naranaswamy, K., Fox, P., and J. E. Drewes, 2001. Water Quality Transformations during Soil Aquifer Treatment at the Mesa Northwest Water Reclamation Plant, USA, Water Science and Technology, 43(10): 343-350.

Quanrud, D., Zhang, J., Tomanek, M., Dong, H., Arnold, R., Ela, W., Sáez, E. 2008. Fate of Polybrominated Diphenyl Ethers, Nonylphenol and Estrogenic Activity during the Managed Infiltration of Wastewater Effluent. Journal of Environmental Engineering. 134(6):433-442.

Rittmann, B.E., McCarty, P.L., 2001. Environmental Biotechnology. Principles and Applications. McGraw-Hill, Boston.

Robinson and Noble, 2005. City of Lacey Construction and Testing of Betti Site Production Well, Source No. 29. Prepared for City of Lacey, Washington.

Robinson & Noble, Inc. 2002. Technical Memorandum 18763.400, LOTT Wastewater Alliance, Monitor Well Drilling and Construction at Groundwater Recharge Basin A. Prepared for LOTT Wastewater Alliance, Olympia, Washington.

Robinson & Noble, Inc., 2000. Technical Memorandum 200F H.P. Area, LOTT Wastewater Resource Management Plan, Hydrogeologic Investigation of the Finley and Corners Properties. Prepared for LOTT Wastewater Alliance, Olympia, Washington.

Stuyfzand, P. J., Segers, W., Van Rooijen, N. (2007) Behavior of pharmaceuticals and other emerging pollutants in various artificial recharge systems in the Netherlands. Proceedings of the 6th International Symposium on Management of Aquifer Recharge, ISMAR6, Phoenix, USA, 15-19 September 2007, 434-441.

Appendix A – Lysimeter and Monitoring Well Boring Logs

This page intentionally left blank.

Boring Log

Project Name		Project No.	Drilling Company	
LOTT - Hawks Prairie		10021292	Holt Services, Inc.	
Boring No	Location		Drilling Rig Type and Drilling Method	
MW-12 (O)	Onsite, west side		Terra Sonic 150CC, track-mounted sonic	

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-5' run		0-5	2.5-inch Sch. 80 PVC monitoring well, screened from 284.7-304.7 ft bgs. Flush-mount completion.	Loose to medium dense, dry, light brown, silty gravel (GW) with trace f-c sand and clay. Few 3-inch cobbles.	TOC = 227.00 ft MSL	Drilling with 8-inch outer casing with 7-inch sampler. Qvr
5-10' run		5-10		Becomes grayish-brown. 8.5-9.5': grayish brown, fine gravelly clay (CL) with silt.		
10-18' run		10-18		Medium stiff, dry, grayish brown, fine gravelly clay (CL) with some silt, trace f-c sand and trace coarse, rounded gravel. Becomes clay (CL) with some f-c gravel.		Till.
18-20' run		18-20		With some f-c sand.		
20-30' run		20-24		Medium dense, most, grayish brown, clayey gravel (GC) with some f-c sand.		
		24-28		Medium dense, moist, grayish brown, fine silty sand (SM). Very dense 27-28'.		
		28-30		Medium dense, moist, grayish brown, fine sand (SP) with some m-c sand and trace fine, rounded gravel.		Clean; free of fines from 28-30'.
30-40' run		30-40		Medium dense, moist, grayish brown, f-c sandy gravel (GW) with trace silt, rounded, f-c sand. Trace clay 32-36'. No silt or clay. Trace clay at 40'.		Outwash (Qva) below 30'. Clean, free of fines from 38-40'.

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Pete Rosenberg
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
129'	133.44' BTOC (well)	6/16/2017	6/5/2017	6/9/2017 (well installed 6/13)

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-12 (O)	Onsite, west side	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
40-50' run			2.5-inch Sch. 80 PVC monitoring well, screened from 284.7-304.7 ft bgs. Flush-mount completion.	SAME: Medium dense, moist, grayish brown, f-c sandy gravel (GW) with trace clay, rounded, f-c sand.		Drilling with 8-inch outer casing with 7-inch sampler.
				Wet 41-44', m-c sand.		
		45		Medium dense, moist, grayish brown, f-c sand (SW) with some f-c rounded gravel, trace clay, trace silt.		
				Silty sand lense 49-50'.		
50-55' run		50				
				4-inch cobble, rounded.		
55-60' run (Submitted 56-58')		55				
				5-inch cobble, rounded		
60-70' run		60				
				Medium dense, moist, grayish brown, f-c gravelly sand (SW), with some silt, trace clay.		
		65				
				Very dense, moist, grayish brown, f-c sandy gravel (GW), f-c sand, with trace clay, trace silt. Few 3-5-inch cobbles.		Slow drilling. Driller indicates high density material. Casing is getting hot (steaming) due to lack of groundwater.
70-76' run		70				
76-86' run		75				

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Pete Rosenberg
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
129'	133.44' BTOC (well)	6/16/2017	6/5/2017	6/9/2017 (well installed 6/13)

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-12 (O)	Onsite, west side	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
76-86' run (cont.)			2.5-inch Sch. 80 PVC monitoring well, screened from 284.7-304.7 ft bgs. Flush-mount completion.	SAME: Very dense, moist, grayish brown, f-c sandy gravel (GW), f-c sand, with trace clay, trace silt. Few 3-5-inch cobbles.		Drilling with 8-inch outer casing with 7-inch sampler.
		85				
86-90' run (Submitted 88-90')				Light, orange oxide staining 88-89'.		
90-96' run		90				
		95				
96-108' run				Fine silty sand lense, 96-98'.		
		100		Very dense, moist, grayish brown, f-c gravelly sand (SW), f-c gravel, with trace silt, trace clay.		
		105		Very dense, moist, grayish brown, f-c sand (SW) with trace f-c gravel.		
				Very dense, moist, grayish brown, f-c sandy gravel (GW), f-c sand, with some clay, trace silt.		
108-110' run				4-inch clay lense with some fine, rounded gravel and trace sand at 109'.		6/5/17: Drilled to 108'.
110-120' run Photo 110-140' Photo 110-210'		110		Moist to wet at 113'.		
		115		Very dense, moist, grayish brown, f-m sand (SP) with some f-c rounded gravel, trace silt.		
				Very dense, moist, grayish brown, f-c sandy gravel (GW), f-c sand, with some clay, trace silt. Few 3-5-inch cobbles.		Water in sampler at 120'.

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Pete Rosenberg
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
129'	133.44' BTOC (well)	6/16/2017	6/5/2017	6/9/2017 (well installed 6/13)

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-12 (O)	Onsite, west side	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
120-130' run			2.5-inch Sch. 80 PVC monitoring well, screened from 284.7-304.7 ft bgs. Flush-mount completion.	Dense, moist, grayish brown, fine, poorly graded sand (SP) with some medium sand and trace silt.		Drilling with 8-inch outer casing with 7-inch sampler.
				Dense, moist, grayish brown, f-c gravelly sand (SW), f-c rounded gravel.		
		125		Dense, moist, grayish brown, f-c sandy gravel (GW), f-c sand, trace silt, trace clay. Few 3-5-inch cobbles.		Lower density at 120'. Drilling speed improves.
					▽	
130-140' run		130				Increasing moisture, some shiny wetness, but no free water in sample.
		135				Driller indicates possible heaving sands. The 140-150' run did not reach 140', and material came up to 132' inside casing after sampler was withdrawn.
				No silt or clay 138-139'.		
				Dense, moist, grayish brown, f-c sand (SW) with some f-c rounded gravel, trace silt, trace clay.		
140-150' run (Submitted 148-150')		140		Dense, moist, f-m sand (SP) with tr coarse sand and silt.		
				Dense, moist, grayish brown, fine silty sand (SM).		Qf confining layer.
		145		Medium stiff, moist, grayish brown, silt (ML) with some fine sand, some rusty red mottling.		
				Medium dense, moist, grayish brown, very fine silty sand (SM).		DTW = 129 feet bgs with casing at 150'.
150-160' Missed sample due to drilling depth error. Partial sample observed on cuttings waste pile.		150				Set 8-inch casing into confining layer at 149' with hydrated bentonite chip seal.
		155		Moist, grayish brown, f-m sand (SP). (Observations made on disturbed sample on cuttings waste pile.)		

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Pete Rosenberg
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
129'	133.44' BTOC (well)	6/16/2017	6/5/2017	6/9/2017 (well installed 6/13)

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-12 (O)	Onsite, west side	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
160-170' run			2.5-inch Sch. 80 PVC monitoring well, screened from 284.7-304.7 ft bgs. Flush-mount completion.	Medium dense, wet, grayish brown, very fine to fine sand (SP) with trace silt.		Drilling with 7-inch outer casing with 6-inch sampler.
		165				
170-180' run		170				
				With trace m-c sand and trace fine, rounded gravel 172-176'.		
		175				
180-190' run (Submitted 185-187')		180		4-inch grayish brown, silty clay lense at 181', some rusty orange mottling.		
		185				
						6/6/17: Drilled 108-190'.
190-200' run Sample fell out. Retrieved on next try.		190		Medium dense, wet, grayish brown, fine silty sand (SM).		Switch from auger bit to flapper bit to contain sample. DTW = 178.8 ft bgs, casing at 190'.
		195				DTW = 162 ft bgs, casing at 200'.

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Pete Rosenberg
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
129'	133.44' BTOC (well)	6/16/2017	6/5/2017	6/9/2017 (well installed 6/13)

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-12 (O)	Onsite, west side	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
200-210' run		205	2.5-inch Sch. 80 PVC monitoring well, screened from 284.7-304.7 ft bgs. Flush-mount completion.	Medium dense, wet, grayish brown, fine, poorly graded sand (SP) with trace m-c sand, trace fine, rounded gravel, trace silt. Fine silty sand 208-210'.		Drilling with 7-inch outer casing with 6-inch sampler. DTW = 159 ft bgs, casing at 210'.
210-220' run Photo 210-240'		210 215		No m-c sand, no fine gravel.		
				Medium stiff, moist, grayish brown, v. fine to fine sandy silt (ML). Light, orangish red oxide staining.		DTW = 157 ft bgs, casing at 220'.
220-230' run Photo 220-250' Photo 220-290'		220 225		Wet 224-225', silty sand (SM).		
				Medium dense, wet, grayish brown, f-c gravelly sand (SW).		DTW = 149 ft bgs, casing at 230'.
				Medium dense, wet, orangish brown, fine, poorly graded sand (SP) with trace medium sand.		Driller indicates sand heaved up into casing to 217', casing at 230'. Heaved to 227' after first cleanout run. Cleaned on second cleanout after pushing casing to 240'.
230-240' run (Submitted 234-236') Photo 232-234'		230 235		Medium stiff, moist, grayish brown, clayey silt (ML). Light, orangish red oxide staining. Occasional fine sand stringers.		DTW = 165.1 ft bgs, casing at 240'.

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Pete Rosenberg
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
129'	133.44' BTOC (well)	6/16/2017	6/5/2017	6/9/2017 (well installed 6/13)

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-12 (O)	Onsite, west side	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
240-250' run			2.5-inch Sch. 80 PVC monitoring well, screened from 284.7-304.7 ft bgs. Flush-mount completion.	Medium dense, wet, grayish brown, fine, poorly graded sand (SP) with some m-c sand, trace fine, rounded gravel.		Drilling with 7-inch outer casing with 6-inch sampler. Sand heaved up to 238', casing at 240'.
		245		Medium stiff, moist, grayish brown, clayey silt (ML). Light, rusty iron oxide staining. 2-inch stringer of wet, coarse sand and fine, rounded gravel at 245.8'. Fine sandy silt (ML) 246-248'.		
250-260' run		250		Medium dense, wet, grayish brown, f-c sandy gravel (GW), f-c sand, rounded gravel, trace silt, trace clay.		Coarse zone 250-261'.
		255		Medium dense, wet, grayish brown, f-m gravelly sand (SW), f-c rounded gravel, trace silt, trace clay. 5-inch cobble at 260'		6/7/17: Drilled 190-260. DTW = 142 ft bgs on 6/8/17. Casing at 250'. Sand heaved to 238'.
260-270' run Photo 260-300'		260		Stiff, dry, light brown, medium plastic clay (CL).		DTW = 141.5 ft bgs, casing at 260'.
		265		Stiff, dry, gray, highly plastic clay (CH). Becomes low plastic clay (CL).		Clay confining layer 261-280'. DTW = 156.5 ft bgs, casing at 270'.
270-276' run		270				
276-290' run		275		Becomes light brown.		DTW = 146.5 ft bgs, casing at 280'.

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Pete Rosenberg
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
129'	133.44' BTOC (well)	6/16/2017	6/5/2017	6/9/2017 (well installed 6/13)

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-12 (O)	Onsite, west side	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
276-290' run (continued)			2.5-inch Sch. 80 PVC monitoring well, screened from 284.7-304.7 ft bgs. Flush-mount completion.	Medium dense, wet, orangish brown, f-m, poorly graded sand (SP) with trace silt, trace clay		Drilling with 7-inch outer casing with 6-inch sampler. Qc aquifer at 280'.
		285				
				Medium dense, wet, orangish brown, f-c sandy gravel (GW), f-c sand, rounded gravel, trace silt, trace clay.		DTW = 142 ft bgs, casing at 290'.
290-300' run (Submitted 295-297')		290				
				Trace f-m sand.		
				Few 3-5-inch cobbles.		
		295				
				1-ft lense washed fine gravel (GP), some coarse sand, no fines.		DTW = 141.5 ft bgs, casing at 300'.
300-310' run		300				
				Occasional thin (0.5-1-inch) light brown clay lense.		
		305				
						DTW = 142 ft bgs, casing at 310'.
310-320' run		310				
				Medium dense, wet, grayish brown, f-c sandy gravel (GW), f-c sand, some clay (likely in lenses), rounded gravel. Few 3-5-inch cobbles.		Increasing clay lenses.
		315				

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Pete Rosenberg
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
129'	133.44' BTOC (well)	6/16/2017	6/5/2017	6/9/2017 (well installed 6/13)

Boring Log

Project Name			Project No.	Drilling Company		
LOTT - Hawks Prairie			10021292	Holt Services, Inc.		
Boring No		**Location**		**Drilling Rig Type and Drilling Method**		
MW-12 (O)		Onsite, west side		Terra Sonic 150CC, track-mounted sonic		
Sample No.	**PID Reading (ppm)**	**Depth (feet)**	**Completion**	**Description (USCS)**	**Elevation (feet)**	**Remarks**
320-330' run			2.5-inch Sch. 80 PVC monitoring well, screened from 284.7-304.7 ft bgs. Flush-mount completion.	SAME: M. dense, wet, gr brn, f-c sandy gravel (GW), f-c sand, some clay, rounded gravel. Few 3-5-inch cobbles.		Drilling with 7-inch outer casing with 6-inch sampler.
				Medium dense, wet, orangish brown, f-c sandy gravel (GW), m-c sand, rounded gravel, trace fin sand. Occasional 0.5-inch clay lense.		Decreasing clays.
		325				
				Medium dense, wet, brownish gray, f-c gravelly sand (SW), f-c gravel, rounded.		
				Medium dense, wet, brown, f-m, poorly graded sand (SP), trace f-c rounded gravel.		Drilled 260-330', 6/8/17.
330-340' run (Submitted 335-337')		330				DTW = 140 ft bgs, casing at 320' (overnight).
				No gravel, trace coarse sand.		
		335				Casing at 340'; sand heaved up to 322'; flushed with water down to 339'.
				Trace clay, likley thin lenses.		
340-360' run		340		Becomes grayish brown.		
		345				
		350				
		355				
				Becomes green-purple-gray.		
				Bottom of boring @ 360', cased to 340'.		

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Pete Rosenberg
While Drilling:	**After Drilling:**	**Hours After:**	**Date Started:**	**Date Completed:**
129'	133.44' BTOC (well)	6/16/2017	6/5/2017	6/9/2017 (well installed 6/13)

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-14 (R)	Basins 4&5 berm	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run		0	2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	Loose, dry, brown, f-c rounded gravel (GW) with silt, clay, and some f-c sand.	TOC = 218.04 ft MSL	Drilling with 8-inch outer casing and 7-inch sampler.
		5		Becomes grayish brown.		
		9		Medium dense, moist, grayish brown, f-c rounded gravel (GW) with trace coarse sand.		Using an auger bit.
10-20' run		10			▽	Qvr/Qva.
		11		Medium dense, wet, grayish brown, f-c clayey sand (SC) with some f-c rounded gravel.		Wet at 11' but no free water in sampler.
		16		5-inch rounded cobble.		
		18		Medium dense, moist, brownish gray, fine, poorly graded sand (SP) with trace clay, trace medium sand, trace silt, trace fine rounded gravel.		
20-30' run		20				
		21		Brownish gray silt (ML) lense 21-22'.		
		22		Medium dense, wet, brownish gray, f-c rounded sandy gravel (GW), f-c sand, trace silt and clay.		
30-39' run		30				
		31		Medium dense, moist, brownish gray, f-m gravelly sand (SW), f-c rounded gravel, trace silt.		
Photo 35'		35				
		37		Medium dense, moist, brownish gray, f-c rounded sandy clayey gravel (GW-GC), f-c sand.		
Photo 40'						
39-50' run		40				

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	**After Drilling:**	**Hours After:**	**Date Started:**	**Date Completed:**
11'			6/26/2017	6/30/2017

Boring Log

Project Name		Project No.	Drilling Company		
LOTT - Hawks Prairie		10021292	Holt Services, Inc.		
Boring No	**Location**		**Drilling Rig Type and Drilling Method**		
MW-14 (R)	Basins 4&5 berm		Terra Sonic 150CC, track-mounted sonic		

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
39-50' run (cont.)			2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	Medium dense, moist to wet, brownish gray, f-c rounded sandy gravel (GW), f-c sand.		Drilling with 8-inch outer casing and 7-inch sampler.
		45		With trace silt and trace clay.		
(Submitted 48-50')						
50-60' run		50		Medium dense, moist, brownish gray, f-c gravelly sand (SW), f-c rounded gravel, trace fines.		
		55				
				Medium dense, moist, grayish brown, fine, poorly graded sand (SP).		
60-65' run		60		Medium dense, moist, grayish tan, f-c rounded gravel (GW) with some coarse sand, trace clay.		60-65' sampler contains free water.
				Medium dense, dry, brownish gray, f-c sandy gravel (GW), f-c sand, some silt and trace clay. Few 3-6-inch cobbles.		
65-70' run		65		Becomes moist-wet at 66'.		Driler notes something hard at 65'.
70-80' run		70		Dense, wet, brownish gray, f-c gravelly sand (SW), f-c rounded gravel. Few 3-6-inch cobbles.		
Photo 75'		75		Trace silt 76-78'.		

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	**After Drilling:**	**Hours After:**	**Date Started:**	**Date Completed:**
11'			6/26/2017	6/30/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-14 (R)	Basins 4&5 berm	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
80-100' run Photo 80'			2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	Dense, wet, brownish gray, f-c sandy rounded gravel (GW), f-c sand.		Drilling with 8-inch outer casing and 7-inch sampler.
Photo 85' (Submitted 86-88')		85		With trace silt and clay.		
Photo 90'		90				
Photo 95'		95		No silt or clay. Thin (likely 1-inch) clay lense.		
Photo 100'				Dense, moist, grayish brown, fine silty sand (SM). Some rusty orange staining.		DTW = 86.1 ft bgs, casing at 100'.
100-120' run		100		Dense, wet, brownish gray, f-c sandy rounded gravel (GW), f-c sand. No f-m sand 102-104'. Coarse.		
Photo 105'		105				
Photo 110'		110		Dense, wet, brownish gray, f-c gravelly sand (SW), f-c rounded gravel, trace silt.		
Photo 115'		115				
Photo 120'				Dense, moist, grayish brown, very fine to fine, poorly graded sand (SP).		Confining layer (Qf)

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
11'			6/26/2017	6/30/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-14 (R)	Basins 4&5 berm	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
120-140' run			2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	SAME: Dense, moist, grayish brown, very fine to fine, poorly graded sand (SP).		Drilling with 8-inch outer casing and 7-inch sampler.
Photo 125'		125				
				Medium stiff, moist, grayish brown, low plastic silt (ML).		
				Dense, moist, grayish brown, very fine to fine silty sand (SM).		
Photo 130' (Submitted 130-132')		130		Medium stiff, moist, grayish brown, low plastic silt (ML).		6/26/17: Drilled 0-140', casing at 130'. Set casing at 130' in bentonite chips from 129-131'.
Photo 135'		135				6/27/17: DTW = 109 ft bgs, casing at 130' in bentonite seal.
				Dense, moist, grayish brown, very fine to fine silty sand (SM). Some rusty orange staining. Occasional 1-inch silt lense.		Drilling with 7-inch outer casing and 6-inch sampler.
140-145' run Photo 140'		140				
145-160' run		145				Some issues with heaving sand in casing.
		150				
		155				
				Very fine to fine sand (SP) lense, 156-158'.		

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
11'			6/26/2017	6/30/2017

Boring Log

Project Name		Project No.	Drilling Company
LOTT - Hawks Prairie		10021292	Holt Services, Inc.
Boring No	Location		Drilling Rig Type and Drilling Method
MW-14 (R)	Basins 4&5 berm		Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
160-170' run		160-165	2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	SAME: Dense, moist, grayish brown, very fine to fine silty sand (SM). Some rusty orange staining. Occasional 1-inch silt lense. Medium stiff, grayish brown, clayey silt (ML) lense, 162-163'. Clayey silt (ML) lense, with rusty orange staining, 168-168.5'		Drilling with 7-inch outer casing and 6-inch sampler.
170-180' run		170-175				6/27/17: Drilled 140-180'. Casing at 180'.
		~178		Dense, wet, grayish brown, f-c well graded sand (SW), with trace fine rounded gravel.		DTW = 130 ft bgs, casing at 180' (overnight).
180-190' run		180-185		Dense, moist, grayish brown, very fine to fine silty sand (SM). Occasional 1-inch clayey silt lense. Silty clay (CL) lense with iron oxide staining, 185-186'.		Sand heaved up to 160' in casing after removing the 180-190' sample.
		~188		Dense, moist, grayish brown, very fine to fine, poorly graded sand (SP). Occasional 1-inch clayey sand lense. With trace coarse sand, trace fine gravel 191-192'.		
190-200' run		190-195		Dense, moist, grayish brown, very fine to fine silty sand (SM). With trace fine, rounded gravel.		
		~197		Dense, moist, grayish brown, very fine to fine poorly graded sand (SP), with trace fine rounded gravel, trace coarse sand.		6/28/17: Drilled 180-200'.

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
11'			6/26/2017	6/30/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-14 (R)	Basins 4&5 berm	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
200-210' run			2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	Dense, moist, grayish brown, very fine to fine, poorly graded sand (SP), with trace fine rounded gravel. Occasional 1-2-inch clay or silty clay lense.		Drilling with 7-inch outer casing and 6-inch sampler. Adding water to casing to control heaving sand.
		205				
210-230' run		210				
				6-inch silty clay (CL) lense with iron oxide staining.		
		215				
		220		With trace medium to coarse sand, 220-222'.		
		225				
				Very fine to fine sandy silt (ML) and low plastic clay (CL) lense, with iron oxide staining, 227-228'.		
230-260' run		230				
		235				
				Stiff, moist, brownish gray, very fine to fine silty sand (SM) lense, 236-238'.		

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
11'			6/26/2017	6/30/2017

Boring Log

Project Name		Project No.	Drilling Company
LOTT - Hawks Prairie		10021292	Holt Services, Inc.
Boring No	**Location**		**Drilling Rig Type and Drilling Method**
MW-14 (R)	Basins 4&5 berm		Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
230-260' run			2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	SAME: Dense, moist, grayish brown, very fine to fine, poorly graded sand (SP), with trace fine rounded gravel. Occasional 1-2-inch clay or silty clay lense.		Drilling with 7-inch outer casing and 6-inch sampler.
		245		Dense, wet, f-c sand (SW) lense with some fine rounded gravel, 245-246'.		
				Stiff, moist, clayey silt (ML) lense, 248-248.5'.		
				F-c sand (SW) and fine gravel lense, 248.5-249'.		
		250				
				Very fine to fine silty sand (SM) lense, 252-253'.		
		255		F-c sand (SW) and fine rounded gravel lense, 255-256'.		
				Stiff, silty clay (CL) lense, 257-257.5'.		
260-290' run		260				
		265		F-c sand (SW) lense with trace fine gravel, 267-268'.		
				Stiff, moist, brownish gray, very fine to fine silty sand (SM).		
		270				
				Stiff, moist, brownish gray, low plastic silty clay (CL).		
		275				
				Dense, moist, brownish gray, very fine to fine silty sand (SM).		
				With trace fine rounded gravel.		

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	**After Drilling:**	**Hours After:**	**Date Started:**	**Date Completed:**
11'			6/26/2017	6/30/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-14 (R)	Basins 4&5 berm	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
260-290' run (cont.)			2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	Stiff, moist, brownish gray, non-plastic silt (ML).		Drilling with 7-inch outer casing and 6-inch sampler.
		285				
				With some very fine to fine sand.		
				Hard, dry, brown to pinkish tan, f-c sandy gravelly clay (CL), rounded gravel. Few 3-4-inch cobbles.		Till. Hard.
		290				
290-310' run				Dense, wet, grayish brown, f-c gravelly sand (SW), f-c rounded gravel, trace clay. Few 3-5-inch cobbles.		6/29/17: Drilled 200-290', casing at 290'.
				Hard, gravelly clay (CL) lense with cobbles, 292-293'.		
				Dense, wet, grayish brown, f-c clayey sand (SC) with f-c rounded gravel. Few 3-5-inch cobbles.		
		295				
				Fine rounded gravel lense with trace m-c sand, 299-300'.		
		300				
		305				
				Stiff, dry, brown to pinkish tan, highly plastic gravelly clay (CH), f-c rounded gravel.		
(Submitted 308-310')				Wet, brown, f-c gravelly sand lense, 308-309'.		
				Dense, wet, grayish brown, f-c well graded sand (SW), with trace fine rounded gravel.		Qc aquifer
		310				
310-330' run						
		315				

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
11'			6/26/2017	6/30/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-14 (R)	Basins 4&5 berm	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
310-330' run (cont.)			2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	SAME: Dense, wet, grayish brown, f-c well graded sand (SW), with trace fine rounded gravel.		Drilling with 7-inch outer casing and 6-inch sampler.
		325				
330-360- run		330		Dense, wet, brown, fine to medium, poorly graded sand (SP) with little gravel up to 2-inch.		Boring logged by John Koreny below 330'.
		335		Dense, brown, wet, fine, poorly graded sand (SP) with trace gravel up to 0.5-inch.		
(Submitted 338-340')						
		340				
		345				
		350				
		355				

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
11'			6/26/2017	6/30/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-14 (R)	Basins 4&5 berm	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
360-390' run			2.5-inch Sch. 80 PVC monitoring well, screened from 310-330 ft bgs. Flush-mount completion.	SAME: Dense, brown, wet, fine, poorly graded sand (SP) with trace gravel up to 0.5-inch.		Drilling with 7-inch outer casing and 6-inch sampler.
		365		Dense, damp, brown, fine poorly graded sand (SP) and silt.		Lower confining unit (TQu)
		370		Dense, damp, black, silty clay (CL) with trace fine sand.		
		375				
(Submitted 378-380')						
		380				
		385				
				Bottom of borehole @ 390', 17:30 on 6/30/17.		
		390				
		395				

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler, John Koreny	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
11'			6/26/2017	6/30/2017

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc

Boring No	Location	Drilling Rig Type and Drilling Method
MW-15 (B1)	Recharge Basin #4 (west)	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run			4-inch Sch. 80 PVC monitoring well, screened from 75-95 ft bgs. Above grade completion.	Loose, dry, gray, medium to fine sand (SW).	TOC = 219.20 ft MSL	Drilling with 8-inch casing and 7-inch sampler.
				Medium dense, dry, f-c gravel (GW), trace sand.		
		5				
Photo 8-10'				With silt from 9-10'.		
10-20' run		10		Medium dense, damp to moist with depth, brownish gray, well graded sand (SW), with f-c gravel. With silt and less gravel from 11-13'.		
		15				
(Submitted 18-20') Photo 18-20'				With silt and less gravel from 18-19'.		
				Stiff, moist, brownish gray silt (ML), trace fine sand.		
20-30' run		20		Dense, wet, brownish gray, f-c gravel (GW), with medium to coarse sand, trace silt, trace cobbles up to 3-6-inch. Saturated, medium sand with silt lense, no gravel, from 22-23'.		Qva outwash.
		25				
(Submitted 28-30') Photo 28-30'						
30-50' run		30		Medium dense, wet, brownish gray, medium to coarse sand (SW), with rounded f-c gravel to 2-inch, trace silt. With silt from 30-31'.		
		35				
(Submitted 38-40') Photo 38-40'						

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Josh Marsh (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
80-ft bgs			7/31/2017	8/1/2017 (well installed 8/2)

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc

Boring No	Location	Drilling Rig Type and Drilling Method
MW-15 (B1)	Recharge Basin #4 (west)	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
30-50' run			4-inch Sch. 80 PVC monitoring well, screened from 75-95 ft bgs. Above grade completion.	Dense, wet, brownish gray, f-c gravel (GW), with medium to coarse sand, with silt, trace cobbles up to 3-6-inch.		Saturated at 40-42'
				Considerably more silt from 44-46'.		
		45				
(Submitted 48-50')						
Photo 48-50'				Considerably more sand with silt at 50'		
50-70' run		50		Medium dense, wet, brownish gray, well graded sand (SW), trace rounded gravel and silt.		
				Medium dense, wet, brownish gray, f-c gravel (GW), with medium to coarse sand, trace silt, trace cobbles up to 3-4-inch.		Saturated at 54'
		55				
(Submitted 58-60')				Wet, medium to fine sand with silt lense from 57-58'		
Photo 58-60'				Medium dense, wet, brownish gray, f-c gravel (GW), with silt, trace medium to coarse sand, trace cobbles up to 3-4-inch.		Saturated at 58-60'
		60				
		65				
(Submitted 68-70')						
Photo 68-70'						
70-90' run		70		Stiff, damp, gray, silt (ML), with gravel.		
				Medium dense, wet, brownish gray, f-c gravel (GW), with silt, with medium to coarse sand.		
		75				
(Submitted 78-80')				More silt from 78-80', not as wet		
Photo 78-80'					▽	

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Josh Marsh (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
80-ft bgs			7/31/2017	8/1/2017 (well installed 8/2)

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc

Boring No	Location	Drilling Rig Type and Drilling Method
MW-15 (B1)	Recharge Basin #4 (west)	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
70-100' run			4-inch Sch. 80 PVC monitoring well, screened from 75-95 ft bgs. Above grade completion.	Very stiff, moist, dark grey, silt (ML), with f-c gravel, trace clay and sand. (Till).		Till.
				Dense, saturated, brownish grey, f-c rounded gravel (GW), with silt, with medium to coarse sand.		Qva outwash.
		85		Medium dense, wet, brownish gray, medium sand (SP), with rounded f-c gravel.		
Photo 88-90'						
		90		Medium dense, wet, brownish gray, f-c rounded gravel (GW), with silt, with medium sand.		
		95		Silty sand lense at 97' More sand below 97', still rounded gravel, trace silt		
Photo 98-100'				Med dense, moist to wet, grayish brown, fine sand (SP).		Boring terminated at 100 ft bgs.
		100		Bottom of Boring at 100 ft bgs.		
		105				
		110				
		115				

Water Level	Logged By:	Drilled/Sampled By:
	Chad Hearn	Josh Marsh (Holt)

While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
80-ft bgs			7/31/2017	8/1/2017 (well installed 8/2)

Boring Log

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc

Boring No	Location	Drilling Rig Type and Drilling Method
MW-16 (B2)	Recharge Basin #4 (east)	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run			4-inch Sch. 80 PVC monitoring well, screened from 74.5-94.5 ft bgs. Above grade completion.	Soft, dry, grayish brown, m sand (SP), with some fine sand.	TOC = 219.34 ft MSL	Drilling with 8-inch casing and 7-inch sampler.
Photo 3-5'				Medium dense, dry to slightly moist with depth, brownish gray, f-c rounded gravel (GW), with sand, trace silt, trace cobbles up to 6-inch.		
		5				
				M dense, dry, gray, f-c silty gravel (GM), with sand.		
Photo 8-10'				Medium dense, wet, brown, medium sand (SP), with silt, trace rounded f-c gravel.		
10-20' run		10				
Photo 13-15'						
		15				
(Submitted 18-20')				With more rounded gravel and trace cobbles up to 6-inch.		
Photo 18-20'						
20-30' run		20		Medium dense, moist, brown, medium sand (SP), with silt.		
				Medium dense, wet, brown, silty sand (SM), with f-c gravel.		
Photo 23-25'				Becomes brownish gray.		
		25		With more gray clayey silt.		
(Submitted 28-30')				Wet, brown, medium sand (SP), trace silt, trace gravel.		
Photo 28-30'				Loose, wet, brownish gray, sand (SP), trace gray silt.		
30-50' run		30		Medium dense, wet, grayish brown, f-c gravel (GW), with sand, trace silt.		Qva outwash.
Photo 33-35'						
		35				
(Submitted 38-40')				Medium dense, moist, brown, sand (SP), trace silt.		
				Stiff, dry to slightly moist, brown clayey silt (ML).		
Photo 38-40'				Dense, wet, brownish gray, f-c gravel, with silt and sand.		

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Pete Rosenberg (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
77-ft and 81-ft bgs			8/3/2017	8/3/2017 (well installed 8/4)

Project Name		Project No.	Drilling Company
LOTT Hawks Prairie		10021292	Holt Services, Inc
Boring No	**Location**		**Drilling Rig Type and Drilling Method**
MW-16 (B2)	Recharge Basin #4 (east)		Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
40-50' run			4-inch Sch. 80 PVC monitoring well, screened from 74.5-94.5 ft bgs. Above grade completion.	Soft, wet, brownish gray, sandy silt (ML), with f-c gravel.		
Photo 43-45'				Dense, wet, grayish brown, medium to coarse sand (SW), with f-c gravel and clayey silt.		
		45		Same as above, but brownish gray and slightly more silt.		
(Submitted 48-50')				Medium dense, wet, brown, medium to coarse sand (SW), trace silt and f-c rounded gravel.		
Photo 48-50'				Becomes brownish gray.		
50-60' run		50		Dense, wet, brownish gray, f-c gravel (GW), with medium to coarse sand, trace silt, trace cobbles up to 4-6-inch.		
Photo 53-55'				With silt lense from 53-55'		
		55				
(Submitted 58-60')				With silt from 58-59'		
Photo 58-60'						
60-65' run		60				
Photo 63-55'						
65-75' run		65				
(Submitted 68-70')						
Photo 68-70'						
		70				
Photo 73-75'				More medium sand from 74-75'		
75-80' run		75			▽	
(Submitted 78-80')				More medium sand from 78-80'		Water level = 77' with casing at 80', open hole to 82'.
Photo 78-80'						

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Pete Rosenberg (Holt)
While Drilling:	**After Drilling:**	**Hours After:**	**Date Started:**	**Date Completed:**
77-ft and 81-ft bgs			8/3/2017	8/3/2017 (well installed 8/4)

Boring Log

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc

Boring No	Location	Drilling Rig Type and Drilling Method
MW-16 (B2)	Recharge Basin #4 (east)	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
80-90' run; Photo 83-85'; Photo 88-90'		85	4-inch Sch. 80 PVC monitoring well, screened from 74.5-94.5 ft bgs. Above grade completion.	Loose, wet, brown, medium sand (SP), some coarse sand, trace rounded gravel.		Water level = 81' with casing at 90', open hole to 92'.
				Loose, wet, brown medium sand (SP). Trace gravel from 89-90'		
90-100' run; Photo 93-95'; Photo 98-100'		90, 95		Dense, wet, brownish gray, f-c gravel (GW), with medium to coarse sand, trace silt, trace cobbles up to 4-inch.		
100-110' run; Photo 103-105'		100		Loose, moist, brown, fine sand (SP). Clean. Trace silt from 103-105'		
Photo 108-110'		105		Medium stiff, moist, brown, silt (ML), with fine sand, orange staining.		
				Medium stiff, wet, brown, low plastic silt (ML), with orange staining.		Boring terminated at 110 ft bgs.
		110, 115		Bottom of Boring at 110 feet bgs.		

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Pete Rosenberg (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
77-ft and 81-ft bgs			8/3/2017	8/3/2017 (well installed 8/4)

Boring Log

Project Name	Project No.	Drilling Company
LOTT	LOTT RWS	Cascade Drilling Co.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-20	Lacey, WA	Sonic Rig Driven Casing

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet bgs)	Remarks
				Loose, moist, brown, organic, silty SAND and GRAVEL	0-5	
		5				
		10		Dense, moist, gray, SILT, SAND, and GRAVEL; (Till)	5-16	
		15				
				Loose, moist, brownish-gray, fine to medium SAND, little gravel, trace silt	16-20	
		20		Loose, damp, brown SAND and GRAVEL, trace silt	20-21.5	
				Dense, brown-gray SAND, GRAVEL, SILT; (Till)	21.5-22	
				Loose, damp, brown, silty fine SAND, trace gravel	22-23.5	
				Dense, brown-gray SAND and GRAVEL (Till)	23.5-24	
		25		Loose, damp, brown SILT, SAND, GRAVEL	24-26.5	
				Dense, brown-gray SAND and GRAVEL (Till)	26.7-27	
				Loose, damp, brown SILT SAND GRAVEL	27-29	
				Dense, moist, brown SILT	29-29.5	
				Fine to coarse SAND and GRAVEL, trace silt	29.5-30	
		30				
		35		Dense, moist, gray SAND, SILT, GRAVEL; (Till)	30-40	
		40				

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer and John Koreny	
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
			1/9/2017	1/13/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT	LOTT RWS	Cascade Drilling Co.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-20	Lacey, WA	Sonic Rig Driven Casing

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet bgs)	Remarks
				Dense, brown-gray SAND SILT GRAVEL; (Till)	40-45	
		45		Brown-gray, fine to coarse SAND and GRAVEL, trace silt	45-50	
		50		Dense, damp, gray SAND, SILT, GRAVEL; (Till)	50-55	
		55		Dense, silty SAND and GRAVEL	55-57	
				Dense, damp, gray SAND, SILT, GRAVEL; (Till)	57-60	
		60		Dense, damp, gray, SAND, SILT, GRAVEL; (Till)	60-64	
		65		Dense, silty SAND and GRAVEL	64-70	
		70		Dense, damp, gray SAND, SILT, GRAVEL; (Till)	70-72	
				Loose, dry, gray-brown SAND and GRAVEL, trace silt	72-75	
		75		Loose, dry, brown SAND and GRAVEL, some silt	75-80	
		80				

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer and John Koreny	
While Drilling:	After Drilling:	Hours After:	Date Started: 1/9/2017	Date Completed: 1/13/2017

Project Name	Project No.	Drilling Company
LOTT	LOTT RWS	Cascade Drilling Co.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-20	Lacey, WA	Sonic Rig Driven Casing

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet bgs)	Remarks
		80		Loose, dry, brown-gray, silty SAND and GRAVEL	80-82	
				Loose, dry, gray SAND and GRAVEL, trace silt	82-84	
		85		Loose, dry, gray SAND and GRAVEL, some silt	84-90	
		90		Compressed, dry, silty SAND and GRAVEL	90-94	
		95		Loose, dry, SAND and GRAVEL, some silt	94-98	
				Dry, silty SAND and GRAVEL	98-100	
		100		Loose, moist SAND and GRAVEL, some silt	100-106	
		105		Loose, moist, silty SAND and GRAVEL	106-110	
		110		Loose, damp, brown-gray SAND and GRAVEL, trace silt	110-115	
		115		Loose, damp, brown, fine SAND, some gravel	115-120	
		120				

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer and John Koreny	
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
			1/9/2017	1/13/2017

Project Name		Project No.	Drilling Company
LOTT		LOTT RWS	Cascade Drilling Co.
Boring No	Location		Drilling Rig Type and Drilling Method
MW-20	Lacey, WA		Sonic Rig Driven Casing

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet bgs)	Remarks
				Loose, dry, gray SAND, GRAVEL, SILT	120-123	
		125		Loose, fine sand, SAND and GRAVEL, trace silt	123-130	
		130, 135		Mostly loose, some compacted, mostly damp - mottled dry, SAND and GRAVEL, some silt	130-140	
		140, 145		Dense, water present, brown, medium SAND, some gravel	140-150	
		150, 155		Dense, water present, brown, medium to fine SAND, some gravel	150-159	
		160		Dense, water present, brown, medium to fine SAND, some gravel, trace silt	159-160	

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer	
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
			1/9/2017	1/13/2017

Project Name		Project No.	Drilling Company		
LOTT		LOTT RWS	Cascade Drilling Co.		
Boring No	Location		Drilling Rig Type and Drilling Method		
MW-20	Lacey, WA		Sonic Rig Driven Casing		

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet bgs)	Remarks
		160–170		Dense, water present, brown, medium to fine SAND, some gravel	160-170	
		170–180		Dense, water present, brown fine SAND, some gravel	170-180	
		180–187		Water present, brown fine SAND	180-187	
		187–190		Looser, brown, medium to fine SAND and GRAVEL	187-190	
		190–191		Wet, brown, SAND and GRAVEL, some silt	190-191	
		191–192		Dense, wet, brown SILT, trace sand	191-192	
		192–195		fine to medium SAND and GRAVEL, trace silt	192-195	
		195–197		Fine SAND, some gravel	195-197	
		197–200		Fine SAND, SILT	197-200	

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer	
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
			1/9/2017	1/13/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT	LOTT RWS	Cascade Drilling Co.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-20	Lacey, WA	Sonic Rig Driven Casing

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet bgs)	Remarks
		200		Fine SAND, trace silt	200-205	
		205		Fine SAND, some silt	205-210	
		210		Fine to medium SAND	210-215	
		215		Fine to medimu SAND, some silt	215-220	
		220		Fine to medium, silty SAND	220-225	
		225				
		230				

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer	
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
			1/9/2017	1/13/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-21 (P)	Twin Oaks Rd.	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run		0	2.5-inch Sch. 80 PVC monitoring well, screened from 220-240 ft bgs. Flush-mount completion.	Wood chips, organic soil.	TOC = 227.16 ft MSL	Drilling with 9-inch casing and 8-inch sampler.
		1		Medium dense, dry, brown, f-m gravelly sand (SP) with some silt, f-c rounded gravel.		
		2		Becomes rusty brown at 2'.		Qvr
		4		Becomes yellowish brown at 4'.		Using straight bit.
		5		Becomes tannish gray at 5'.		
Photo 10'		10				
10-20' run		10		Medium stiff, dry, brownish gray, low plastic gravelly clay (CL) with trace silt and f-c sand, f-c rounded gravel.		Till.
		15				
		18		More sand, less clay.		
Photo 20'		20				
20-30' run		20		Becomes moist.		
		21		Medium dense, moist, brownish gray, fine clayey sand (SC).		
		25				
		26		Medium dense, dry, brownish gray, fine, poorly graded sand (SP).		
Photo 30'		30				
30-40' run		30		Medium dense, moist, brownish gray, f-c gravelly sand (SW) with trace clay, f-c rounded gravel, few 3-6-inch rounded cobbles.		Outwash (Qva).
		35				
Photo 40'		38		Medium dense, moist, brownish gray, f-c sandy rounded gravel (GW) with trace clay, f-c sand, few 3-6-inch cobbles.		

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
132'			7/10/2017	7/17/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-21 (P)	Twin Oaks Rd.	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
40-50' run			2.5-inch Sch. 80 PVC monitoring well, screened from 220-240 ft bgs. Flush-mount completion.	Dense, moist, grayish brown, f-m sand (SP) with some f-c rounded gravel, trace c sand, few 3-6-inch rounded cobbles.		Drilling with 9-inch casing and 8-inch sampler.
				Wet, f-c gravel (GW) lense, trace clay, 42-43'.		
		45				
				Dense, moist, grayish brown, f-c sandy rounded gravel (GW), f-m sand, few 3-6-inch rounded cobbles.		
Photo 50'						
50-60' run		50				
				Not as wet, moist.		
(Submitted 54-56')		55				
Photo 60'						
60-70' run		60		With trace clay.		
		65				
				6-inch dry, stiff, gravelly clay lense.		
				Dense, wet, brownish gray, f-c sandy rounded gravel (GW), m-c sand, trace clay, few 3-6-inch rounded cobbles.		Free water in sampler. Perched zone.
Photo 70'						
70-80' run		70				
		75				
				Sand becomes finer, f-c.		
Photo 80'						

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
132'			7/10/2017	7/17/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-21 (P)	Twin Oaks Rd.	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
80-90' run			2.5-inch Sch. 80 PVC monitoring well, screened from 220-240 ft bgs. Flush-mount completion.	Dense, wet, brownish gray, f-c rounded gravel (GW) with trace coarse sand, trace clay.		Drilling with 9-inch casing and 8-inch sampler.
				Dense, wet, brownish gray, f-c sandy rounded gravel (GW), f-c sand, trace silt and clay.		
		85				
				4-inch dry, gravelly clay (CL) lense.		
				Less fine sand.		
Photo 90'						
90-100' run		90				Switch to auger bit; sample fell out.
				Dense, wet, brownish gray, f-c rounded gravel (GW) with some m-c sand, trace silt and clay.		
		95				
						7/10/17: Drilled 0-100'.
Photo 100'						7/11/17: No water in casing after overnight. Casing at 100'. Tagged wet soil in casing at 94 ft bgs.
100-110' run		100		With few 3-6-inch rounded cobbles.		
		105				
				Becomes brown, trace medium sand.		
				Dense, dry, brownish gray, f-c clayey rounded gravel (GC), trace f-c sand, few 3-6-inch rounded cobbles.		Dry.
Photo 110'						
110-120' run		110		Stiff, dry, light brown, low plastic clay (CL).		
				With some f-c rounded gravel below 112.5'.		
		115		Dense, moist, brownish gray, f-c clayey gravel (GC), with some f-c sand, trace silt.		
				Less clay.		
Photo 120'						

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
132'			7/10/2017	7/17/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-21 (P)	Twin Oaks Rd.	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
120-130' run			2.5-inch Sch. 80 PVC monitoring well, screened from 220-240 ft bgs. Flush-mount completion.	SAME: Dense, moist, brownish gray, f-c clayey gravel (GC), with some f-c sand, trace silt.		Drilling with 9-inch casing and 8-inch sampler.
		125				
				6-inch moist, f-c sand (SW) lense.		
Photo 130'						
130-140' run		130			▽	
				Dense, wet, brownish gray, f-c gravelly sand (SW), f-c rounded gravel.		
		135		4-inch silty sand (SM) lense at 135'.		DTW = 135 ft bgs, casing at 140'.
(Submitted 136-138')				Dense, wet, brownish gray, f-m, poorly graded sand (SP).		
				Dense, wet, brownish gray, f-c sand (SW), with some f-c rounded gravel.		
Photo 140'						
140-150' run		140		Medium stiff, moist, grayish brown, low plastic silt (ML), with some clay. Low plastic clay (CL) lense with rusty orange iron oxide staining, 142.5-144'. No clay 144-145'.		Confining layer (Qf).
		145				
(Submitted 148-150')						7/11/17: Set casing in bentonite chips at 150'; bentonite from 147-150'.
Photo 150'						
150-160' run		150				
		155				
Photo 160'						7/11/17: Drilled 100-160'.

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
132'			7/10/2017	7/17/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-21 (P)	Twin Oaks Rd.	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
160-170' run			2.5-inch Sch. 80 PVC monitoring well, screened from 220-240 ft bgs. Flush-mount completion.	SAME: Medium stiff, moist, grayish brown, low plastic silt (ML), with some clay. Some iron oxide staining.		Drilling with 8-inch casing and 7-inch sampler.
		165		Dense, moist, brownish gray, f-m, poorly graded sand (SP), with some silt and clay, trace f-c rounded gravel, few 3-6-inch rounded cobbles.		
				No clay, trace silt.		
170-180' run		170		No gravel, no cobbles.		
				6-inch clayey silt (ML) lense.		
		175		With trace coarse sand.		
Photo 180'						
180-200' run		180		Dense, wet, brownish gray, fine, poorly graded sand (SP), with trace m-c sand, trace silt.		Free water in sample.
		185				
(Submitted 186-188')						
Photo 190'		190		Dense, moist, brownish gray, fine silty sand (SM).		Moist only.
				Stiff, moist, clayey silt (ML) lense, iron oxide staining, trace f-c rounded gravel, 193-194'.		
		195		Dense, wet, brownish gray, f-c sandy gravel (GW), f-c sand, trace silt, some 3-6-inch rounded cobbles.		Wet. Qc aquifer (estimated at 195')
				Becomes moist.		Moist only.
Photo 200'				4-inch clay (CL) lense with iron oxide staining.		

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
132'			7/10/2017	7/17/2017

HDR

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-21 (P)	Twin Oaks Rd.	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
200-220' run			2.5-inch Sch. 80 PVC monitoring well, screened from 220-240 ft bgs. Flush-mount completion.	Dense, moist, dark brown, f-c sandy rounded gravel (GW), with some clay, few 3-6-inch rounded cobbles.		Drilling with 8-inch casing and 7-inch sampler.
				Dense, wet, reddish brown, f-c well graded rounded gravel (GW), with trace f-c sand, trace clay, few 3-6-inch cobbles.		
		205		Dense, moist, grayish brown, f-c sandy rounded gravel (GW), f-c sand, with trace silt, trace clay, some iron oxide staining		
				Dense, moist, grayish brown, f-c gravelly sand (SW), f-c rounded gravel, trace silt, trace clay.		
Photo 210'		210		Dense, moist, grayish brown, f-c sandy gravel (GW), f-c sand, some silt, trace clay, few 3-6-inch rounded cobbles.		
		215		Dense, moist, grayish brown, fine silty sand (SM), with trace f-c rounded gravel, few 3-6-inch rounded cobbles. 2-inch stiff, gravelly clay (CL) lense at 217.9'.		
Photo 220'				Dense, moist, grayish brown, f-c sandy rounded gravel (GW), f-c sand, with trace silt, trace clay.		
220-230' run		220		Becomes wet.		Wet.
		225		Dense, moist, brown, f-c sand (SW) with some f-c rounded gravel, few 3-6-inch rounded cobbles, trace silt, some iron oxidation.		Moist only.
(Submitted 228-230')				3-inch wet, orangish brown, f-c rounded gravel (GW) lense.		
Photo 230'				Less fines, less fine sand.		
230-240' run		230		Dense, wet, grayish brown, f-m sand (SW), trace coarse sand,		
		235		Dense, moist, grayish brown, f-m sand (SP), trace f-c rounded gravel, few 3-6-inch rounded cobbles.		7/12/17: Drilled 160-240', casing set to 240'.
Photo 240'						7/13/17: DTW = 159 ft bgs

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
132'			7/10/2017	7/17/2017

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-21 (P)	Twin Oaks Rd.	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
240-250' run Sample fell out; retrieved using flapper bit.			2.5-inch Sch. 80 PVC monitoring well, screened from 220-240 ft bgs. Flush-mount completion.	Dense, moist to wet, gray, fine, poorly graded sand (SP), with trace m-c sand, some silt, trace fine rounded gravel. Disturbed sample 240-250'.		Drilling with 8-inch casing and 7-inch sampler. Switch to flapper bit to retrieve sample.
		245				
				No coarse sand, no gravel.		
Photo 250'						
250-260' run		250				Switch to auger bit.
				F-m sand becomes slightly finer.		Floating/ partitioned sand and muck is up in casing to 211', causing sammpler to jam often. Black wood also found floating on water in casing. Driller is adding water to casing.
				Less silt (trace).		
		255				
Photo 260'						
260-270' run Sample fell out; retrieved using flapper bit.		260		More silt (some). Disturbed sample 260-269'.		Switch to flapper bit to retrieve sample.
		265				
						7/13/17: Drilled 240-270'. At end of day: pulling casing out to get muck to fall out.
Photo 270'				1' v dense, dry, gray, fine silty sand (SM) lense, trace clay.		
270-280' run		270		Dense, moist, gray, fine, poorly graded sand (SP), with trace m-c sand.		
				Dense, moist, fine silty sand (SM), with ocassional 1-2-inch silt (ML) lenses.		
		275				
Photo 280'						DTW = 134 ft bgs, casing at 280', sampled to 290'.

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
132'			7/10/2017	7/17/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-21 (P)	Twin Oaks Rd.	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
280-290' run			2.5-inch Sch. 80 PVC monitoring well, screened from 220-240 ft bgs. Flush-mount completion.	Dense, moist, gray, fine, poorly graded sand (SP), with some silt, trace m-c sand.		Drilling with 8-inch casing and 7-inch sampler.
		285		Trace silt.		
				1-ft f-c gravelly sand (SW) lense, fine rounded gravel.		
				Trace fine, rounded gravel.		7/14/17: Drilled 270-290', casing at 280' and jammed inside 9-inch casing.
Photo 290'		290				
290-300' run				1-ft f-c gravelly sand (SW) lense, fine rounded gravel.		7/17/17: DTW = 107.5 ft bgs, casing at 280'.
				0.5-inch stiff, brown clay (CL) lense.		Casing moved ok on 7/17/17.
		295				
Photo 300'		300				
300-310' run				3-inch stiff, dry, low plastic clay (CL) lense.		
		305		6-inch stiff, dry, low plastic silty clay (CL) lense.		
				Increasing medium sand, less fine sand (SP), 306-308'.		
				Some silt.		7/17/17: Drilled 290-310', casing to 290'.
Photo 310'		310		Bottom of borehole @ 310', 7/17/17.		
		315				

Water Level			Logged By:	Drilled/Sampled By:
			Adam Kessler	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
132'			7/10/2017	7/17/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-23 (Q)	30th Ave. NE	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run		0	2.5-inch Sch. 80 PVC monitoring well, screened from 259.8-289.8 ft bgs. Flush-mount completion.	Dry to moist. F-c gravelly sand (SW). Trace clay.	TOC = 204.54 ft MSL	Drilling with 8-inch casing, 7-inch sampler.
		2		Dry to moist. M-c gravelly sand (SW). Some clay.		Qvr
		5				
Photo 10'		10				
10'-20' run		10		Moist. Brown. F-c gravelly sand (SW). Trace clay.		
		11		Wet. Brown. F-c gravel (GW). Some f-c sand. Trace clay.		
		13		Moist. Brown. M-c gravelly sand (SW). Trace clay.		
		15				
Photo 20'		20				
20'-30' run		20		Moist. Brown -gray. F-c gravel (GW). Some f-c sand. Trace clay.		
		25				
		28		28'-30' inceases in clay content to some clay.		
Photo 30'		30				
30'-40' run		30		Moist. Brown-gray. F-c gravelly sand (SW). Some clay.		
		32		Moist. Brown gray. Clayey gravel. (GC). Trace f - c sand. Very sticky. Till.		Till (Qvt)
		35				
		36		36' - 37' gravelly clay (CL) lense.		
		38		Dry. Gray mottled. F-c gravelly sand (SW). Some clay. Till.		
Photo 40'		40				

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
75 ft bgs			7/10/2017	7/13/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-23 (Q)	30th Ave. NE	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
40'-50' run		40	2.5-inch Sch. 80 PVC monitoring well, screened from 259.8-289.8 ft bgs. Flush-mount completion.	Wet. F-c sandy gravel (GW). Dominated by coarse gravel. Some clay, sticky.		
				Wet. F-c gravel (GW). Some f-c sand. Trace clay, trace silt. Cobbles.		Qva
		45				
Photo 50'						
50'-60' run		50		Wet. Brown. F-c gravelly sand (SW). Trace clay.		
				Brown. F-m gravelly sand (SP). F-c gravel. Trace silt.		
		55				
Photo 60'						
60'-70'run		60				
				Moist. Gray. Fine sand (SP). Some gravel. Lenses of trace silt, 64-65'.		
		65				
Photo 70'						
70'-80' run (Submitted 72-74')		70				
				Moist. Gray. F-m sand (SP). Trace gravel.	▽	
		75		Wet. Gray. F-c gravelly sand (SW). Cobbles. Tr silt.		
				Dense. Moist. Gray-brown. Low plasticity. Gravel, silt and clay (GC). Trace sand. Till.		
Photo 80'		80		Moist. Gray-brown. Sandy gravel. (GW). Some silt and clay.		

Water Level			Logged By: Ida Fischer	Drilled/Sampled By: Ben Johnson
While Drilling: 75 ft bgs	After Drilling:	Hours After:	Date Started: 7/10/2017	Date Completed: 7/13/2017

Project Name		Project No.	Drilling Company
LOTT - Hawks Prairie		10021292	Holt Services, Inc.
Boring No	**Location**		**Drilling Rig Type and Drilling Method**
MW-23 (Q)	30th Ave. NE		Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
80'-90' run		80	2.5-inch Sch. 80 PVC monitoring well, screened from 259.8-289.8 ft bgs. Flush-mount completion.	Moist. Gray. F-c gravelly sand (SW). Trace clay.		
				Dense. Moist. Brown. F-c clayey gravelly sand (SC). F-c gravel. Cobbles. Till.		Till
				Moist. Brown-gray. F-c gravelly sand (SW). Trace clay.		
		85		Wet. Brown-red. F-c sandy gravel (GW). Small cobbles. Trace silt.		
Photo 90'				Dense. Wet. Gray-brown. Well graded gravelly sand (SW). Trace silt.		
90'-100' run		90				
				Wet. Brown. F-m sand (SP). Trace c. sand. Trace silt.		
(Submitted 95-97')		95		Moist. Brown. F-c gravelly sand (SW). Trace silt.		
				Moist. Brown. F-m sand (SP). Trace c. sand. Trace f-c gravel.		At 16:15 7/10 depth to water 75'. Casing at 110'. At 8:15 on 7/11 depth to water 71.2
Photo 100'						
100'-110' run		100		Wet. Brown-gray fine sand (SP) with trace m-c sand. Trace silt.		
		105		Wet. Brown-gray fine sand (SP) with trace m-c sand. Some fine gravel		
(Submitted 107-109')				Dry. Gray non plastic clay (CL).		Qf confining unit.
Photo 110'						
110'-130' run		110		Dense. Wet. Gray silty fine sand (SM).		Drilling with 7-inch casing, 6-inch sampler, straight bit
				Moist. Gray fine sand (SP). Trace to some silt. Interbedded silty clay layers.		
		115				
Photo 120'		120		6" Dry brown wood with some clay.		

Water Level:			Logged By:	Drilled/Sampled By:
			Ida Fischer	Ben Johnson
While Drilling:	**After Drilling:**	**Hours After:**	**Date Started:**	**Date Completed:**
75 ft bgs			7/10/2017	7/13/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-23 (Q)	30th Ave. NE	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
110'-130' run		120	2.5-inch Sch. 80 PVC monitoring well, screened from 259.8-289.8 ft bgs. Flush-mount completion.	Stiff. Dry to moist. Gray. Non-plastic clay (CL).		
				Moist. Gray. Very fine sand. (SP).		
		125		Stiff. Dry to moist. Gray. Non-plastic silty clay (CL). Dry from 126-128'. Moist and green gray from 128-130'.		
Photo 130'						
130'-150' run		130		Wet. Gray. Fine sand (SP). Layers of trace to some silt. Decreasing silt to almost no silt by 139'.		130-140' sample dropped sample inside casing
		135		2-inch medium plastic clay (CL) lense.		
Photo 140'				6-inch lense. Wet. Brown. Wood with some clay.		Auger bit
		140		Stiff. Dry. Brow-gray. Low plastic clay (CL) with pockets of medium plastic clay.		
		145		Moist. Gray. Very fine sand (SP).		
Photo 150'						
150-170' run		150		Stiff. Gray-brown. Slightly moist. Low to medium plastic clay (CL). Becomes gray, silty clay (CL).		
		155				
Photo 160'		160				

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
75 ft bgs			7/10/2017	7/13/2017

Boring Log

Project Name		Project No.	Drilling Company		
LOTT - Hawks Prairie		10021292	Holt Services, Inc.		
Boring No	**Location**		**Drilling Rig Type and Drilling Method**		
MW-23 (Q)	30th Ave. NE		Terra Sonic 150CC, track-mounted sonic		

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
150-170' run (Submitted 160-162')		160	2.5-inch Sch. 80 PVC monitoring well, screened from 259.8-289.8 ft bgs. Flush-mount completion.	SAME: Stiff. Gray. Slightly moist. Low to medium plastic clay (CL).		
		165		Becomes dark gray. Dry 168-170'. 168: 4" brown black, stiff crumbly wood with clay. 169: 3" brown black, stiff crumbly wood with clay.		
Photo 170'						
170'-180' run		170		Stiff. Moist-dry. Brown. Low to medium plastic silt (ML). Moist, silty fine sand lense 170-170.5.		
				Stiff. Moist. Gray-brown. Low to medium plastic silty clay (CL).		
		175		Becomes dry, gray.		
Photo 180'						Casing at 180 heaved sands to 135'.
180' - 200' run		180		Moist. Blue green. Low plasticity silty clay (CL). Trace fine sand. Sand fraction increases.		Begin drilling with water.
		185		Moist. Fine silty sand (SM). Trace m-c sand. Trace clay.		
				Stiff. Gray. Low plastic silty clay (CL). With ocassional lenses of light brown, fine sandy silt.		
Photo 190'		190				
		195				
Photo 200'		200				

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer	Ben Johnson
While Drilling:	**After Drilling:**	**Hours After:**	**Date Started:**	**Date Completed:**
75 ft bgs			7/10/2017	7/13/2017

HDR

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-23 (Q)	30th Ave. NE	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
200' -220' run		200	2.5-inch Sch. 80 PVC monitoring well, screened from 259.8-289.8 ft bgs. Flush-mount completion.	Stiff. Moist. Gray. Medium plastic silty clay (CL). With some areas of less silt.		
		205		204-210': Dark gray-black. Medium plasticity. Decrease in silt.		
Photo 210'		210				
		215				
Photo 220'						
220' -227' run		220		Medium dense. Moist. Gray. Silty-clayey fine sand (SM).		Changed from auger to straight bit
				Dry. Gray. Gravely clay (CL). Trace sand.		
				Decreasing clay, turning gray to brown.		
				Dry. Brown. F-c clayey gravel (GC). Some c. sand.		
		225		Gravelly clay (CL), 225-226'.		
227' - 234' run				Damp. Gray. Fine sand (SP) lense, trace silt, 227-228'.		
Photo 230'				Dry to moist. Gray and brown. Medium plastic f-c gravelly clay (CL).		
		230		With trace sand.		
234' - 250' run		235		Moist. Gray and brown. Well graded sandy gravel (GW). Some clay.		
Photo 240'		240				

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
75 ft bgs			7/10/2017	7/13/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-23 (Q)	30th Ave. NE	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
234' - 250' run		240	2.5-inch Sch. 80 PVC monitoring well, screened from 259.8-289.8 ft bgs. Flush-mount completion.	SAME: Moist. Gray and brown. Well graded sandy gravel (GW). Some clay. 243-244': increased clay content.		
				Stiff. Dry. Brown-gray. Low plastic clay (CL).		
(Submitted 247-249') Photo 250'		245		Wet. Brown-gray. Sandy gravel (GW). 250.5': 6-inch clay lense		Qc DTW: 150' Casing at 250'
250'-260' run Photo 260'		250 255		Wet. Brown. Sand (SW). Trace gravel. Trace silt. Increased gravel 256-257'.		
260' - 270' run		260		Dense, moist, grayish-brown f-c sand (SW) with trace silt, trace clay, trace f-c rounded gravel, few 3-6-inch cobbles. Gravel increases to some gravel. 5-inch lense, f-c gravelly sand with some fines, iron oxide.		
Photo 270'		265		Dense, wet, grayish-brown, f-c gravelly sand (SW), some silt, trace clay, f-c rounded gravel, few 3-6-inch cobbles. More c. sand 252'. More f-m sand than c. sand, less fines.		
270' - 290' run		270		Dense, wet, grayish-brown, f-c silty sand (SM), some clay, some f-c rounded gravel.		
(Submitted 273-275')		275		Dense, wet, grayish-brown, f-c sand (SW), trace silt, trace clay, some f-c rounded gravel, few 3-6-inch cobbles. Some lenses with some clay. 6-inch lense f-c sandy gravel (GW).		
Photo 280'		280		Dense, wet, grayish-brown, f-c gravelly sand (SW), trace silt, some clay, rounded f-c gravel, few 3-6-inch cobbles.		

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer, Alyssa Chase	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
75 ft bgs			7/10/2017	7/13/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-23 (Q)	30th Ave. NE	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
270 ' - 290' run		280	2.5-inch Sch. 80 PVC monitoring well, screened from 259.8-289.8 ft bgs. Flush-mount completion.	SAME: Dense, wet, grayish-brown, f-c gravelly sand (SW), trace silt, some clay, rounded f-c gravel, few 3-6-inch cobbles. Occasional lenses with less fine sand. 282': Some iron oxidation - reddish brown coloring.		
		285		Dense, wet, grayish brown, f-c sandy gravel (GW), some clay, some silt, f-c sand, few 3-6-inch cobbles, more f. sand and fines closer to 290'.		
Photo 290'						
290' - 310' run		290		Grades to trace clay. Wet, free water 290'-293'.		
				Stiff, moist, brown to light gray, medium plasticity clay (CL), trace gravel, few 3-6-inch cobbles, some iron oxidation.		
		295		5-inch lense brown, f-c sand (SW), some rounded gravel.		
				Dense, wet, grayish-brown, f-c gravelly sand (SW), some silt, trace clay, f-c rounded gravel, few 3-6-inch cobbles.		
Photo 300'		300		Dense, wet, grayish-brown, f-c sand (SW), trace f-c rounded gravel, trace silt and trace clay, few 3-6-inch cobbles.		
				Grades to f-m sand with some c. sand.		
(Submitted 305-307')		305				
				4-inch purple-brown, clayey sand lense with some silt.		
Photo 310'				F-m sand with trace c. sand at 310', more fines.		
310'-320' run		310		Wet, free water.		
				Very stiff, moist, purplish-gray, clay (CL).		
(Submitted 314-316')				Stiff, wet, dark brown-gray, silt (ML) with some clay.		
		315		Dense, wet, brown-gray, f. silty sand (SM), trace clay. No clay, less silt.		
Photo 320'		320		Bottom of boring @ 320'.		

Water Level	Logged By:	Drilled/Sampled By:
	Alyssa Chase	Ben Johnson

While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
75 ft bgs			7/10/2017	7/13/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-25 (K)	Walseth Parcel	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run		0	2-inch Sch. 40 PVC monitoring well, screened from 118-168 ft bgs. Flush-mount completion.	No recovery 0'-5', sample fell out of sampler.	TOC = 228.95 ft MSL	Drilling with 7 inch casing and 6 inch sampler
		5		Very soft, dry, dark brown, non plastic silt (ML), some f-c sand, trace f-c rounded gravel, some clay, few 3-6-inch cobbles, some roots .		Runs are in 5' increments due to large cobbles and/or boulders during drilling (from 5' to 20')
				6-in f-c rounded gravel lense (GW) with trace f-c sand, trace silt.		
Photo 10'				Dense, moist, brownish gray, f-c sandy gravel (GW) with f-c sand, rounded gravel, trace silt, few 3-6-inch cobbles.		
10-15' run		10		Stiff, moist, grayish brown, gravelly clay (CL) with some silt, some f-c sand, f-c rounded gravel, few 3-6-inch cobbles.		Till.
15-20' run		15				
Photo 20'				Dense, moist, grayish brown, f-c sand (SW) with some f-c rounded gravel, some silt, few 3-6-inch cobbles.		Qva outwash.
20-30' run		20		Trace clay Less clay, more m-c sand		
		25		Dense, wet, grayish brown, f-c silty sand (SM) with trace clay, trace f-c rounded gravel, few 3-6-inch cobbles.		
Photo 30'						
30-40' run		30		Dense, wet, light brown, f-c sandy gravel (GW) with f-c sand, rounded gravel, some clay, few 3-6-inch cobbles, clay is highly plastic.		
		35		Color is more brownish gray		
Photo 40'						

Water Level			Logged By:	Drilled/Sampled By:
			Alyssa Chase	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
133 ft bgs			7/18/2017	7/19/2017

Boring Log

Project Name		Project No.	Drilling Company		
LOTT - Hawks Prairie		10021292	Holt Services, Inc.		
Boring No	Location		Drilling Rig Type and Drilling Method		
MW-25 (K)	Walseth Parcel		Terra Sonic 150CC, track-mounted sonic		

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
40-50' run			2-inch Sch. 40 PVC monitoring well, screened from 118-168 ft bgs. Flush-mount completion.	SAME: Dense, wet, brownish gray, f-c sandy gravel (GW) with f-c sand, rounded gravel, some clay, few 3-6-inch cobbles, clay is highly plastic. 6-inch lense: dense, wet, f-c gravelly sand (SW), trace silt, trace clay, f-c rounded gravel, few 3-6-inch cobbles		Drilling with 7-inch casing and 6-inch sampler.
		45				
Photo 50'				Lense with some clay		
50-60' run		50		Increase in f-m sand and decrease to trace clay		
				Decrease in amount of f-m sand		
		55				
				Increase in amount of f-m sand		
				2-ft lense, dense, wet, grayish brown, f-c gravelly sand (SW), trace silt, trace clay, f-c rounded gravel, few 3-6-inch cobbles		
Photo 60'						
60-70' run		60		60-62', trace clay and increase in amount of f-m sand		
				62', back to some clay and decrease in amount of f-m sand		
		65		6-inch lense with some f-m sand		
				Alternating lenses of clayey gravel (GC), and sandy gravel (GW) with some clay.		
Photo 70'						
70-80' run		70		Trace clay		
		75		No clay		
				1-ft lense, dense, wet, grayish brown, f-m sand (SW) with some c sand, some f-c rounded gravel, few 3-6-inch cobbles		
Photo 80'				78-80', trace silt, increase in amount of f-m sand, less wet		

Water Level			Logged By:	Drilled/Sampled By:
			Alyssa Chase	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
133 ft bgs	0	0	7/18/2017	7/19/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-25 (K)	Walseth Parcel	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
80-90' run			2-inch Sch. 40 PVC monitoring well, screened from 118-168 ft bgs. Flush-mount completion.	SAME: Dense, wet, brownish gray, f-c sandy gravel (GW) with f-c sand, rounded gravel, trace silt, few 3-6-inch cobbles.		Drilling with 7-inch casing and 6-inch sampler.
				Less silt from 83' to 88'		DTW=Dry, casing at 80', sampler at 90'
		85				
				Some iron oxidation		
				Slightly drier lense		
Photo 90'						
90-100' run		90		Trace clay from 90' to 100'		
				Some silt		
		95				
				Slightly more f-m sand		
				Less wet, more on the moist side from 98' to 100'		
Photo 100'						
100-110' run		100		More grayish brown		
				Trace silt 100' to 103'		
				Back to some silt, trace clay		
		105				
				107': moist lense, 6-inch with some clay		
Photo 110'				More f-m sand than c sand, more moist than wet		
110-120' run		110		Dense, moist, browninsh gray, f-c clayey gravel (GC), some f-c sand, rounded gravel, some silt, few 3-6-inch cobbles.		DTW=Dry; sampler at 110'
		115				
				116-117'; gray, clay (CL) lense with some f-c rounded gravel, trace f-c sand, trace silt		
				More grayish brown		
Photo 120'						

Water Level			Logged By:	Drilled/Sampled By:
			Alyssa Chase	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
133 ft bgs	0	0	7/18/2017	7/19/2017

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-25 (K)	Walseth Parcel	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
120-130' run			2-inch Sch. 40 PVC monitoring well, screened from 118-168 ft bgs. Flush-mount completion.	SAME: browninsh gray, f-c clayey gravel (GC), some f-c sand, rounded gravel, some silt, few 3-6-inch cobbles.		Drilling with 7-inch casing and 6-inch sampler.
				Stiff, moist, brownish gray, silty clay (CL), with trace f-c sand, trace f-c rounded gravel.		
		125		Dense, moist, grayish brown, f-c silty sand (SM) with trace clay, a few clayey lenses, few 3-6 inch cobbles. 1-ft silty clay (CL) lense, trace f-c, trace f-c rounded gravel.		
Photo 130'				Dense, moist, grayish brown, f-c silty sand (SM), some clay, some f-c rounded gravel. 4-inch lense of hard, moist, low plastic clay (CL)		
130-140' run		130		Dense, moist, grayish-brown, f sand (SP), trace silt, occasional plastic clay lenses, trace c sand.		DTW=Dry, casing at 120', sampler at 130'
				Dense, wet, grayish brown, f-m sand (SP), trace c sand, some f-c rounded gravel.	▽	
Photo 140'		135		Dense, wet, grayish brown, f-c gravelly sand (SW), barely trace silt, rounded gravel.		7-18-2017, drilled to 140', casing to 120'
140-150' run (Submitted 148-150') Photo 150'		140 145		Dense, wet, brownish gray, f-c sandy gravel (GW), f-c sand, rounded gravel, trace silt, trace clay. Clay lenses at 142' with trace gravel (CL) Turns more grayish brown Small, clayey, silty lenses 147': less fines, no silt, no clay		DTW=Dry: 7-19-2017, 1st thing in the morning, caved in at 133'
150-160' run		150		Trace silt, trace clay		DTW=134', sampler to 150', casing to 130'
				Dense, wet, grayish brown, f-c sand (SW) with trace f. gravel, few small silty lenses.		
		155		Dense, wet, grayish brown, f-c gravel (GW) with trace f-c sand, few 3-6-inch cobbles.		
Photo 160'				Dense, wet, ,grayish brown, f-c sandy gravel (GW), f-c sand, rounded gravel, slight trace silt. 159': 1-inch lense of f-c gravel with trace sand		DTW=135', sampler at 160', casing at 150'

Water Level			Logged By:	Drilled/Sampled By:
			Alyssa Chase	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
133 ft bgs	0	0	7/18/2017	7/19/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-25 (K)	Walseth Parcel	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
160-170' run			2-inch Sch. 40 PVC monitoring well, screened from 118-168 ft bgs. Flush-mount completion.	SAME: Dense, wet, ,grayish brown, f-c sandy gravel (GW), f-c sand, rounded gravel, slight trace silt.		Drilling with 7-inch casing and 6-inch sampler.
(Submitted 166-168')		165		Dense, wet, grayish brown, f-c gravelly sand (SW) with f-c rounded gravel.		
				1-ft f-c sandy gravel (GW) lense, f-c sand, rounded gravel, trace silt.		
Photo 170'				Dense, wet, grayish brown, f sand (SP) with trace f gravel, some m sand, trace silt.		Qf confining unit at 169'
170-180' run		170		No gravel after 171'		
(Submitted 171-172')				Less wet, no gravel, small 1/2 inch silty lenses, more brownish gray		
		175		Small silty lenses		
(Submitted 179-180')				Dense, dry, brownish gray, f-c clayey gravel (GC) with trace f-c sand, rounded gravel, few 3-6-inch cobbles.		
Photo 180'						
180-200' run		180		1-ft f-c sandy gravel (GW) lense, f-c sand, trace silt, few 3-6-inch cobbles		DTW=133', casing at 160', sampler at 180'
				Dense, wet, grayish brown, f-c sand (SW), trace f gravel, small 1/2-inch silty clay lenses.		
		185		Slight increase in amount of c sand		DTW=140', sampler at 190', casing at 180'
Photo 190'				Trace silt		
		190		Bottom of boring at 190'		Drilling finished at 190' on 7-19-2017
		195				

Water Level			Logged By:	Drilled/Sampled By:
			Alyssa Chase	Ben Johnson
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
133 ft bgs	0	0	7/18/2017	7/19/2017

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-26 (J)	School property	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run Photo 0-8'		0	2-inch Sch. 40 PVC monitoring well, screened from 75-105 ft bgs. Flush-mount completion.	Dry, dark grey, organic (topsoil).	TOC = 233.18 ft MSL	Qvr
		1–5		Dry, grey, poorly graded gravel with silt (GP-GM), trace sand.		
10-20' run Photo 14-19'		10–15				
20-30' run Photo 20-25' Photo 25-30'		20		Slightly moist, brownish gray, poorly graded gravel with silt (GP-GM), trace sand.		
		27		Moist, light brown and dark grey, poorly graded sand (SP), trace clay.		
30-40' run		30		Moist, greyish brown, silty gravel (GM), trace sand, gravel up to 3-inch.		
Photo 35-40'		35		Slightly moist, greyish brown, silty gravel (GM) with well graded sand.		

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	HOLT
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
83.5 ft bgs (7/25 at 0750)			7/24/2017	7/25/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-26 (J)	School property	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
40-50' run			2-inch Sch. 40 PVC monitoring well, screened from 75-105 ft bgs. Flush-mount completion.	SAME: Slightly moist, greyish brown, silty gravel (GM) with well graded sand.		
Photo 45-50'		45				
				Moist, brownish-grey, poorly graded gravel (GP) with silty sand.		
50-60' run		50				Hard drilling 50-53'
Photo 55-60'		55				
60-70' run		60		Slightly moist, brownish grey, poorly graded gravel (GP) with trace silt, trace 3-inch cobbles.		
Photo 65-70'		65				Hard drilling 64-67'
70-80' run (Submitted 73-75')		70		Slightly moist to dry, grey, silty clay with gravel (CL) (Till).		Hard drilling 70-75'
				Dry, brownish grey, poorly graded gravel (GP) with trace silt, trace 3-inch cobbles.		Qva outwash
Photo 75-80'		75				

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	HOLT
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
83.5 ft bgs (7/25 at 0750)			7/24/2017	7/25/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-26 (J)	School property	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
80-90' run			2-inch Sch. 40 PVC monitoring well, screened from 75-105 ft bgs. Flush-mount completion.	SAME, but becomes wet.		
				Wet, greyish brown, well graded sand (SW), trace silt.	▽	Hard drilling 82-88'
Photo 85-89'		85				
				Wet, greyish brown, well graded sand (SW) with cobbles, trace silt and clay.		Driller switched bit after run to 89'
				Wet, greyish brown, poorly graded gravel (GP), trace sand, gravel up to 1-inch.		
90-100' run (Submitted 96-98')		90		With gravel up to 2-inch, below 90'.		
Photo 90-100'						
		95				
				With poorly graded sand.		
100-110' run		100		Wet, brown, poorly graded gravel (GP), trace poorly graded sand, gravel up to 1-inch.		
Photo 105-110'		105		Wet, greyish brown, well graded sand (SW), trace cobbles.		
110-120' run		110		No cobbles.		
Photo 115-120'		115		Wet, greyish brown, well graded silty sand (SM).		

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	HOLT
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
83.5 ft bgs (7/25 at 0750)			7/24/2017	7/25/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-26 (J)	School property	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
120-130' run Photo 120-130'		125	2-inch Sch. 40 PVC monitoring well, screened from 75-105 ft bgs. Flush-mount completion.	SAME: Wet, greyish brown, well graded silty sand (SM).		Only ~3 feet recovered from 120-130' run.
130-140' run (Submitted 138-140') Photo 130-135' Photo 135-140'		130 135		Moist to dry with depth, dark blueish grey with trace green with depth, stiffer with depth, silt (ML). (Kitsap Fm)		Qf confining layer
140-150' run (Submitted 153-145') Photo 145-150'		140		Moist, grey silt (ML), trace petrified wood from 140-141'. (Kitsap Fm)		
		145		Slightly moist, dark grey, fine sandy silt (ML). (Kitsap Fm)		
				Dry, grey silt (ML), trace clay lenses. (Kitsap Fm)		Boring terminated at 150 ft bgs.
		150 155		Bottom of Boring @ 150 feet bgs		

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	HOLT
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
83.5 ft bgs (7/25 at 0750)			7/24/2017	7/25/2017

Project Name		Project No.	Drilling Company
LOTT - Hawks Prairie		10021292	Holt Services, Inc.
Boring No	Location		Drilling Rig Type and Drilling Method
MW-27 (E)	28th Ct. NE		Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run		0	2-inch Sch. 40 PVC monitoring well, screened from 95-120 ft bgs. Flush-mount completion.	Mowed sod and topsoil.	TOC = 220.16 ft MSL	Drilling with 6-inch casing and 4-inch sampler, straight bit. Note: 0-10' not sampled
		5				
10-20' run		10		Dry, brown, f-c gravel and f-c sand (GW), trace clay.		Qvr
				Dry, brown, f-c sand (SW), trace clay, trace gravel.		
		15				
				Moist, brown, low plastic sandy clay (CL), trace gravel.		Till (Qvt)
Photo 18-20'				Moist, brown, f sand (SP) with some clay, trace gravel, trace cobbles.		
20-30' run		20		Dry to moist, gray, clayey f-c gravel (GC) and sand.		
Photo 25-26'		25				
				Drier, less clay, 27-31'.		
30-40' run		30				
				Moist, brown, medium sand (SP), trace gravel, trace 1-inch clay lenses.		
		35		Moist, gray, f-c gravel and sand (GW), some clay.		Qva outwash
				6-inch fine sand lense, 36'.		
Photo 37-38'				Decrease in clay to trace clay, with cobbles.		

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer	Josh Marsh (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
98 ft bgs			7/25/2017	7/27/2017 (well installed 7/28

HDR

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-27 (E)	28th Ct. NE	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
40-50' run Photo 40-42'			2-inch Sch. 40 PVC monitoring well, screened from 95-120 ft bgs. Flush-mount completion.	Moist to dry, gray, f-c gravel and sand (GW), some clay. 3-inch clay lense, 41'. Decrease to trace clay.		Drilling with 6-inch casing and 4-inch sampler, straight bit.
		45				
				Increase to some clay.		
50-60' run		50				
				2-inch gravel.		
		55				
Photo 55-58'				1-ft lense fine sand, trace silt, 55-56'. Trace clay.		
60-70' run		60		2-inch gravel.		
		65				
				Increase in moisture, decrease in fine sand.		
Photo 67-68'						
70-80' run Photo 70-72' (Submitted 70-72')		70		Wet, even less sand, minimal clay.		
		75				
						DTW = dry, casing at 80'. Stop drilling at 80 feet 7/25/17.

Water Level			Logged By:	Drilled/Sampled By:
			Ida Fischer	Josh Marsh (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
98 ft bgs			7/25/2017	7/27/2017 (well installed 7/28

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-27 (E)	28th Ct. NE	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
80-90' run Photo 80-90'			2-inch Sch. 40 PVC monitoring well, screened from 95-120 ft bgs. Flush-mount completion.	Dense, dry to slightly moist, gray, coarse sand (SP), with f-c gravel. Trace clay lenses from 80-82'. Mostly well graded sand, 88-89'.		Drilling with 6-inch casing and 4-inch sampler, straight bit. Resume drilling at 80' on 7/27/17. Borehole was dry with casing at 80' when continuing.
		85				
90-100' run Photo 90-100'		90		Dense, moist, gray, well graded sand (SW), with f-c gravel, gravel up to 1-inch. Sand becomes medium to fine, 96-98'. Slightly wet at 97'. Wet at 98'.	▽	
		95				
100-110' run Photo 100-110' (Submitted 106-108')		100		Dense, wet, brownish gray, f-c rounded gravel (GW), with well graded sand, gravel up to 2-inch.		
		105				
				Medium dense, wet, brownish gray, f-c rounded gravel (GW), gravel up to 3-inch.		
110-120' run Photo 110-120'		110				
		115				
				Dense, wet, brownish gray, f-c gravel (GW), with sand, gravel up to 1-inch.		
				Medium dense, wet, brownish gray, medium sand (SP), trace gravel.		

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Josh Marsh (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
98 ft bgs			7/25/2017	7/27/2017 (well installed 7/28

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
MW-27 (E)	28th Ct. NE	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
120-130' run Photo 120-130'			2-inch Sch. 40 PVC monitoring well, screened from 95-120 ft bgs. Flush-mount completion.	Dense, wet, brownish gray, medium sand (SP), trace rounded gravel. Sand becomes finer, less gravel with depth.		Drilling with 6-inch casing and 4-inch sampler, straight bit.
		125		Medium stiff silt (ML) lense, 126-127'.		
130-140' run Photo 130-140'		130		Dense, wet, grayish brown, fine sand (SP), trace rounded gravel from 130-131'.		Qf
		135		Sand becomes finer with depth.		
(Submitted 138-140')						
140-145' run Photo 140-145' (Submitted 143-145')		140				
145-150' run Photo 145-150'		145		Trace rounded gravel 145-150'.		
		150		Bottom of Boring @ 150 feet bgs.		
		155				

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Josh Marsh (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
98 ft bgs			7/25/2017	7/27/2017 (well installed 7/28

Boring Log

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc

Boring No	Location	Drilling Rig Type and Drilling Method
MW-28 (G)	Marvin Rd/Willamette Dr	Terra Sonic 150 CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run		0	2.5-inch Sch. 80 PVC monitoring well, screened from 130 -170 ft bgs. Flush mount completion.	Stiff, dry, brownish gray, silt (ML), with gravel, trace sand.	TOC = 224.85 ft MSL	Drilling with 6-inch casing and 4-inch sampler.
		5				
Photo 8-10'						
10-20' run		10		Medium dense, dry, gray, medium sand (SP), trace silt, trace gravel. Sand becomes finer.		Qvr
		15				
Photo 18-20'				Medium dense, moist, brownish gray, medium sand (SP), trace silt, trace gravel. Silt increases 19-25'.		
20-30' run		20				
				Wet at 22'		
		25				
				Dense, with more silty sand from 26-27'		
Photo 28-30'				Loose, slightly moist, gray, fine sand (SP).		
30-40' run		30		Loose, wet, brownish gray, medium sand (SP), trace f-c gravel, trace silt. Sand becomes coarser.		
		35		Medium dense, wet, brownish gray, f-c gravel (GW), with medium to coarse sand, trace silt.		
Photo 38-40'						
				Loose, moist, brownish gray, m sand (SP), tr silt & gravel.		

Water Level			Logged By: Chad Hearn	Drilled/Sampled By: Ben Johnson (Holt)
While Drilling: 130-ft bgs	After Drilling:	Hours After:	Date Started: 8/3/2017	Date Completed: 8/4/2017 (well installed 8/5)

Boring Log

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc

Boring No	Location	Drilling Rig Type and Drilling Method
MW-28 (G)	Marvin Rd/Willamette Dr	Terra Sonic 150 CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
30-40' run			2.5-inch Sch. 80 PVC monitoring well, screened from 130 -170 ft bgs. Flush mount completion.	SAME: Loose, moist, brownish gray, medium sand (SP), trace silt & gravel.		Drilling with 6-inch casing and 4-inch sampler.
				Medium dense, slightly moist, brownish gray, sand (SW), with f-c gravel, trace silt.		
		45		Medium dense, slightly moist, brownish gray, f-c gravel (GW), with silt, trace sand.		
Photo 48-50'						
50-60' run		50		Dense, slightly moist, brownish gray, f-c gravel (GW), with silt, trace m-c sand, trace rounded cobbles to 4-inch.		
				Wet, silty lense from 52-53'		
		55				
Photo 58-60'						
60-70' run		60		Angular cobbles. Becomes wet 61-64'.		Wet from 61-64'
		65				
Photo 68-70'						
70-80' run		70		Slightly more silt from 71-72'. Becomes wet 71-72'.		Wet from 71-72'
				Wet, sandy lense from 72-75'.		
		75		Becomes moist to slightly moist with depth, more medium sand and trace fine sand, 75-80'.		
Photo 78-80'						

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Ben Johnson (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
130-ft bgs			8/3/2017	8/4/2017 (well installed 8/5)

Boring Log

Project Name		Project No.	Drilling Company
LOTT Hawks Prairie		10021292	Holt Services, Inc
Boring No	Location		Drilling Rig Type and Drilling Method
MW-28 (G)	Marvin Rd/Willamette Dr		Terra Sonic 150 CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
80-90' run			2.5-inch Sch. 80 PVC monitoring well, screened from 130 -170 ft bgs. Flush mount completion.	Very stiff, dry, gray, silt (ML), with f-c gravel, trace sand (Till).		Drilling with 6-inch casing and 4-inch sampler.
				Dense, slightly moist, brownish gray, f-c gravel (GW), with sand, trace silt, some angular cobbles (boulder fragments).		
		85				
Photo 88-90'						
90-100' run		90		Becomes moist, trace rounded cobbles to 4-inch.		
				Dry at 92' (rock dust, likely large cobble).		
		95				Wet from 93-95'
				Slightly moist, silt (ML) lense, 96-97'.		
Photo 98-100'				Dry to slightly moist, silt (ML) lense, 99-100'.		
100-110' run		100		Very dense, slightly moist, brownish gray, f-c gravel (GW), with silt, trace sand.		
		105		Very stiff, dry, brownish gray, silt (ML), with f-c gravel, trace sand, trace cobbles up to 4-inch.		Till
Photo 108-100'						
110-120' run		110				
		115		Loose, slightly moist, brown, sand (SP). Trace gravel at 117'.		Qva
				Dense, slightly moist, f-c gravel (GW), with medium to coarse sand, trace silt.		
Photo 118-120'						Wet from 119-120'

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Ben Johnson (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
130-ft bgs			8/3/2017	8/4/2017 (well installed 8/5)

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc

Boring No	Location	Drilling Rig Type and Drilling Method
MW-28 (G)	Marvin Rd/Willamette Dr	Terra Sonic 150 CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
120-130' run			2.5-inch Sch. 80 PVC monitoring well, screened from 130 -170 ft bgs. Flush mount completion.	Medium dense, wet, brownish gray, f-c gravel (GW), with medium to coarse brown sand, trace silt.		Drilling with 6-inch casing and 4-inch sampler.
				Very stiff, dry, blueish gray, low plastic clayey silt (ML).		
		125				
Photo 128-130'						
130-135' run		130				
135-140' run		135				
				Very stiff, dry to slightly moist with depth, brown, clayey silt (ML), with orange staining.		
Photo 138-140'						
140-150' run		140				
				Stiff, moist, brown, clayey silt (ML), with gravel, trace wet sand lenses.		
		145		Dense, wet, brown, silty f-c gravel (GM), with sand, trace 3-inch cobbles.		
Photo 148-150'						
150-160' run		150		Medium dense, wet, brownish gray, f-c gravel (GW), with sand and silt, trace rounded 3-inch cobbles. With clayey silt from 150-157'.		
(Submitted 153-155')						
		155				
Photo 158-160'						

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Ben Johnson (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
130-ft bgs			8/3/2017	8/4/2017 (well installed 8/5)

Boring Log

Project Name	Project No.	Drilling Company
LOTT Hawks Prairie	10021292	Holt Services, Inc

Boring No	Location	Drilling Rig Type and Drilling Method
MW-28 (G)	Marvin Rd/Willamette Dr	Terra Sonic 150 CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
160-170' run			2.5-inch Sch. 80 PVC monitoring well, screened from 130 -170 ft bgs. Flush mount completion.	SAME: Medium dense, wet, brownish gray, f-c gravel (GW), with sand and silt, trace rounded 3-inch cobbles.		Drilling with 6-inch casing and 4-inch sampler.
		165				
Photo 168-170' (Submitted 168-170')						
		170		Bottom of Borehole @ 170 feet bgs.		Boring terminated at 170-ft bgs
		175				
		180				
		185				
		190				
		195				

Water Level			Logged By:	Drilled/Sampled By:
			Chad Hearn	Ben Johnson (Holt)
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
130-ft bgs			8/3/2017	8/4/2017 (well installed 8/5)

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
Basin 4 East Lysimeters	East half Basin 4	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run (Submitted 0-10')		0–5	Nested lysimeters installed in separate boreholes at 50', 25' and 10' depths. Lysimeter attached to 2-inch Sch. 40 PVC pipe.	No recovery.		
		5–12		Brown, damp, fine to coarse sand (SW) and gravel up to 2-inch. Moist.		
10-20' run		12–25		Moist, fine to medium sand (SP), little gravel up to 2-inch.		
20-30' run		25–30		Gray, damp, fine to medium sand (SP) with little silt, trace gravel.	▽	
30-40' run (Core sample submitted 32-35', 1-ft sections)		30–36		Gray, wet, fine to coarse sand (SW) and gravel up to 2-inch, trace silt. With some gray clay.		
		36–40		Gray, wet, fine to medium sand (SP) with some gravel up to 1-inch, trace silt.		

Water Level			Logged By:	Drilled/Sampled By:
			John Koreny	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
30'	20', in 50' lysimeter	2 days, 6/30/2017	6/28/2017	6/28/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
Basin 4 East Lysimeters	East half Basin 4	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
40-50' run (Core sample submitted 42-45', 1-ft sections)			Nested lysimeters installed in separate boreholes at 50', 25' and 10' depths. Lysimeter attached to 2-inch Sch. 40 PVC pipe.	SAME: Gray, wet, fine to medium sand (SP) with some gravel up to 1-inch, trace silt.		
		45		Gray, wet, fine to medium silty sand (SM) and gravel up to 2-inch. Bottom of boring @ 50 feet, 6/28/2017		
		50				
		55				
		60				
		65				
		70				
		75				

Water Level			Logged By:	Drilled/Sampled By:
			John Koreny	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
30'	20', in 50' lysimeter	2 days, 6/30/2017	6/28/2017	6/28/2017

Boring Log

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
Basin 4 West Lysimeters	West half Basin 4	Terra Sonic 150CC, track-mounted sonic

Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
0-10' run (Submitted 0-10')		0	Nested lysimeters installed in separate boreholes at 50', 25' and 10' depths. Lysimeter attached to 2-inch Sch. 40 PVC pipe.	No recovery		
		5				
		7		Dry, brown, fine to medium sand (SP) and gravel up to 1-inch, trace silt.		
10-20' run		10		No recovery		
		13		Dry, brown, fine to medium sand (SP) with little gravel, trace silt. Becomes gray and moist at 14'.		
		15				
		18		Gray, moist, fine to coarse sand (SW) and gravel up to 1.5-inch.		
20-30' run (Core samples submitted 22-25', 1-ft sections)		20		Gray, moist, fine to coarse sand (SW) with some silt and clay, gravel up to 2-inch.		
		24		Increasing clay, wet.	▽	
		25				
30-40' run		30				
		35		Gray, wet, fine to coarse sand (SW) with trace silt.		

Water Level			Logged By:	Drilled/Sampled By:
			John Koreny	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
24'	38', in 50' lysimeter	4 days, 6/30/2017	6/26/2017	6/26/2017

Project Name	Project No.	Drilling Company
LOTT - Hawks Prairie	10021292	Holt Services, Inc.

Boring No	Location	Drilling Rig Type and Drilling Method
Basin 4 West Lysimeters	West half Basin 4	Terra Sonic 150CC, track-mounted sonic

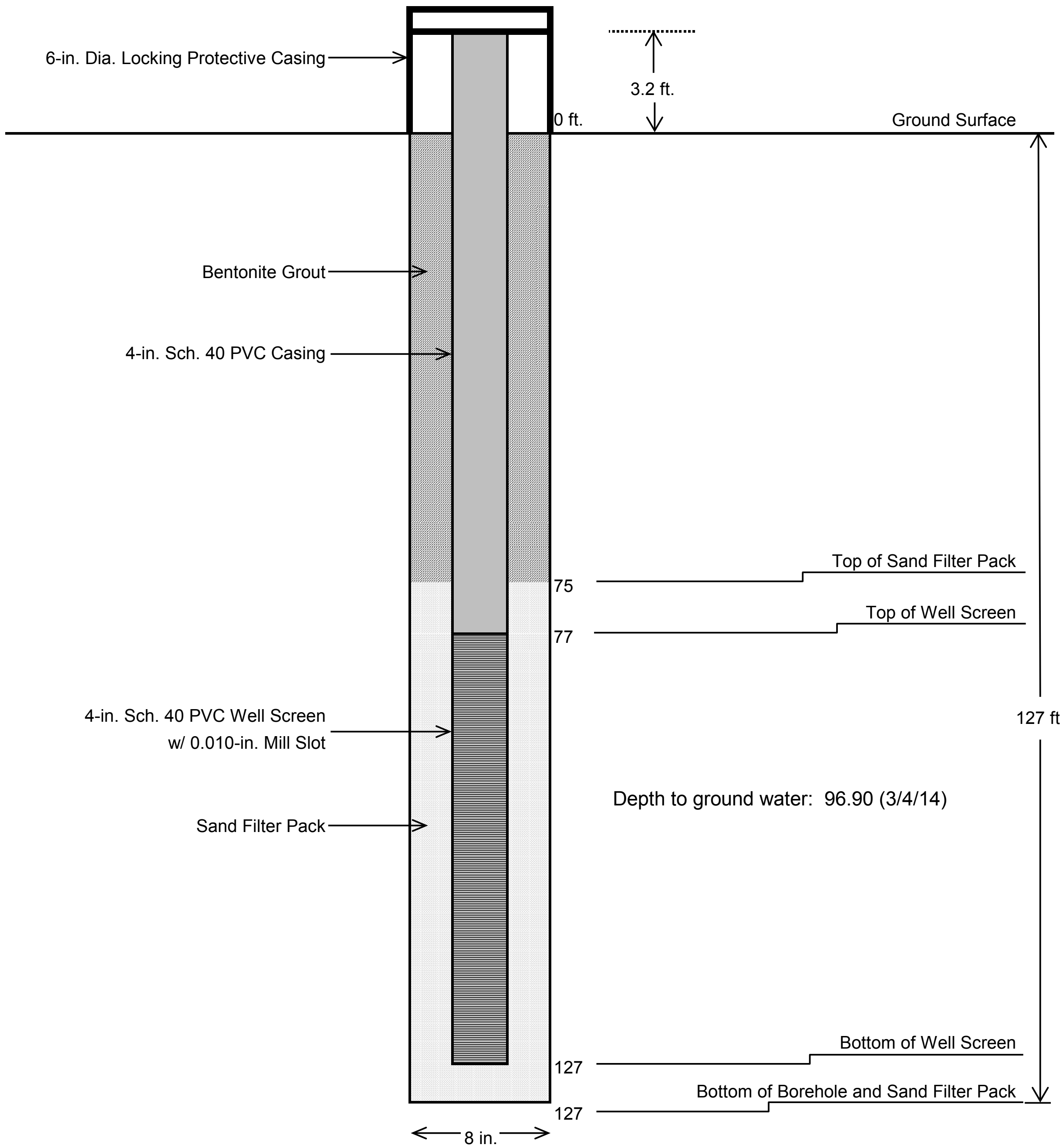
Sample No.	PID Reading (ppm)	Depth (feet)	Completion	Description (USCS)	Elevation (feet)	Remarks
40-50' run (Core samples submitted 42-45', 1-ft sections)			Nested lysimeters installed in separate boreholes at 50', 25' and 10' depths. Lysimeter attached to 2-inch Sch. 40 PVC pipe.	SAME: Gray, wet, fine to coarse sand (SW) with trace silt.		
		45		Gray, wet, fine to coarse sand (SW) and gravel up to 1-inch.		
				Gray, wet, fine to medium sand (SP), clean. Bottom of boring @ 50 feet, 6/26/2017		
		50				
		55				
		60				
		65				
		70				
		75				

Water Level			Logged By:	Drilled/Sampled By:
			John Koreny	Josh Marsh
While Drilling:	After Drilling:	Hours After:	Date Started:	Date Completed:
24'	38', in 50' lysimeter	4 days, 6/30/2017	6/26/2017	6/26/2017

This page intentionally left blank.

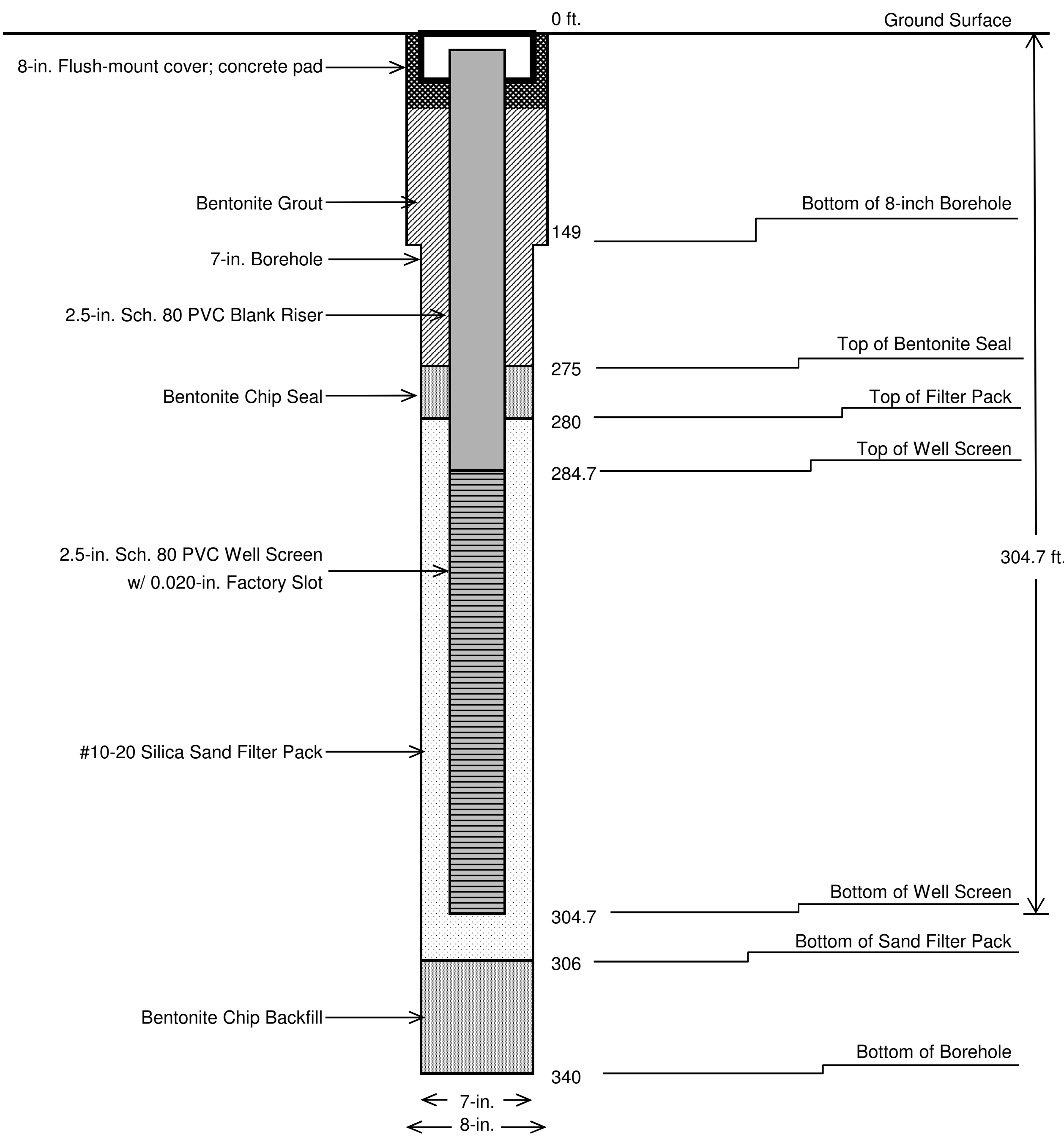
Appendix B – Lysimeter and Monitoring Well Construction Diagrams

This page intentionally left blank.



Constructed: **12/17/2013**
Drilled By: **Holt Services, Inc.**
PVC Casing EL: **214.34 ft amsl**
Water EL: **117.51 ft amsl (3/4/14)**

MW-3a Monitoring Well Construction Diagram
Hawks Prairie Aquifer Recharge Facility
LOTT Clean Water Alliance

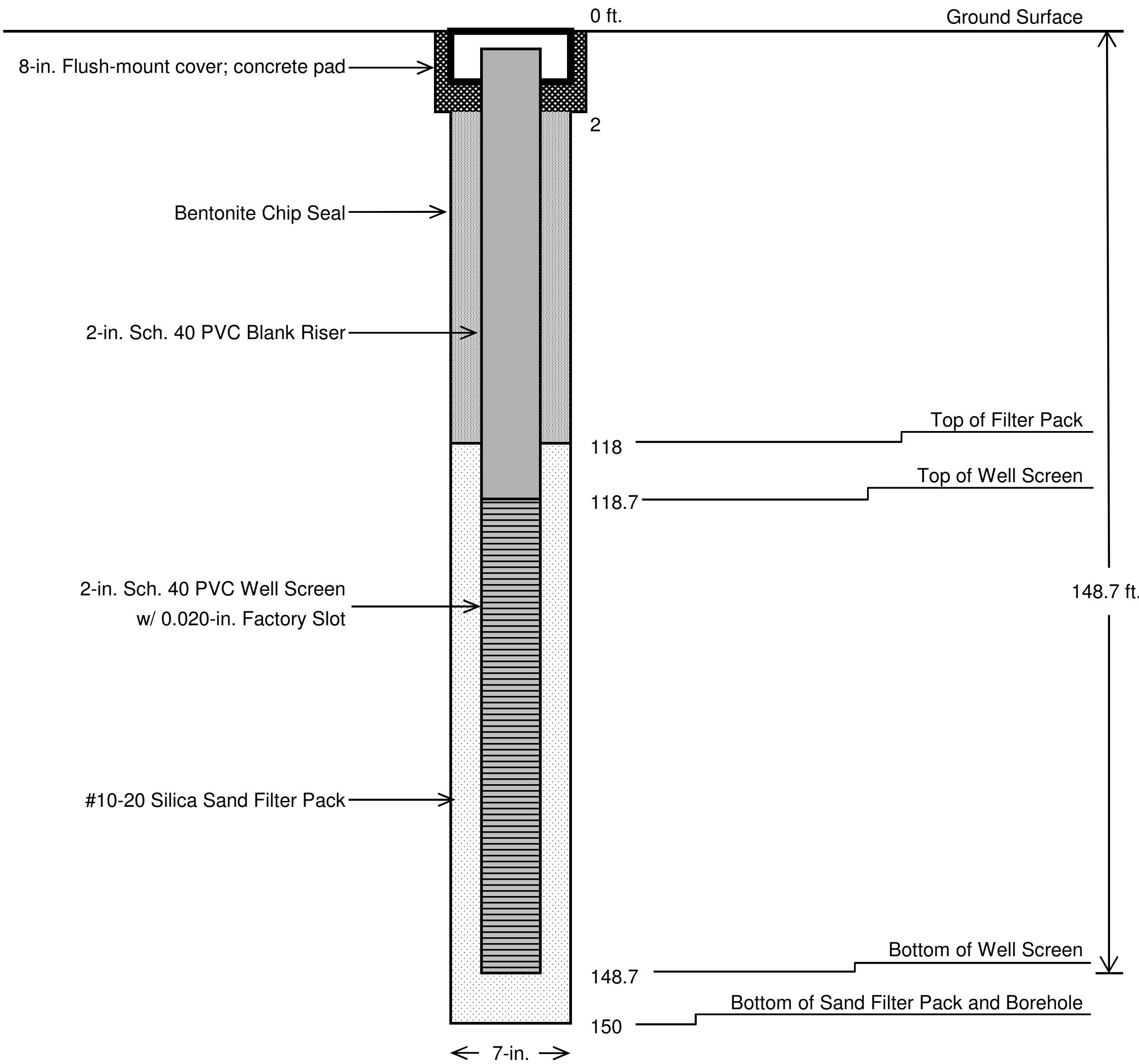


Constructed:	**06/13/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**227.00 ft MSL**
Depth to Water:	**136.27 ft bgs, 8/11/2017**
Water EL:	**90.73 ft MSL, 8/11/2017**

MW-12 (O) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

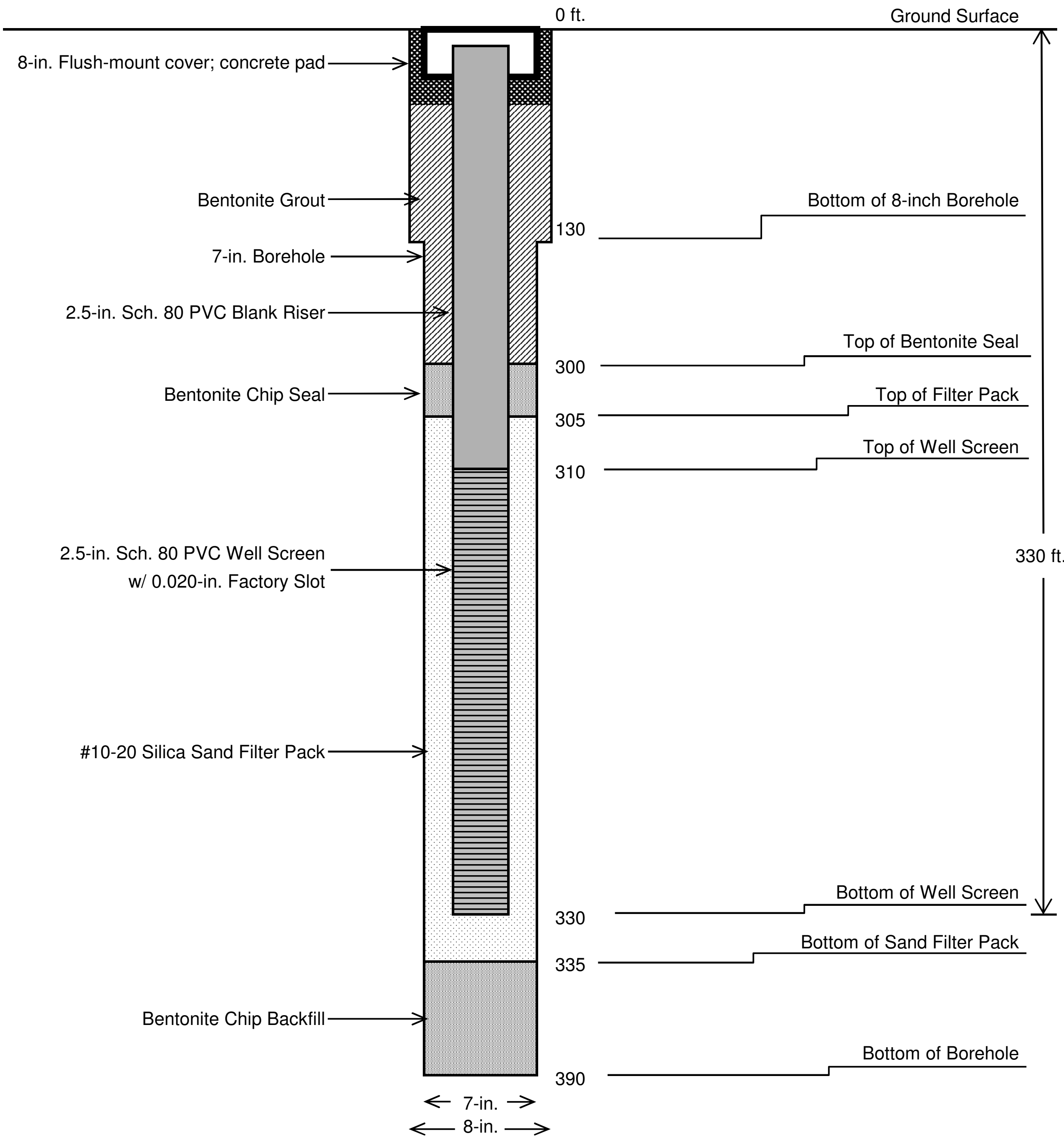


Constructed:	**06/15/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**226.80 ft MSL**
Depth to Water:	**121.48 ft bgs, 8/11/2017**
Water EL:	**105.32 ft MSL, 8/11/2017**

MW-13 (F) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

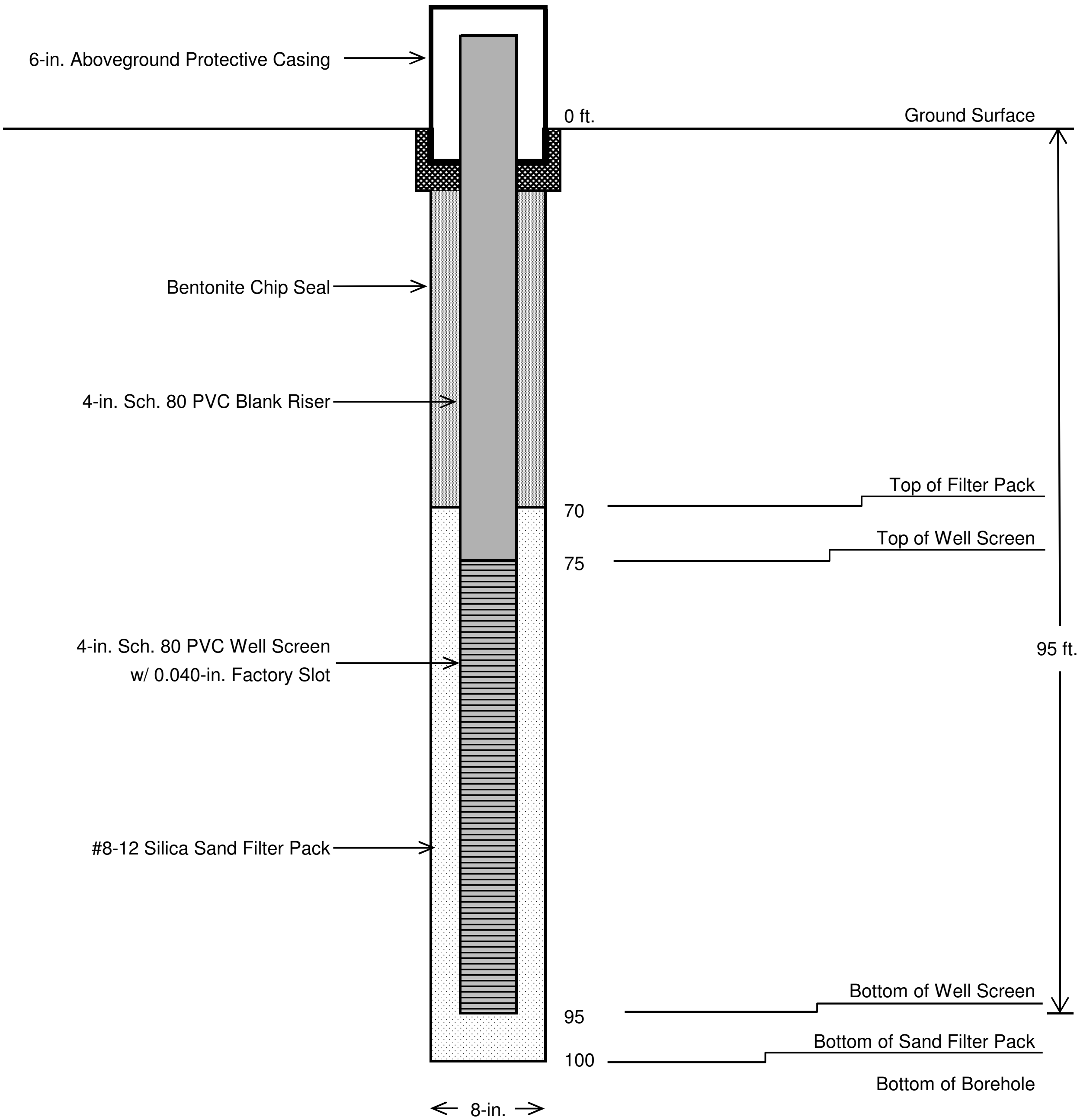


Constructed:	**07/05/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**218.04 ft MSL**
Depth to Water:	**156.45 ft bgs, 8/9/2017**
Water EL:	**61.59 ft MSL, 8/9/2017**

MW-14 (R) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

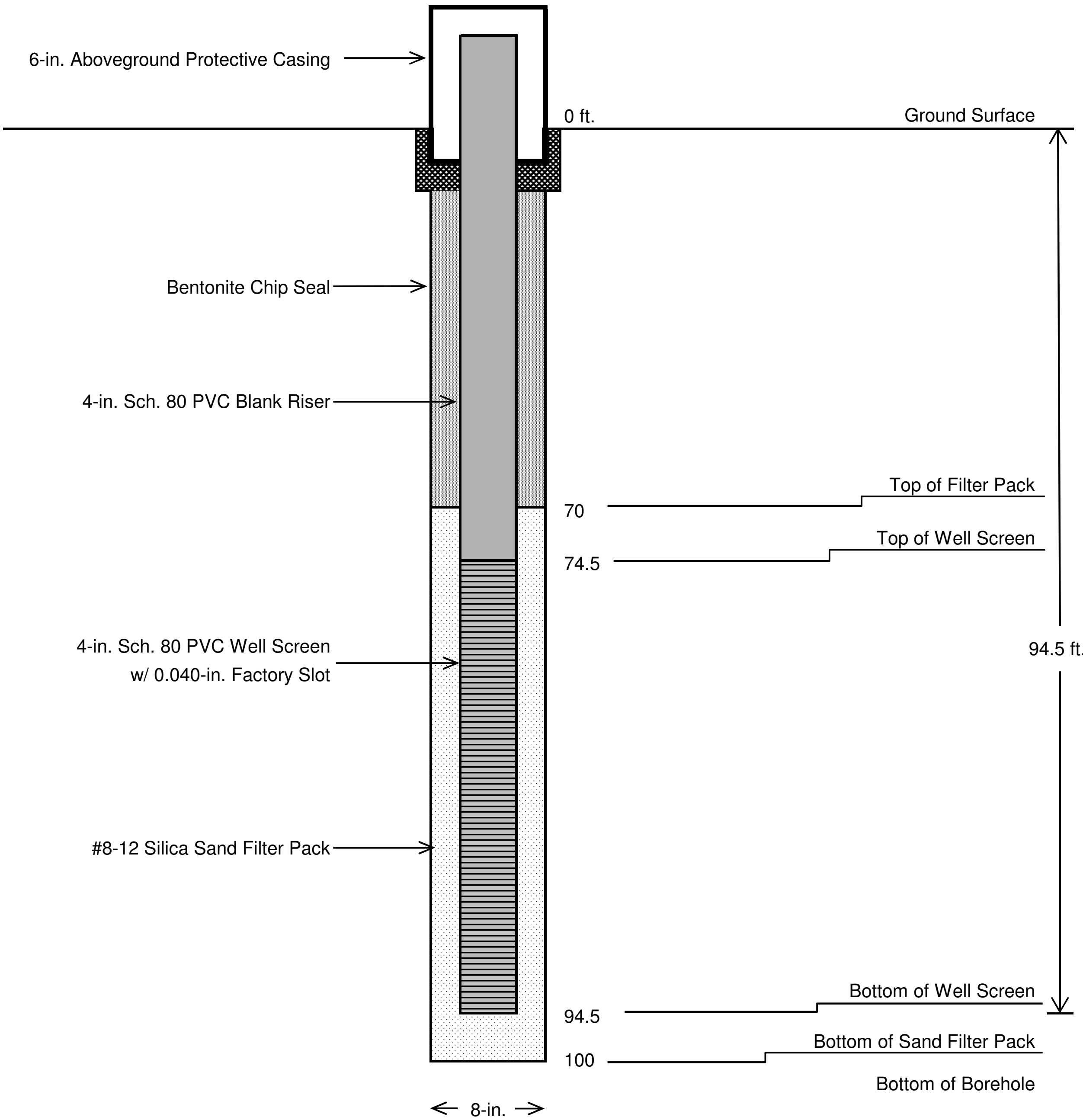


Constructed:	**08/02/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**219.20 ft MSL**
Depth to Water:	**82.69 ft bgs, 8/18/2017**
Water EL:	**136.51 ft MSL, 8/18/2017**

MW-15(B1) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

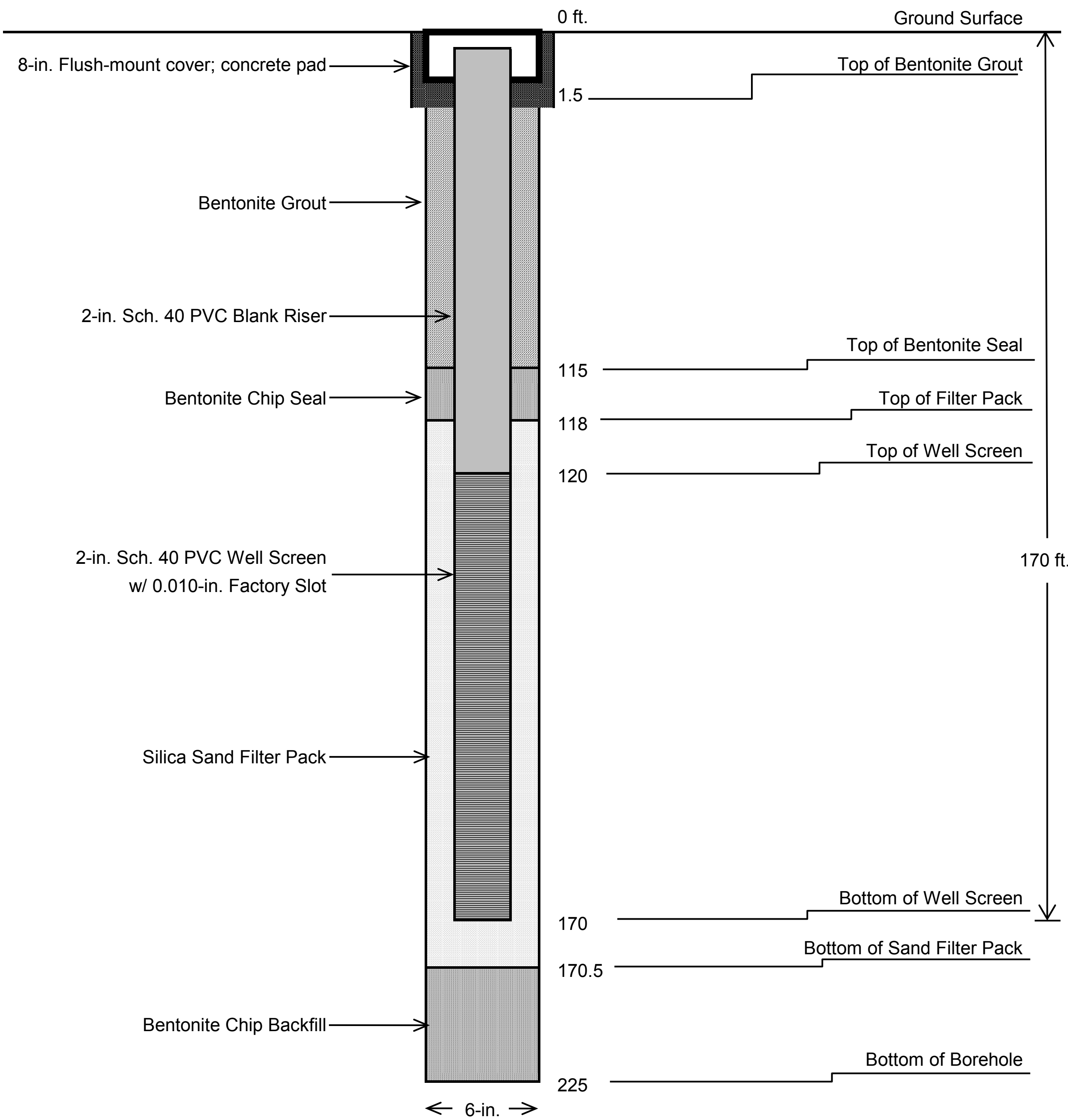


Constructed:	**08/04/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**219.34 ft MSL**
Depth to Water:	**82.09 ft bgs, 8/18/2017**
Water EL:	**137.25 ft MSL, 8/18/2017**

MW-16(B2) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

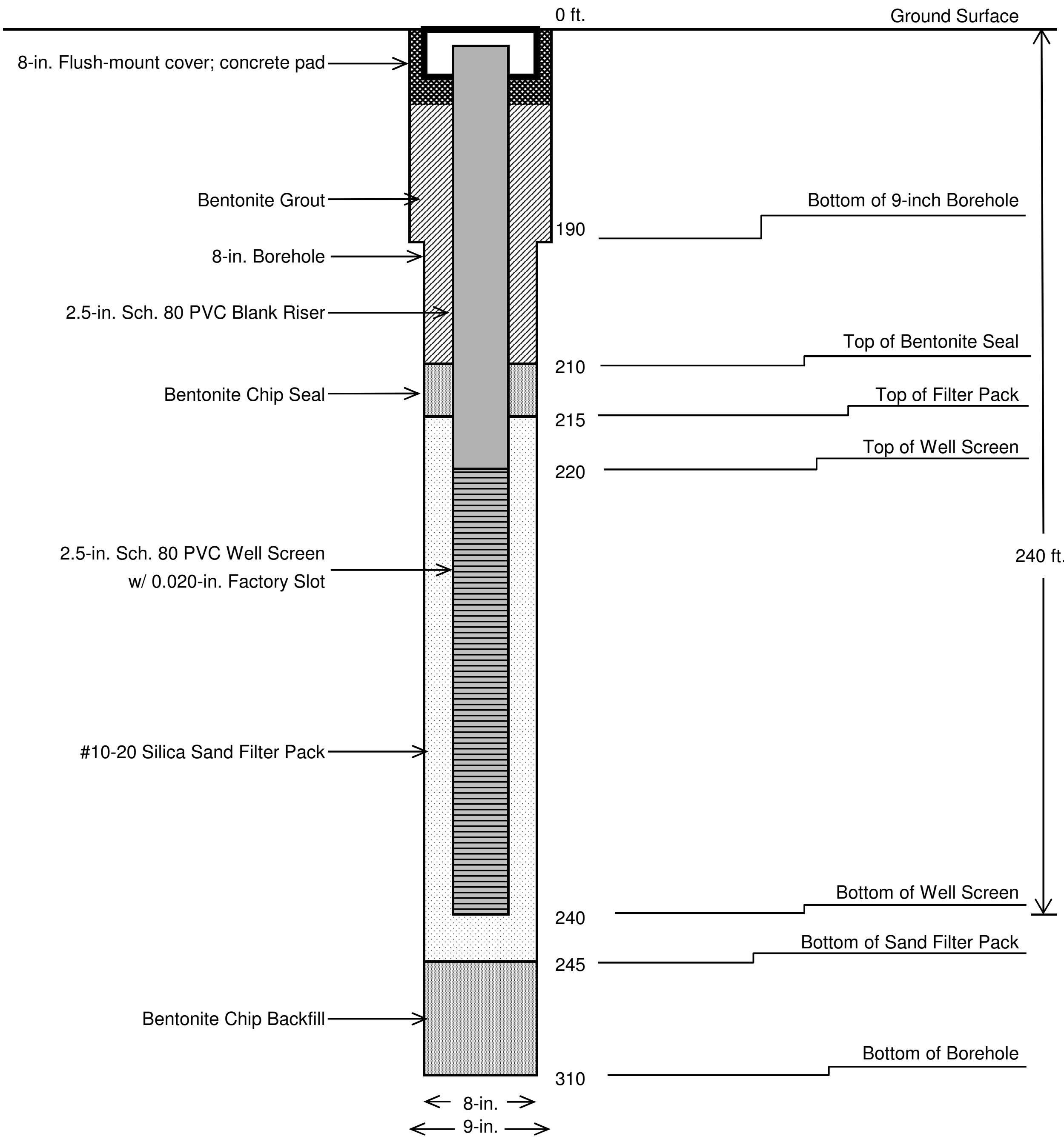


Constructed:	**1/13/2017**
Drilled By:	**Cascade Drilling Company**
Casing EL:	**219.22 ft (NAVD88)**
Water EL:	**84.92 ft on 1/12/2017**

MW-20 Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

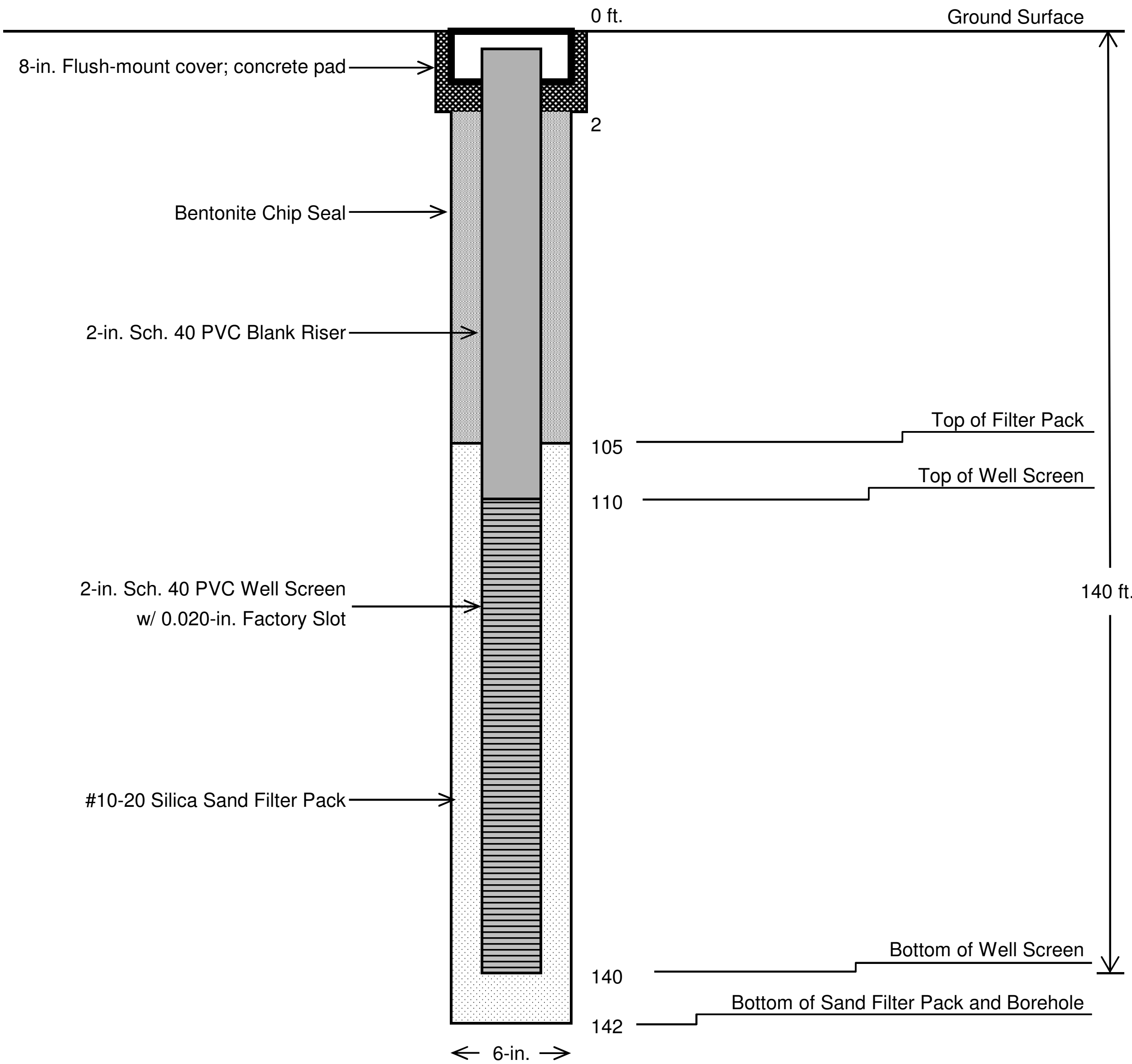


Constructed:	**07/19/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**227.16 ft MSL**
Depth to Water:	**137.37 ft bgs, 8/15/2017**
Water EL:	**89.79 ft MSL, 8/15/2017**

MW-21 (P) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

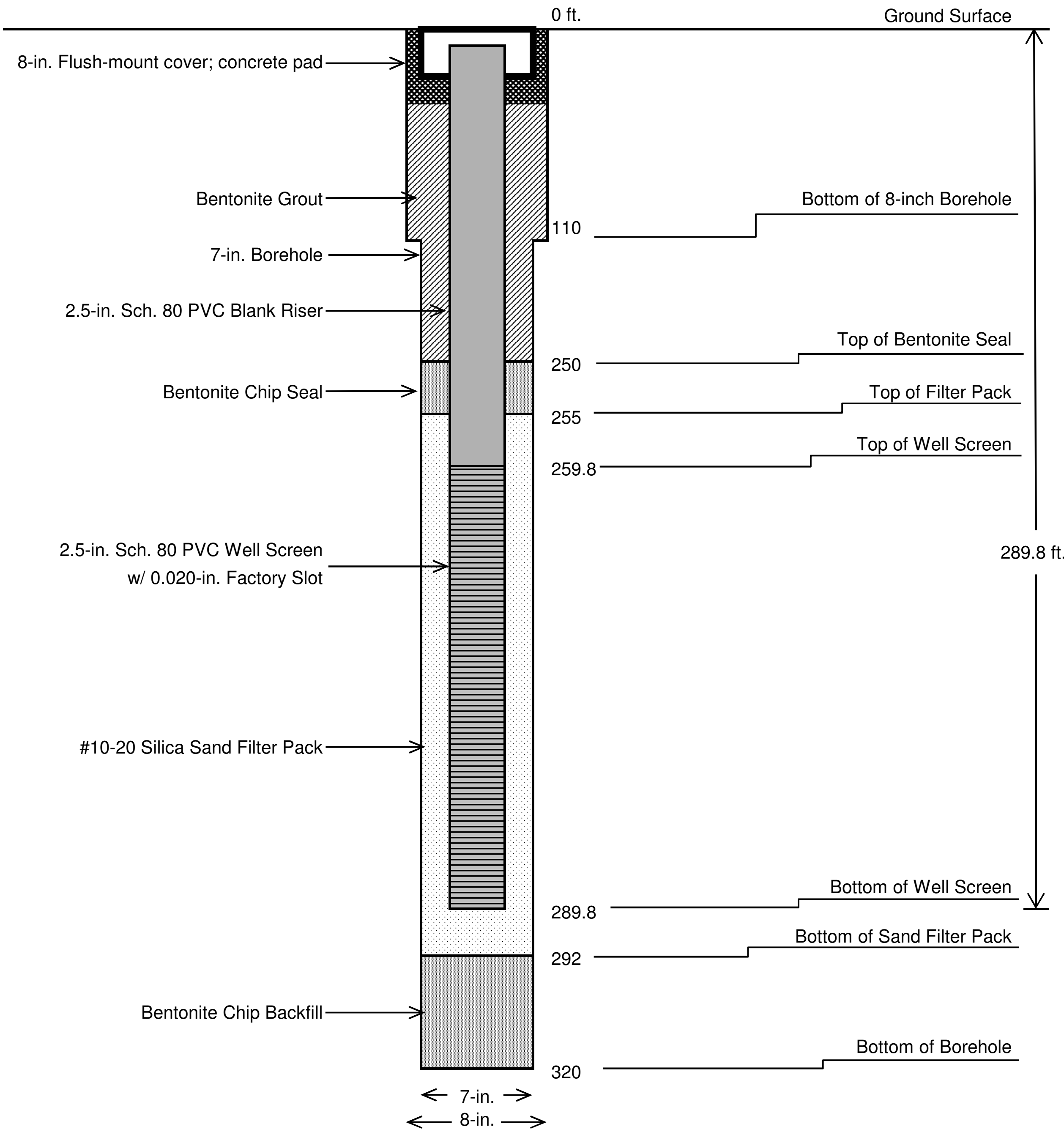


Constructed:	**07/21/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**227.23 ft MSL**
Depth to Water:	**137.16 ft bgs, 8/15/2017**
Water EL:	**90.07 ft MSL, 8/15/2017**

MW-22 (I) Monitoring Well Construction Diagram

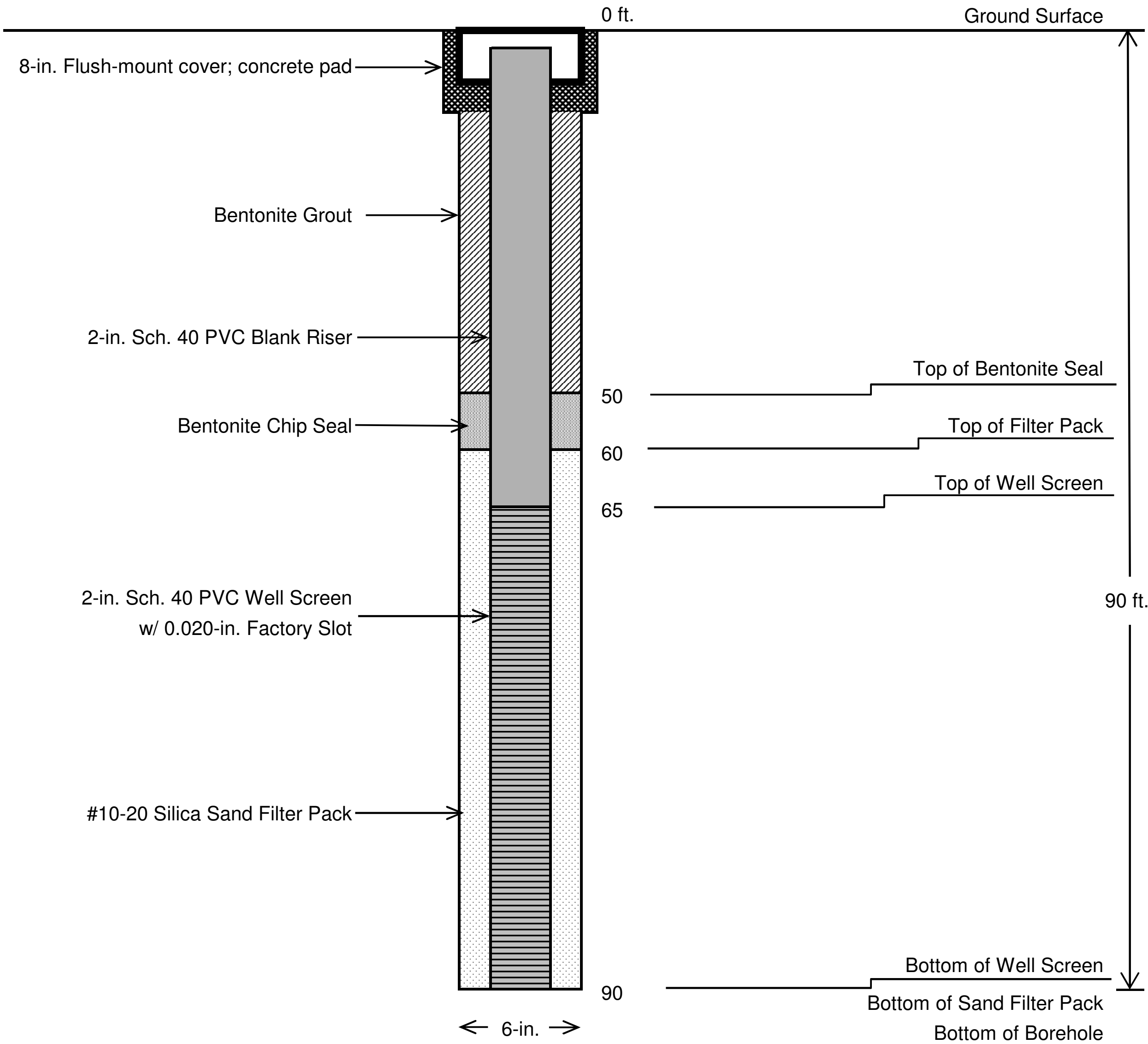
LOTT Clean Water Alliance

Hawks Prairie



Constructed:	**07/17/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**204.54 ft MSL**
Depth to Water:	**151.16 ft bgs, 8/10/2017**
Water EL:	**53.38 ft MSL, 8/10/2017**

MW-23 (Q) Monitoring Well Construction Diagram
LOTT Clean Water Alliance
Hawks Prairie

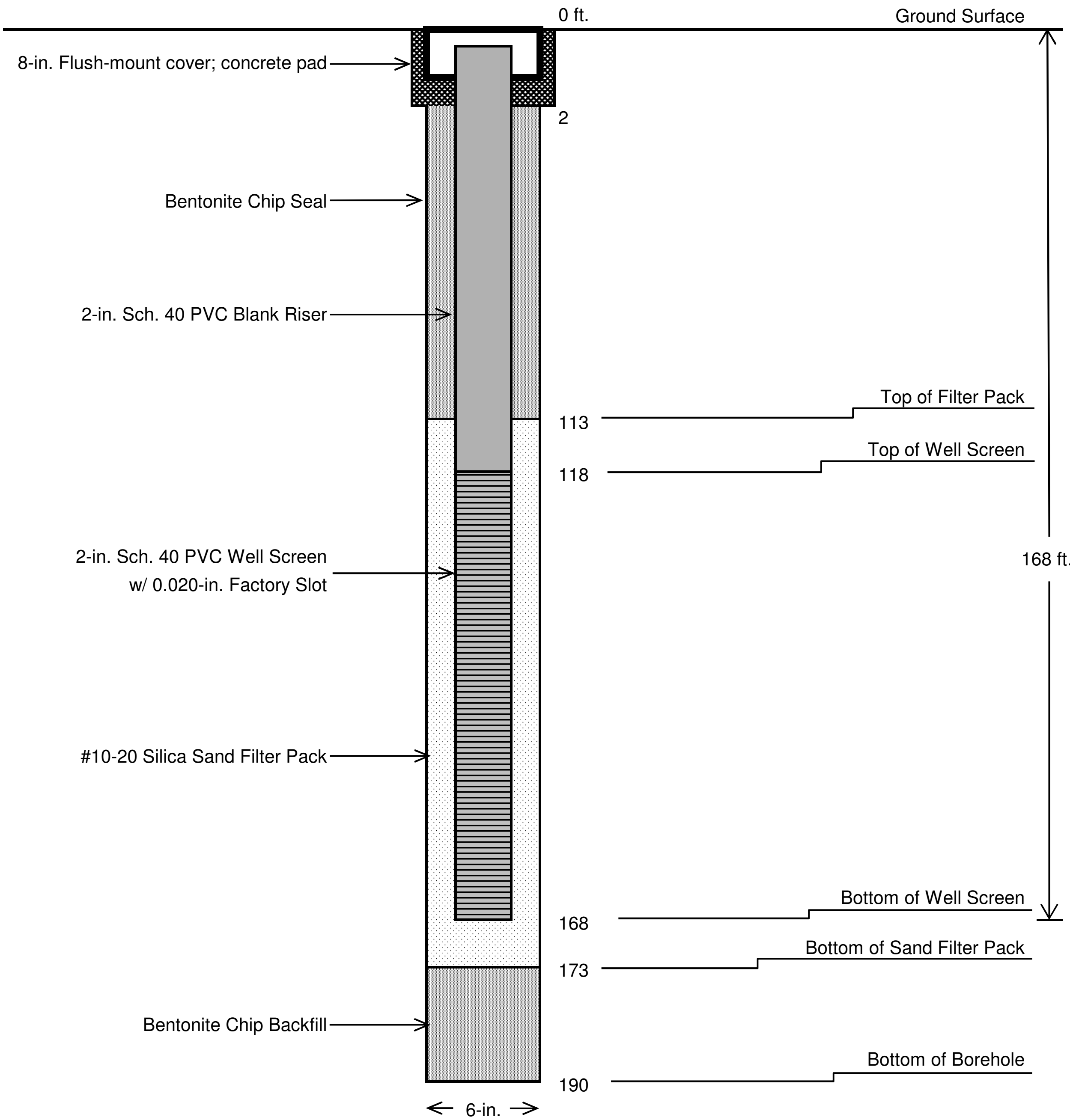


Constructed:	**07/28/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**204.90 ft MSL**
Depth to Water:	**62.11 ft bgs, 8/16/2017**
Water EL:	**142.79 ft MSL, 8/16/2017**

MW-24(C) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

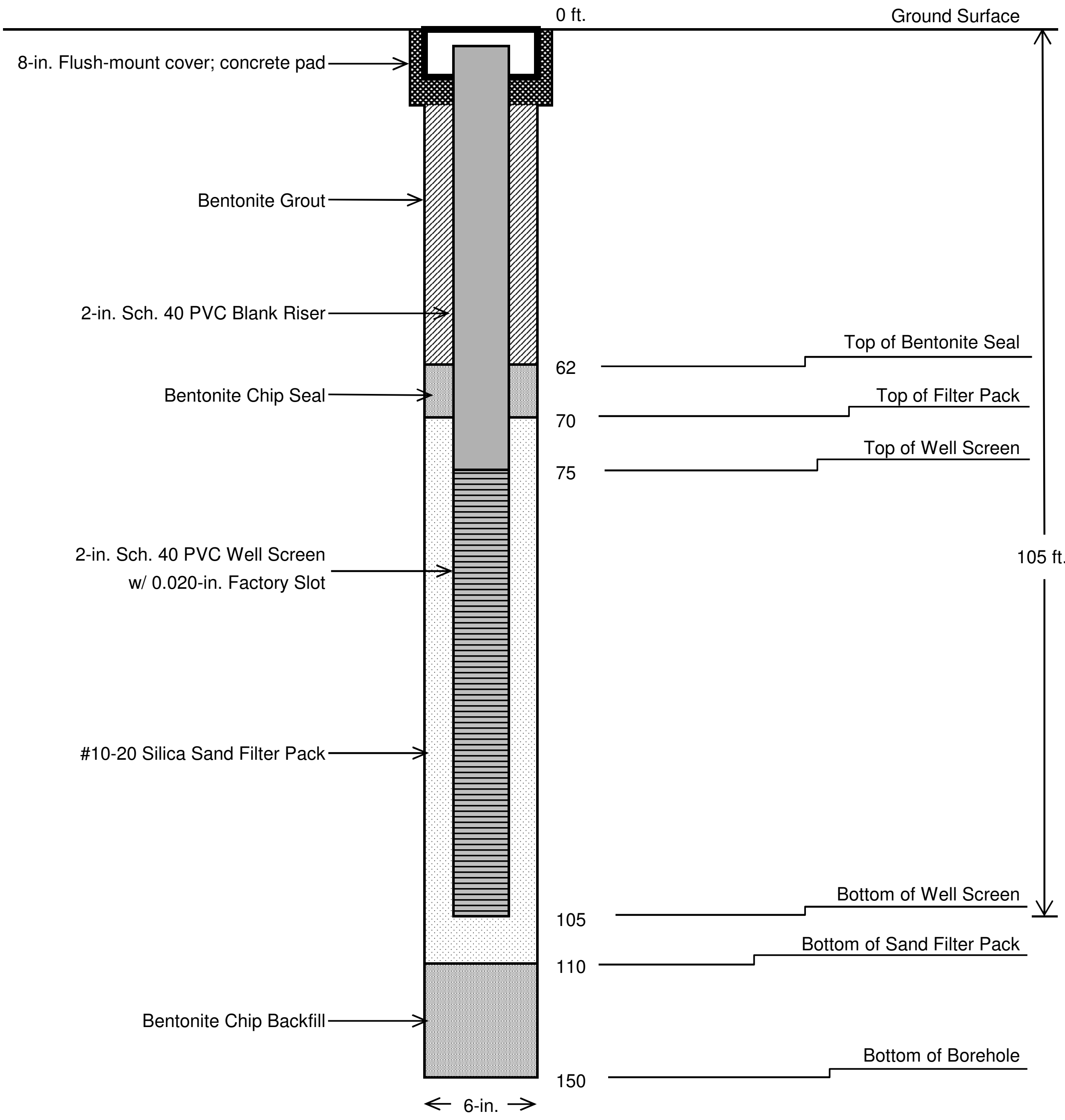


Constructed:	**07/20/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**228.95 ft MSL**
Depth to Water:	**135.34 ft bgs, 8/18/2017**
Water EL:	**93.61 ft MSL, 8/18/2017**

MW-25 (K) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

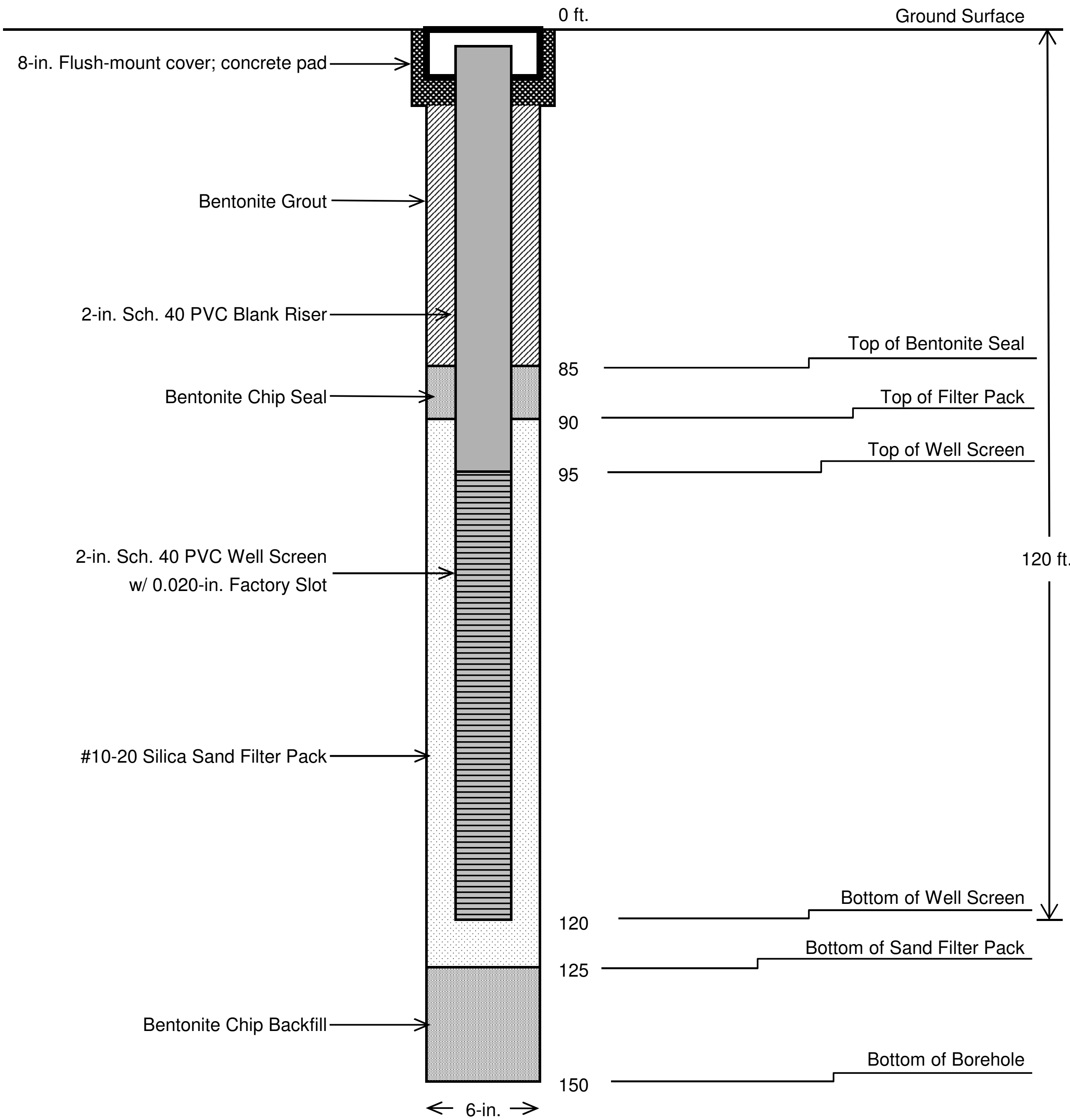
Hawks Prairie



Constructed: 07/26/2017
Drilled By: Holt Services, Inc.
Casing EL: 233.18 ft MSL
Depth to Water: 82.88 ft bgs, 8/11/2017
Water EL: 150.30 ft MSL, 8/11/2017

MW-26(J) Monitoring Well Construction Diagram

LOTT Clean Water Alliance
Hawks Prairie

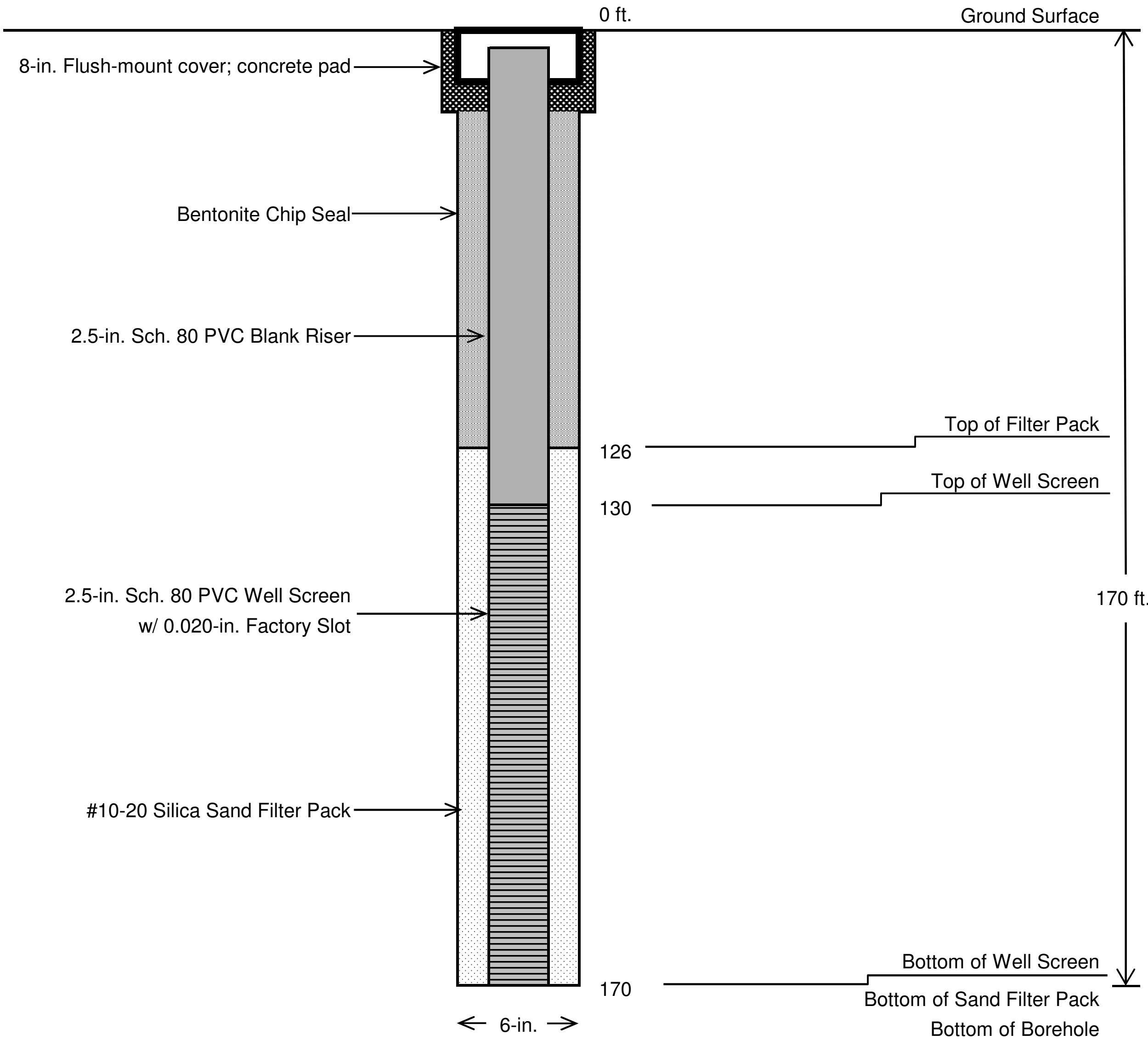


Constructed:	**07/28/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**220.16 ft MSL**
Depth to Water:	**97.20 ft bgs, 8/15/2017**
Water EL:	**122.96 ft MSL, 8/15/2017**

MW-27(E) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

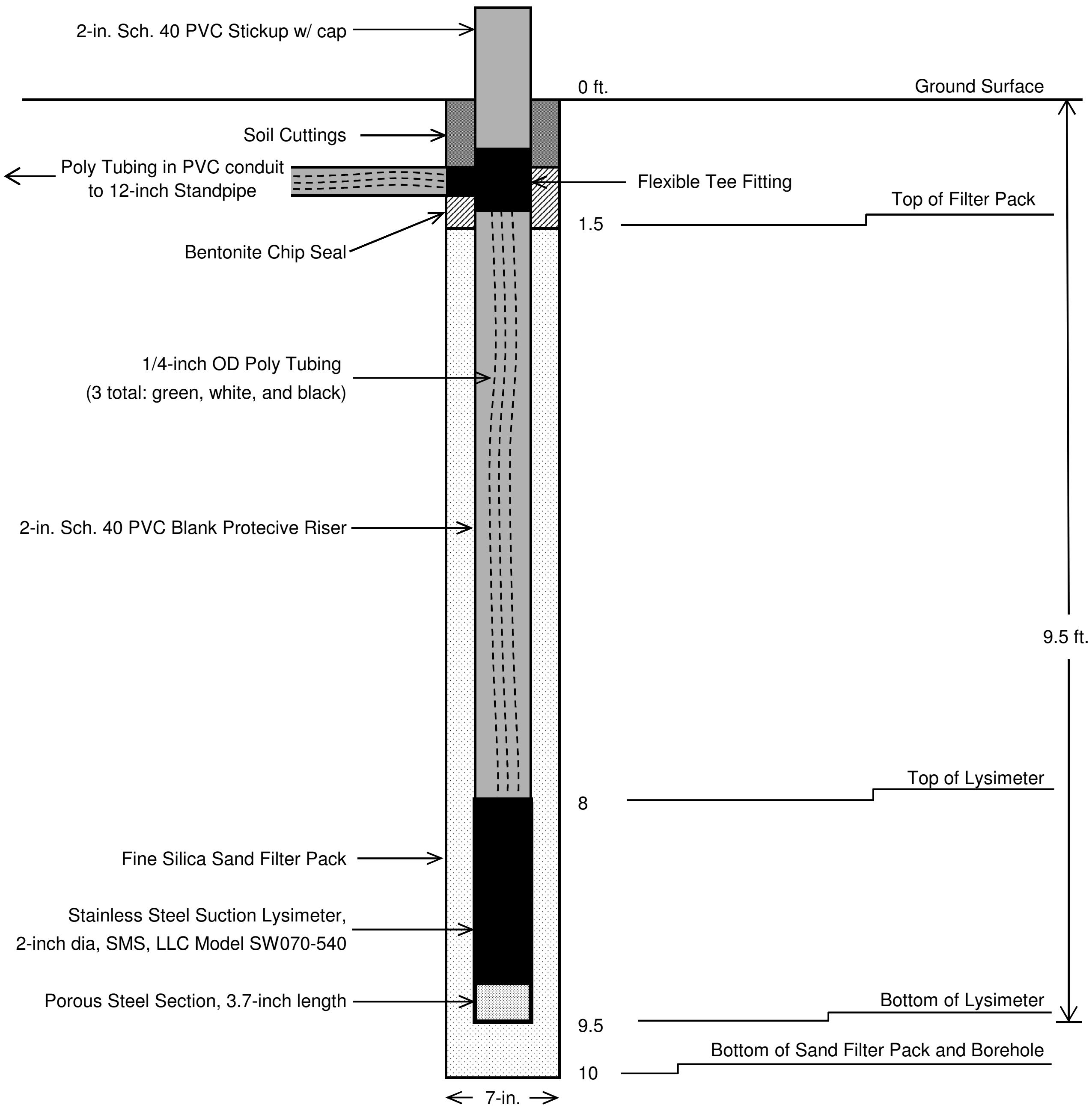


Constructed:	**08/05/2017**
Drilled By:	**Holt Services, Inc.**
Casing EL:	**224.85 ft MSL**
Depth to Water:	**130.08 ft bgs, 8/18/2017**
Water EL:	**94.77 ft MSL, 8/18/2017**

MW-28(G) Monitoring Well Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie



Constructed: 06/27/2017

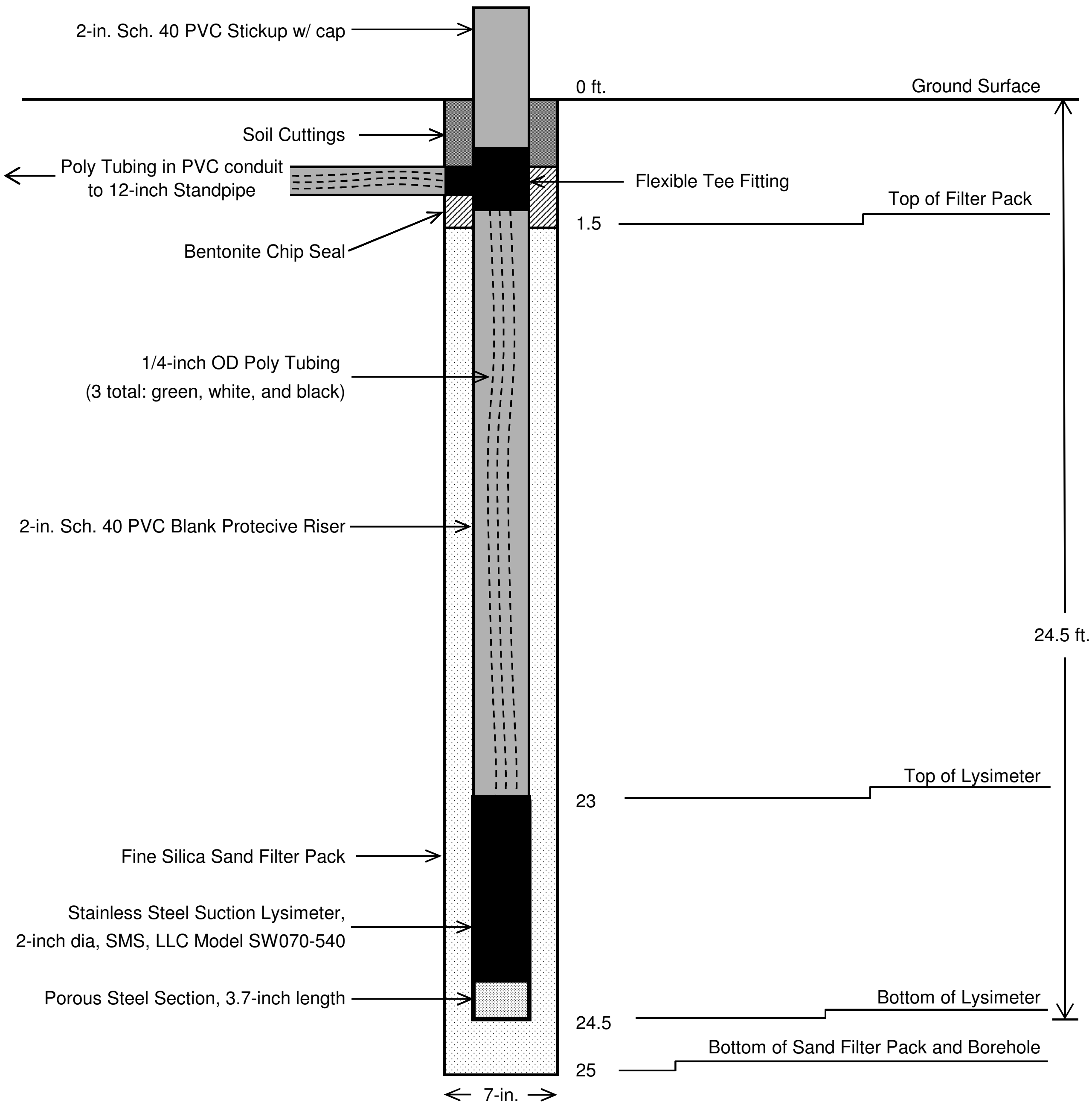
Drilled By: Holt Services, Inc.

Depth to Water: 2.8 ft bgs, 6/30/2017

Basin 4 West Lysimeter (10') Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

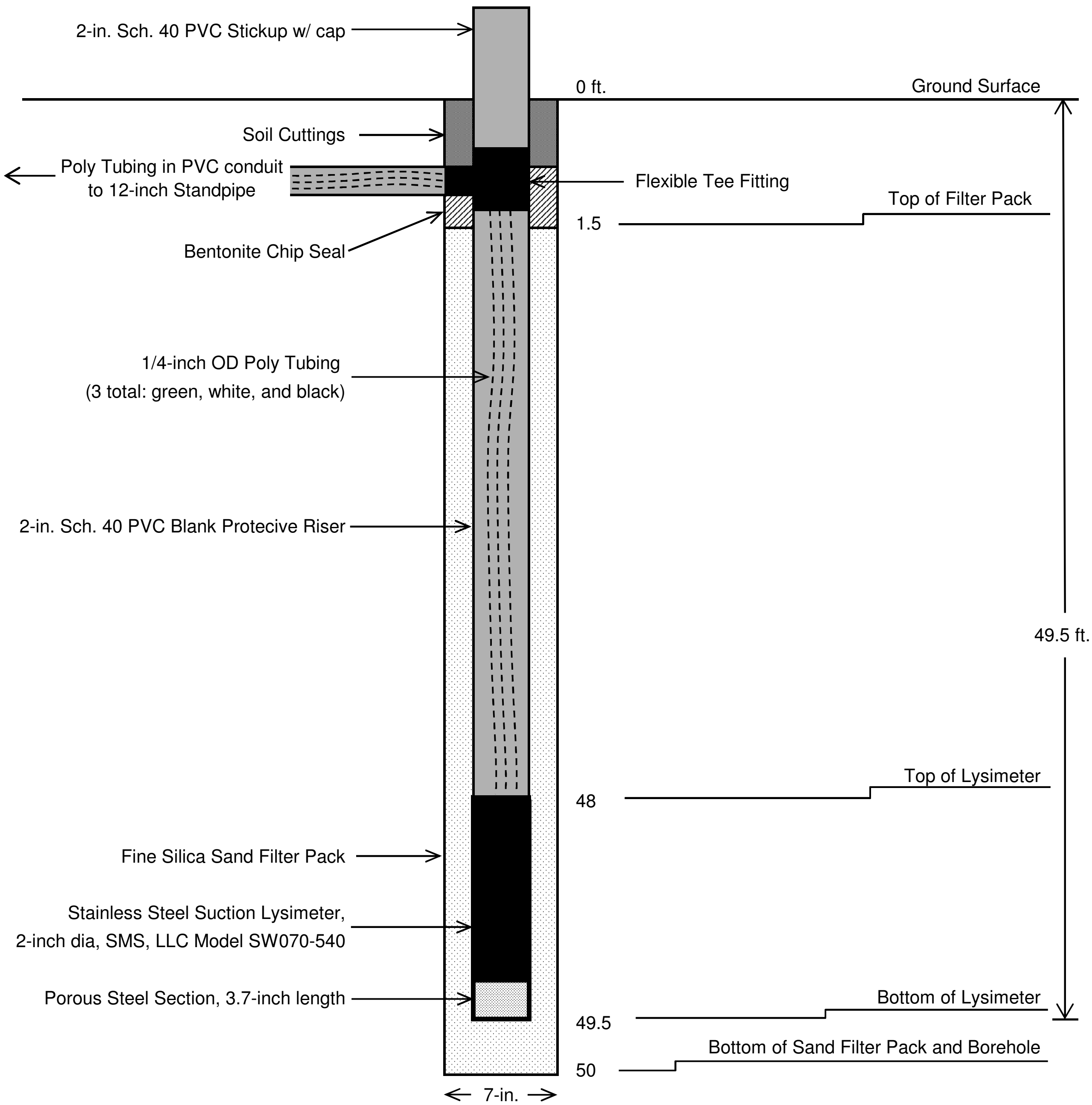


Constructed:	**06/27/2017**
Drilled By:	**Holt Services, Inc.**
Depth to Water:	**8.6 ft bgs, 6/30/2017**

Basin 4 West Lysimeter (25') Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

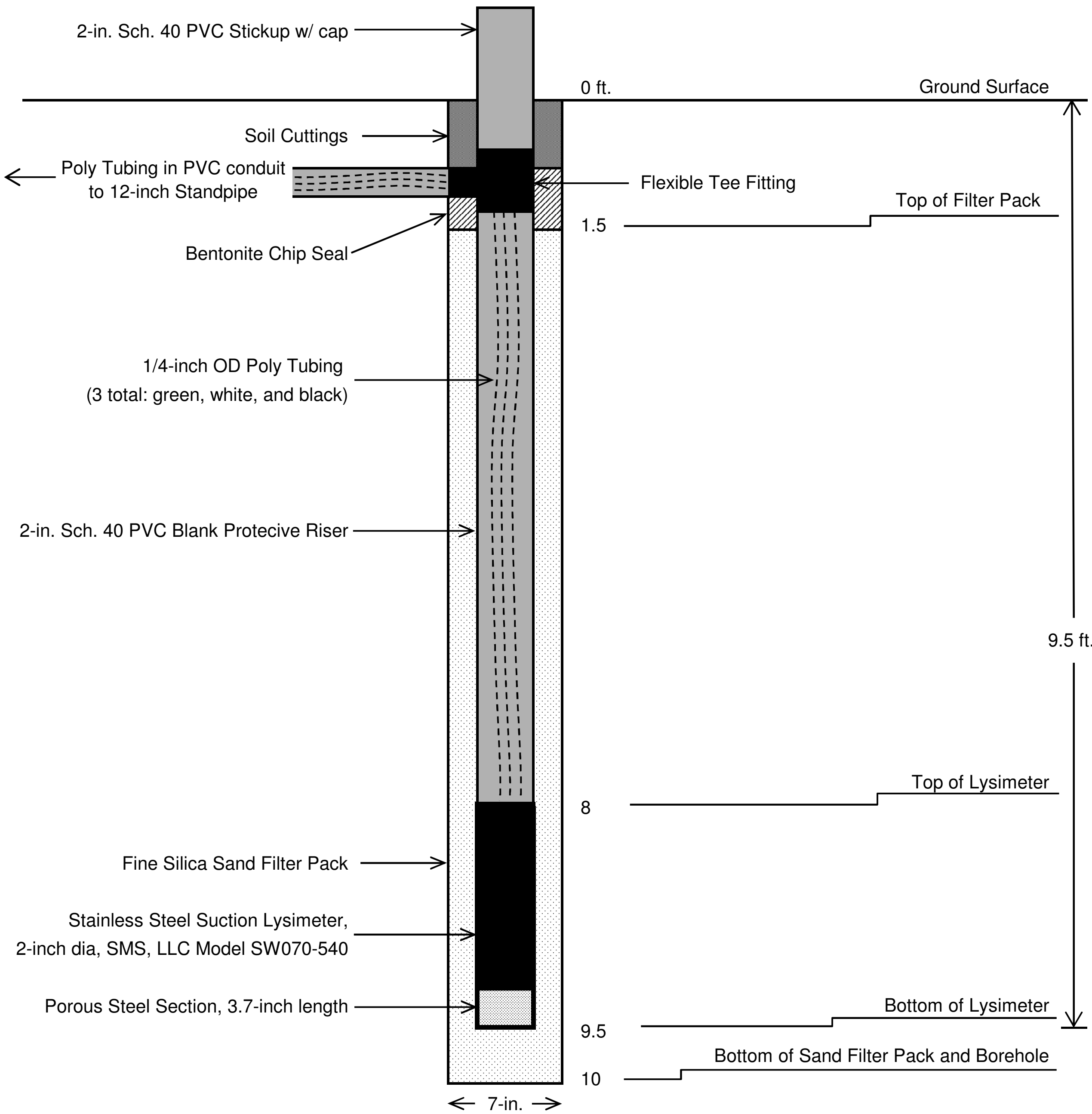


Constructed:	**06/26/2017**
Drilled By:	**Holt Services, Inc.**
Depth to Water:	**38 ft bgs, 6/30/2017**

Basin 4 West Lysimeter (50') Construction Diagram

LOTT Clean Water Alliance

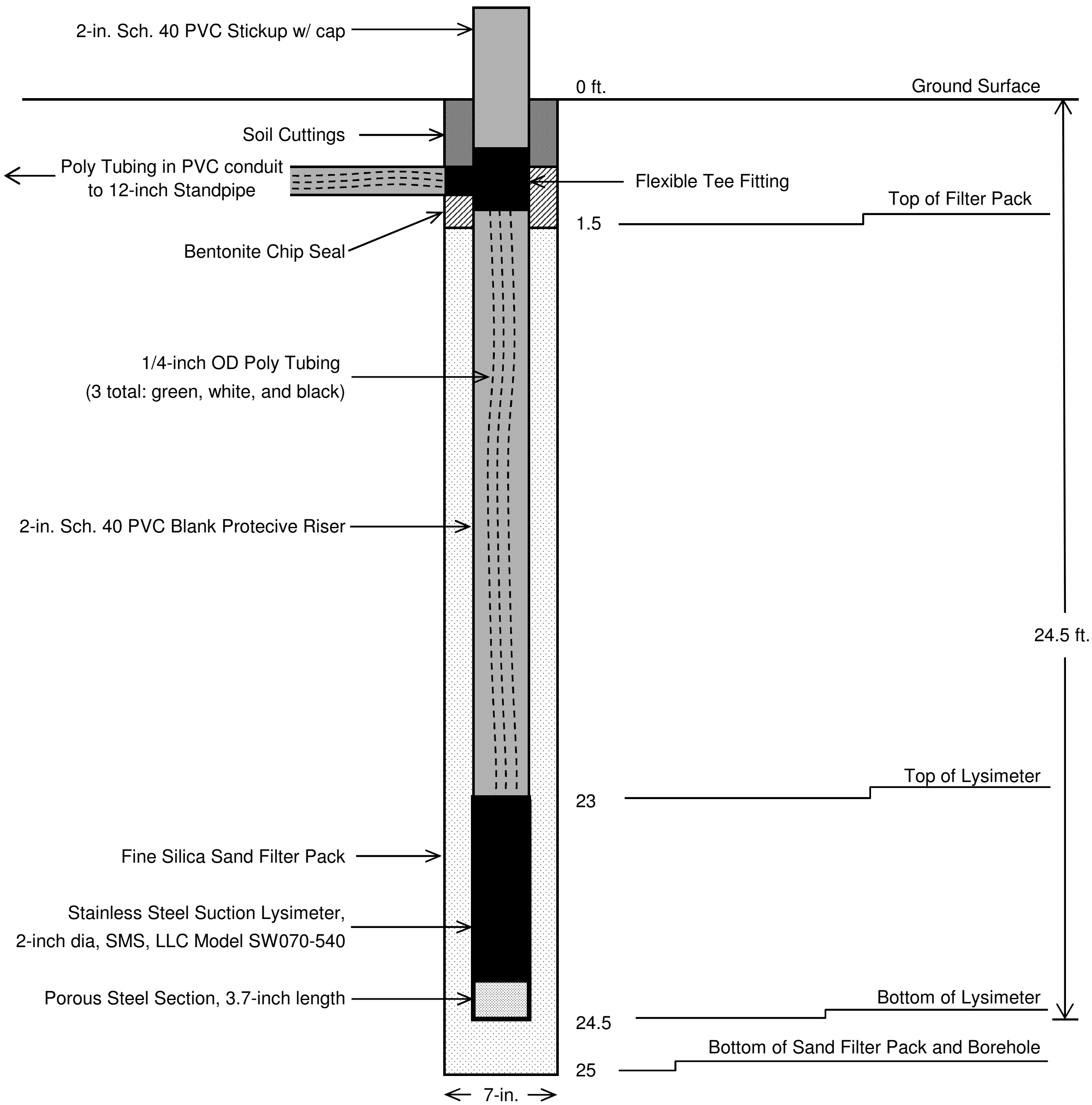
Hawks Prairie



Constructed: 06/29/2017
Drilled By: Holt Services, Inc.
Depth to Water: 8.2 ft bgs, 6/30/2017

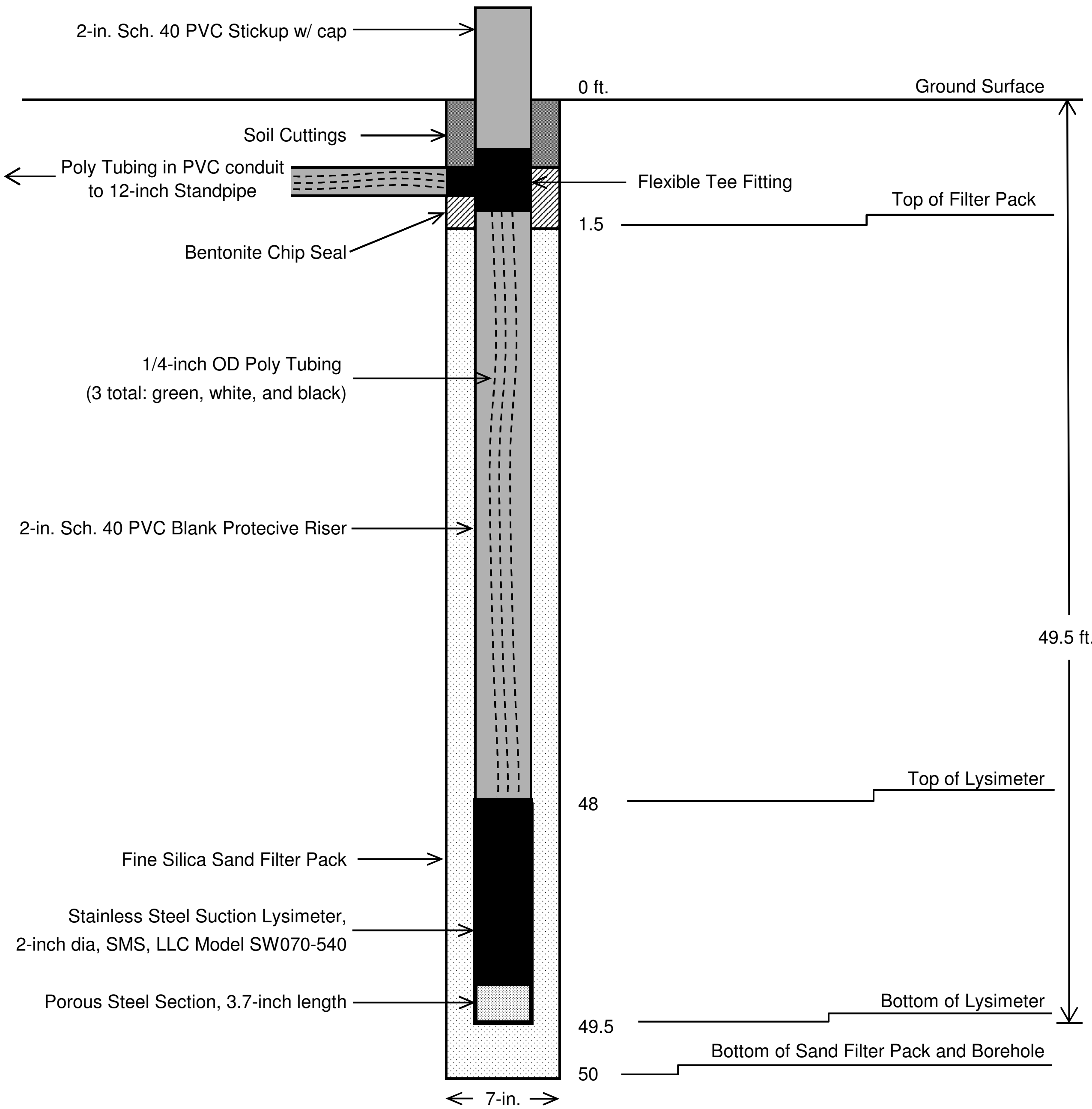
Basin 4 East Lysimeter (10') Construction Diagram

LOTT Clean Water Alliance
Hawks Prairie



Constructed: 06/29/2017
Drilled By: Holt Services, Inc.
Depth to Water: 8.4 ft bgs, 6/30/2017

Basin 4 East Lysimeter (25') Construction Diagram
LOTT Clean Water Alliance
Hawks Prairie



Constructed: 06/28/2017

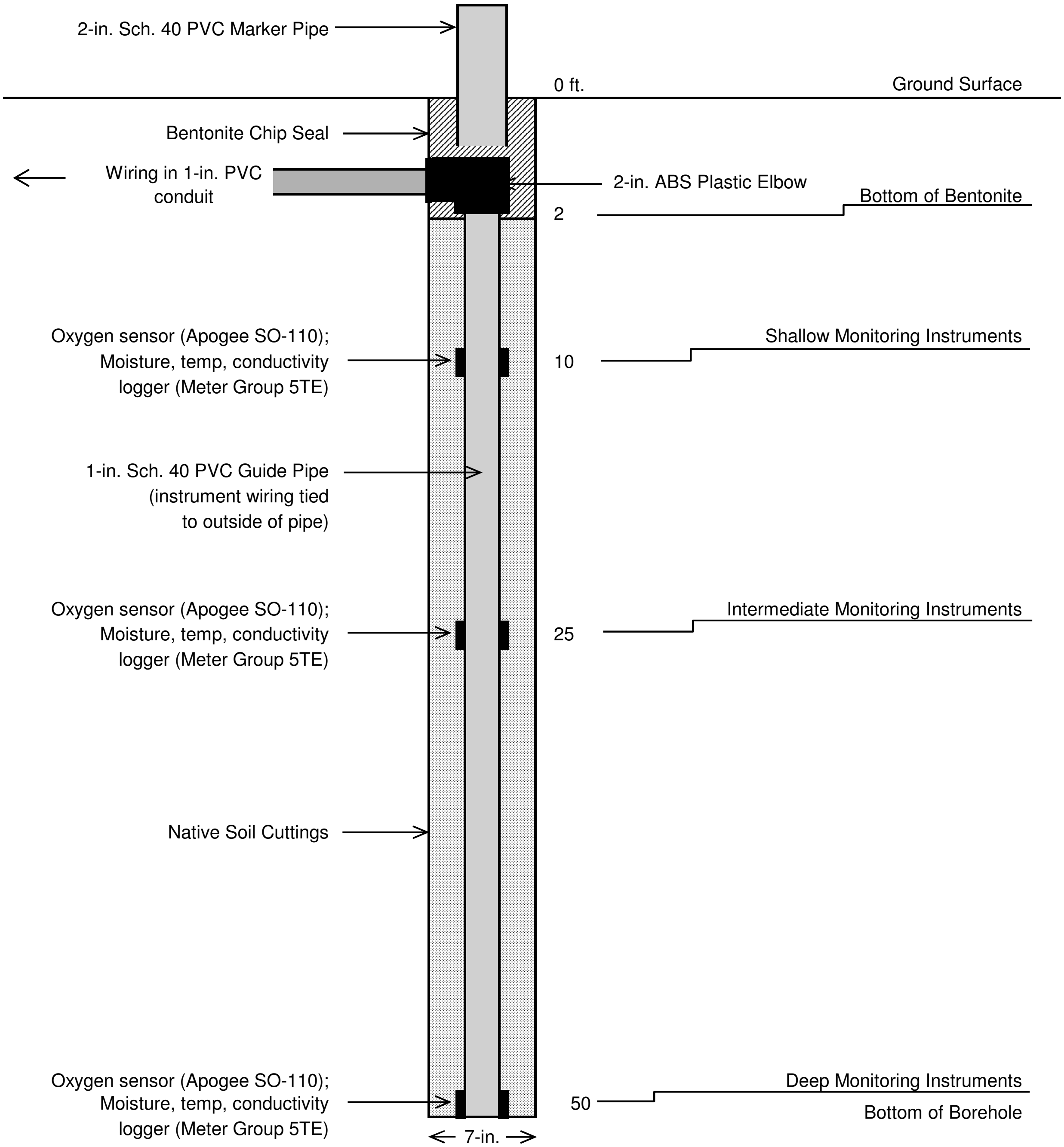
Drilled By: Holt Services, Inc.

Depth to Water: 19.9 ft bgs, 6/30/2017

Basin 4 East Lysimeter (50') Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie



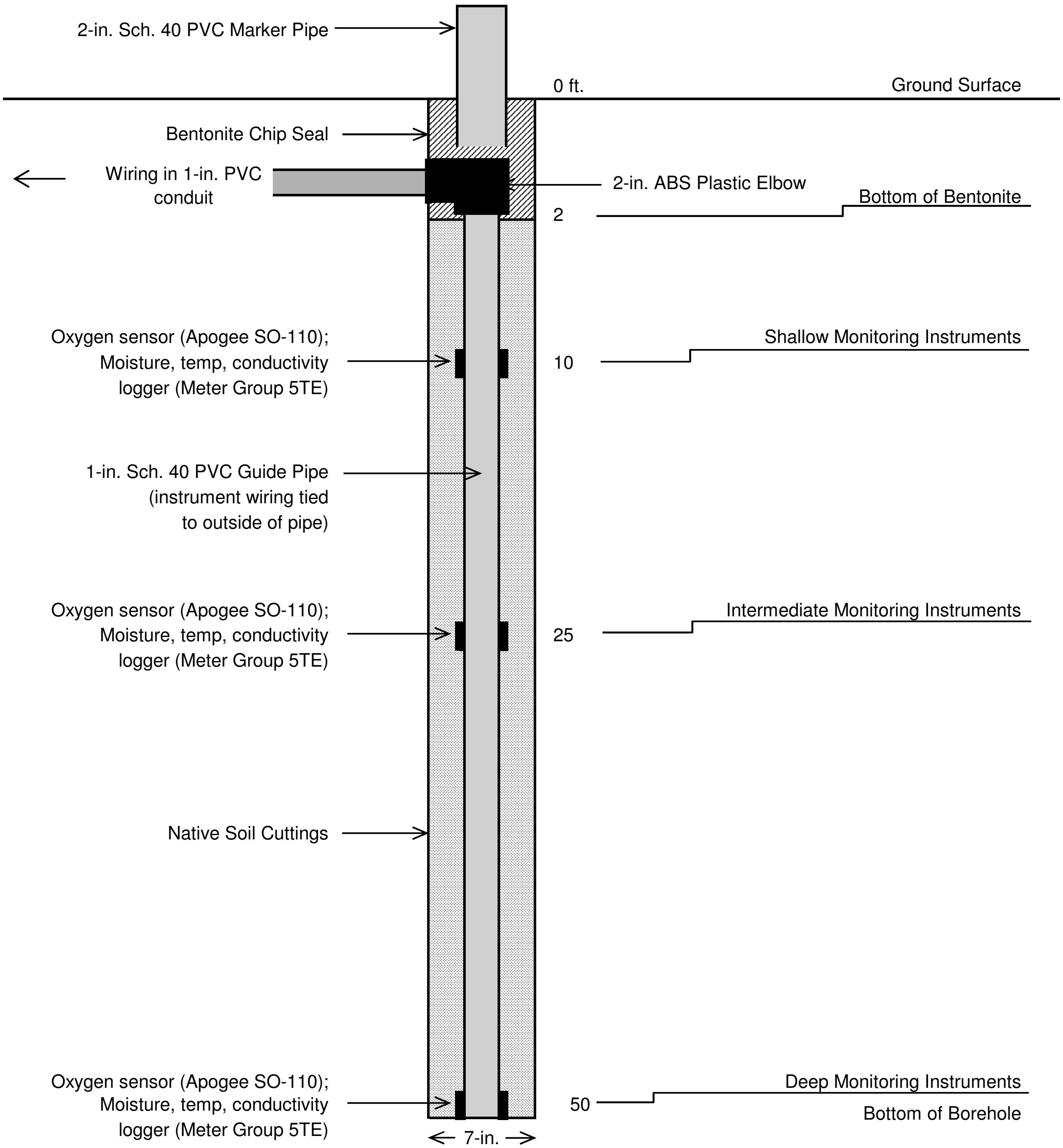
Constructed: 06/26/2017

Drilled By: Holt Services, Inc.

Basin 4 West Soil Instruments Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie



Constructed: 06/27/2017

Drilled By: Holt Services, Inc.

Basin 4 East Soil Instruments Construction Diagram

LOTT Clean Water Alliance

Hawks Prairie

This page intentionally left blank.

Appendix C – Well Surveying Report

This page intentionally left blank.

SKILLINGS CONNOLLY
5016 Lacey Boulevard S.E., Lacey, WA 98503
(360) 491-3399 1-800-454-7545 Fax (360) 491-3857
skillings@skillings.com www.skillings.com

MEMORANDUM

August 25, 2017

ATTN: *John Koreny*

RE: LOTT Monitoring Well Survey

Below are the results from the requested survey.

Monitoring Well ID	Northing	Easting	Elevation
MW-12	642690	1074893	227.00
MW-13	642684	1074897	226.80
MW-14	642641	1075991	218.04
MW-15	642742	1076002	219.20
MW-16	642738	1076203	219.34
MW-20	641507	1074874	219.22
MW-21	641077	1073574	227.16
MW-22	641051	1073575	227.23
MW-23	643061	1077296	204.54
MW-24	643021	1077296	204.90
MW-25	641496	1075647	228.95
MW-26	644799	1077568	233.18
MW-27	642077	1075465	220.16
MW-28	641129	1074790	224.85

Notes:
Horizontal ± 10 FT and Vertical ±0.01
Elevation is based on NAV D88

Enclosures:
(14) Monitoring Wells Photos
Excel file with the information in the table above

17202 - LOTT MONITORING WELL SURVEY

WELL #	NORTHING	EASTING	ELEV.	COLLECTED
MW-01			219.46	9/27/2017
MW-02			218.27	9/27/2017
MW-3A			219.17	9/28/2017
MW-03			218.15	9/27/2017
MW-04			217.74	9/27/2017
MW-05			219.09	9/27/2017
MW-06			218.97	9/27/2017
MW-07			218.91	9/27/2017
MW-08			218.70	9/27/2017
MW-09			218.69	9/27/2017
MW-10			224.89	9/27/2017
MW-11			228.00	9/27/2017
MW-12	642689.77	1074893.04	227.00	8/16/2017
MW-13	642684.06	1074896.57	226.80	8/16/2017
MW-14	642641.45	1075990.94	218.04	8/16/2017
MW-15	642741.74	1076002.38	219.20	8/16/2017
MW-16	642737.52	1076202.69	219.34	8/16/2017
MW-20	641507.21	1074873.59	219.22	8/16/2017
MW-21	641076.65	1073574.30	227.16	8/16/2017
MW-22	641050.50	1073575.31	227.23	8/16/2017
MW-23	643061.31	1077296.34	204.54	8/16/2017
MW-24	643021.20	1077296.25	204.90	8/16/2017
MW-25	641496.45	1075647.43	228.95	8/16/2017
MW-26	644798.85	1077567.68	233.18	8/16/2017
MW-27	642077.44	1075465.49	220.16	8/16/2017
MW-28	641129.02	1074790.41	224.85	8/16/2017

Appendix D – Analytical Reports - Lysimeter Boring Soil Samples

This page intentionally left blank.

Laboratory Report for

HDR

Lott, RWIS, Hawks Prairie Property

August 29, 2017

Daniel B. Stephens & Associates, Inc.

4400 Alameda Blvd. NE, Suite C • Albuquerque, New Mexico 87113

August 29, 2017

John Koreny
HDR
500 108th Ave NE STE 1200
Bellevue, WA 98004
(425) 450-6321

Re: DBS&A Laboratory Report for the HDR Lott, RWIS, Hawks Prairie Property Project

Dear Mr. Koreny:

Enclosed is the report for the HDR Lott, RWIS, Hawks Prairie Property project samples. Please review this report and provide any comments as samples will be held for a maximum of 30 days. After 30 days samples will be returned or disposed of in an appropriate manner.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

The testing utilized to generate the enclosed report employs methods that are standard for the industry. The results do not constitute a professional opinion by DBS&A, nor can the results affect any professional or expert opinions rendered with respect thereto by DBS&A. You have acknowledged that all the testing undertaken by us, and the report provided, constitutes mere test results using standardized methods, and cannot be used to disqualify DBS&A from rendering any professional or expert opinion, having waived any claim of conflict of interest by DBS&A.

We are pleased to provide this service to HDR and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.
SOIL TESTING & RESEARCH LABORATORY

Joleen Hines

Joleen Hines
Laboratory Manager

Enclosure

Daniel B. Stephens & Associates, Inc.
Soil Testing & Research Laboratory
4400 Alameda Blvd. NE, Suite C
Albuquerque, NM 87113
505-889-7752
FAX 505-889-0258

Summaries

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-eability	Percent Organic Matter	Cation Exchange Capacity
	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C			
West Lysimeter Boring (22'-25')	X	X		X			X	X		X	X			X		X	X				X	X
West Lysimeter Boring (42'-45')	X	X			X		X	X		X	X			X		X	X				X	X
East Lysimeter Boring (32'-35')	X	X			X		X	X		X	X			X		X	X				X	X
East Lysimeter Boring (42'-45')	X	X			X		X	X		X	X			X		X	X				X	X
LOTT Hawks Prarie Lysimeter West, Upper 10 feet																X	X				X	X
LOTT Hawks Prarie Lysimeter East, Upper 10 feet																X	X				X	X

[1] G = Gravimetric Moisture Content, VM = Volume Measurement Method, VD = Volume Displacement Method

[2] CH = Constant Head Rigid Wall, FH = Falling Head Rigid Wall, FW = Falling Head Rising Tail Flexible Wall

[3] HC = Hanging Column, PP = Pressure Plate, FP = Filter Paper, DPP = Dew Point Potentiometer, RH = Relative Humidity Box, EP = Effective Porosity, WHC = Water Holding Capacity, Kunsat = Calculated Unsaturated Hydraulic Conductivity

[4] DS = Dry Sieve, WS = Wet Sieve, H = Hydrometer

[5] F = Fine (<4.75mm), C = Coarse (>4.75mm)

Notes

Sample Receipt:
Six samples were received between July 10, 2017 and July 21, 2017. Four samples arrived each consisting of three ~3" x 12" cores sealed with tape. Two samples arrived each in a 1/3 full 1-gallon Ziploc bag. Each sample was delivered in good order.

Sample Preparation and Testing Notes:
An intact sub-sample was obtained from each of the core samples in the following intervals: West Lysimeter Boring (23-24'), West Lysimeter Boring (42-43'), East Lysimeter Boring (34-35'), and East Lysimeter Boring (43-44'). The subsamples were obtain by using a pipe cutter to remove an intact section from the original sample. The sub-samples were subjected to initial properties analysis, saturated hydraulic conductivity testing, and the hanging column and pressure chamber portions of the moisture retention testing.

Adjacent core sample material was obtained for the dewpoint potentiometer and relative humidity chamber portions of the moisture retention testing.

Material was obtained from both bag samples, and from adjacent core sample material, for particle size analysis, percent organic matter, and cation exchange capacity (CEC) testing. The CEC testing was performed by Energy Laboratories in Billings, MT.

Porosity calculations, and the particle diameter calculations in the hydrometer portion of the particle size analysis testing, are based on the use of an assumed specific gravity value of 2.65 or 2.68.

Summary of Sample Preparation/Volume Changes

Sample Number	Initial Sample Data[1]		Volume Change Post Saturation[2]			Volume Change Post Drying Curve[3]		
	Moisture Content (%, g/g)	Dry Bulk Density (g/cm^3)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Initial Density (%)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Initial Density (%)
West Lysimeter Boring (22'-25')	11.2	2.04	2.04	---	100.0%	2.04	---	100.0%
West Lysimeter Boring (42'-45')	7.1	2.16	2.16	---	100.0%	2.16	---	100.0%
East Lysimeter Boring (32'-35')	6.3	2.27	2.27	---	100.0%	2.27	---	100.0%
East Lysimeter Boring (42'-45')	7.5	2.19	2.19	---	100.0%	2.19	---	100.0%

[1]Initial Sample Data: The 'as received' dry bulk density and moisture content.

[2]Volume Change Post Saturation: Volume change measurements were obtained after saturated hydraulic conductivity testing.

[3]Volume Change Post Drying Curve: Volume change measurements were obtained throughout hanging column and pressure plate testing. The 'Volume Change Post Drying Curve' values represent the final sample dimensions after the last pressure plate point.

Notes:

"+" indicates sample swelling, "-" indicates sample settling, and "---" indicates no volume change occurred.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

	Moisture Content						
	As Received		Remolded		Dry Bulk Density	Wet Bulk Density	Calculated Porosity
Sample Number	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	(g/cm^3)	(g/cm^3)	(%)
West Lysimeter Boring (22'-25')	11.2	22.8	---	---	2.04	2.27	23.8
West Lysimeter Boring (42'-45')	7.1	15.5	---	---	2.16	2.32	19.3
East Lysimeter Boring (32'-35')	6.3	14.3	---	---	2.27	2.42	15.2
East Lysimeter Boring (42'-45')	7.5	16.4	---	---	2.19	2.36	18.2

NA = Not analyzed
--- = This sample was not remolded

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis	
			Constant Head	Falling Head
West Lysimeter Boring (22'-25')	5.2E-05	NA	X	
West Lysimeter Boring (42'-45')	1.2E-05	NA		X
East Lysimeter Boring (32'-35')	2.3E-06	NA		X
East Lysimeter Boring (42'-45')	8.0E-07	NA		X

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NR = Not requested
NA = Not applicable

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
West Lysimeter Boring (22'-25')	0	24.6
	17	22.9
	49	19.8
	123	18.0
	337	12.7
	5609	7.5
	20396	5.3
	58027	4.2
	281465	3.5
	851293	1.8
West Lysimeter Boring (42'-45')	0	18.9
	17	18.4
	49	18.3
	123	18.1
	337	15.9
	6527	6.8
	23863	4.3
	65369	3.1
	261681	2.3
	851293	1.4
East Lysimeter Boring (32'-35')	0	15.8
	24	14.8
	69	14.5
	142	14.0
	337	12.6
	3059	5.6
	17745	2.7
	74955	1.3
	400883	0.8
	851293	0.6

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
East Lysimeter Boring (42'-45')	0	18.5
	51	17.8
	141	17.4
	337	16.9
	1530	15.9
	3365	11.6
	14379	6.4
	62004	3.2
	281261	1.9
	851293	1.3

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Calculated Unsaturated Hydraulic Properties

Sample Number	α (cm^{-1})	N (dimensionless)	θ_r (% vol)	θ_s (% vol)	Oversize Corrected θ_r (% vol)	Oversize Corrected θ_s (% vol)
West Lysimeter Boring (22'-25')	0.0335	1.2447	0.40	24.66	NA	NA
West Lysimeter Boring (42'-45')	0.0027	1.3435	0.00	18.74	NA	NA
East Lysimeter Boring (32'-35')	0.0029	1.4423	0.00	15.25	NA	NA
East Lysimeter Boring (42'-45')	0.0005	1.4831	0.00	17.90	NA	NA

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NR = Not requested

NA = Not applicable

Summary of Particle Size Characteristics

Sample Number	d_{10} (mm)	d_{50} (mm)	d_{60} (mm)	C_u	C_c	Method	ASTM Classification	USDA Classification
West Lysimeter Boring (22'-25')	0.036	0.47	0.57	16	4.1	WS/H	Classification by ASTM 2487 requires Atterberg test	Sand †
West Lysimeter Boring (42'-45')	0.023	0.63	1.0	43	4.5	WS/H	Classification by ASTM 2487 requires Atterberg test	Loamy Sand †
East Lysimeter Boring (32'-35')	0.078	7.1	9.5	122	9.8	WS/H	Classification by ASTM 2487 requires Atterberg test	Sandy Loam †
East Lysimeter Boring (42'-45')	0.0038	1.2	3.5	921	1.5	WS/H	Classification by ASTM 2487 requires Atterberg test	Sandy Loam †
LOTT Hawks Prarie Lysimeter West, Upper 10 feet	0.30	6.9	10	33	2.1	WS/H	Classification by ASTM 2487 requires Atterberg test	Loamy Sand †
LOTT Hawks Prarie Lysimeter East, Upper 10 feet	0.30	2.4	3.6	12	1.3	WS/H	Classification by ASTM 2487 requires Atterberg test	Sand †

d_{50} = Median particle diameter

Est = Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

$$C_u = \frac{d_{60}}{d_{10}}$$

$$C_c = \frac{(d_{30})^2}{(d_{10})(d_{60})}$$

DS = Dry sieve

H = Hydrometer

WS = Wet sieve

† Greater than 10% of sample is coarse material

Percent Gravel, Sand, Silt and Clay*

Sample Number	% Gravel (>4.75mm)	% Sand (<4.75mm, >0.075mm)	% Silt (<0.075mm, >0.002mm)	% Clay (<0.002mm)
West Lysimeter Boring (22'-25')	6.0	79.6	11.3	3.2
West Lysimeter Boring (42'-45')	28.8	55.8	10.4	5.1
East Lysimeter Boring (32'-35')	63.3	26.8	7.0	2.9
East Lysimeter Boring (42'-45')	36.8	37.3	18.5	7.4
LOTT Hawks Prarie Lysimeter West, Upper 10 feet	59.0	35.1	4.7	1.1
LOTT Hawks Prarie Lysimeter East, Upper 10 feet	32.7	61.2	4.6	1.5

*USCS classification does not classify clay fraction based on particle size. USDA definition of clay (<0.002mm) used in this table.

Summary of Percent Organic Matter

Sample Number	Organic Matter* (%, g/g)
West Lysimeter Boring (22'-25')	0.6
West Lysimeter Boring (42'-45')	0.6
East Lysimeter Boring (32'-35')	0.7
East Lysimeter Boring (42'-45')	1.0
LOTT Hawks Prarie Lysimeter West, Upper 10 feet	0.7
LOTT Hawks Prarie Lysimeter East, Upper 10 feet	0.7

*Correction for oversize material applied, if necessary

Summary of Cation Exchange Capacity

Sample Number	CEC (meq/100g)	Reporting Detection Limit
West Lysimeter Boring (22'-25')	4.86	0.09
West Lysimeter Boring (42'-45')	5.61	0.09
East Lysimeter Boring (32'-35')	6.84	0.09
East Lysimeter Boring (42'-45')	7.10	0.09
LOTT Hawks Prarie Lysimeter West, Upper 10 feet	3.43	0.09
LOTT Hawks Prarie Lysimeter East, Upper 10 feet	3.04	0.09

"<" Indicates value is less than the detection limit.
Analysis performed by Hall Environmental Analysis Laboratory

Initial Properties

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received Gravimetric (%, g/g)	Moisture Content: As Received Volumetric (%, cm^3/cm^3)	Moisture Content: Remolded Gravimetric (%, g/g)	Moisture Content: Remolded Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
West Lysimeter Boring (22'-25')	11.2	22.8	---	---	2.04	2.27	23.8
West Lysimeter Boring (42'-45')	7.1	15.5	---	---	2.16	2.32	19.3
East Lysimeter Boring (32'-35')	6.3	14.3	---	---	2.27	2.42	15.2
East Lysimeter Boring (42'-45')	7.5	16.4	---	---	2.19	2.36	18.2

NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: HDR
Job Number: DB17.1173.00
Sample Number: West Lysimeter Boring (22'-25')
Project: Lott, RWIS, Hawks Prarie Property
Depth (ft): 22'-25'

	As Received	Remolded
Test Date:	12-Jul-17	---
Field weight of sample* (g):	1192.58	
Tare weight, ring (g):	88.01	
Tare weight, pan/plate (g):	0.00	
Tare weight, other (g):	0.00	
Dry weight of sample (g):	993.52	
Sample volume (cm^3):	486.38	
Assumed particle density (g/cm^3):	2.68	
Gravimetric Moisture Content (% g/g):	11.2	
Volumetric Moisture Content (% vol):	22.8	
Dry bulk density (g/cm^3):	2.04	
Wet bulk density (g/cm^3):	2.27	
Calculated Porosity (% vol):	23.8	
Percent Saturation:	96.0	

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	HDR
Job Number:	DB17.1173.00
Sample Number:	West Lysimeter Boring (42'-45')
Project:	Lott, RWIS, Hawks Prarie Property
Depth (ft):	42'-45'

	As Received	Remolded
Test Date:	12-Jul-17	---
Field weight of sample* (g):	1116.98	
Tare weight, ring (g):	81.30	
Tare weight, pan/plate (g):	0.00	
Tare weight, other (g):	0.00	
Dry weight of sample (g):	966.59	
Sample volume (cm^3):	447.05	
Assumed particle density (g/cm^3):	2.68	
Gravimetric Moisture Content (% g/g):	7.1	
Volumetric Moisture Content (% vol):	15.5	
Dry bulk density (g/cm^3):	2.16	
Wet bulk density (g/cm^3):	2.32	
Calculated Porosity (% vol):	19.3	
Percent Saturation:	80.0	

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	HDR
Job Number:	DB17.1173.00
Sample Number:	East Lysimeter Boring (32'-35')
Project:	Lott, RWIS, Hawks Prarie Property
Depth (ft):	32'-35'

	As Received	Remolded
Test Date:	12-Jul-17	---
Field weight of sample* (g):	1354.67	
Tare weight, ring (g):	94.90	
Tare weight, pan/plate (g):	0.00	
Tare weight, other (g):	0.00	
Dry weight of sample (g):	1185.04	
Sample volume (cm^3):	521.22	
Assumed particle density (g/cm^3):	2.68	
Gravimetric Moisture Content (% g/g):	6.3	
Volumetric Moisture Content (% vol):	14.3	
Dry bulk density (g/cm^3):	2.27	
Wet bulk density (g/cm^3):	2.42	
Calculated Porosity (% vol):	15.2	
Percent Saturation:	94.5	

Laboratory analysis by:	D. O'Dowd
Data entered by:	D. O'Dowd
Checked by:	J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	HDR	
Job Number:	DB17.1173.00	
Sample Number:	East Lysimeter Boring (42'-45')	
Project:	Lott, RWIS, Hawks Prarie Property	
Depth (ft):	42'-45'	
	As Received	Remolded
Test Date:	12-Jul-17	---
Field weight of sample* (g):	1128.84	
Tare weight, ring (g):	80.10	
Tare weight, pan/plate (g):	0.00	
Tare weight, other (g):	0.00	
Dry weight of sample (g):	975.59	
Sample volume (cm^3):	445.25	
Assumed particle density (g/cm^3):	2.68	
Gravimetric Moisture Content (% g/g):	7.5	
Volumetric Moisture Content (% vol):	16.4	
Dry bulk density (g/cm^3):	2.19	
Wet bulk density (g/cm^3):	2.36	
Calculated Porosity (% vol):	18.2	
Percent Saturation:	90.1	

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Saturated Hydraulic Conductivity

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis	
			Constant Head	Falling Head
West Lysimeter Boring (22'-25')	5.2E-05	NA	X	
West Lysimeter Boring (42'-45')	1.2E-05	NA		X
East Lysimeter Boring (32'-35')	2.3E-06	NA		X
East Lysimeter Boring (42'-45')	8.0E-07	NA		X

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NR = Not requested
NA = Not applicable

Saturated Hydraulic Conductivity
Constant Head Method

Job Name:	HDR	*Type of water used:*	TAP
Job Number:	DB17.1173.00	*Collection vessel tare* (g)*:*	10.93
Sample Number:	West Lysimeter Boring (22'-25')	*Sample length* (cm)*:*	7.83
Project:	Lott, RWIS, Hawks Prarie Property	*Sample diameter* (cm)*:*	8.90
Depth (ft):	22'-25'	*Sample x-sectional area* (cm^2)*:*	62.14

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
13-Jul-17	10:05:00	22.5	13.5	12.67	1.7	300	5.4E-05	5.1E-05
13-Jul-17	10:10:00							
Test # 2:								
13-Jul-17	10:20:00	22.5	7.4	11.90	1.0	300	5.5E-05	5.2E-05
13-Jul-17	10:25:00							
Test # 3:								
13-Jul-17	10:37:00	22.5	4.5	11.53	0.6	300	5.6E-05	5.3E-05
13-Jul-17	10:42:00							

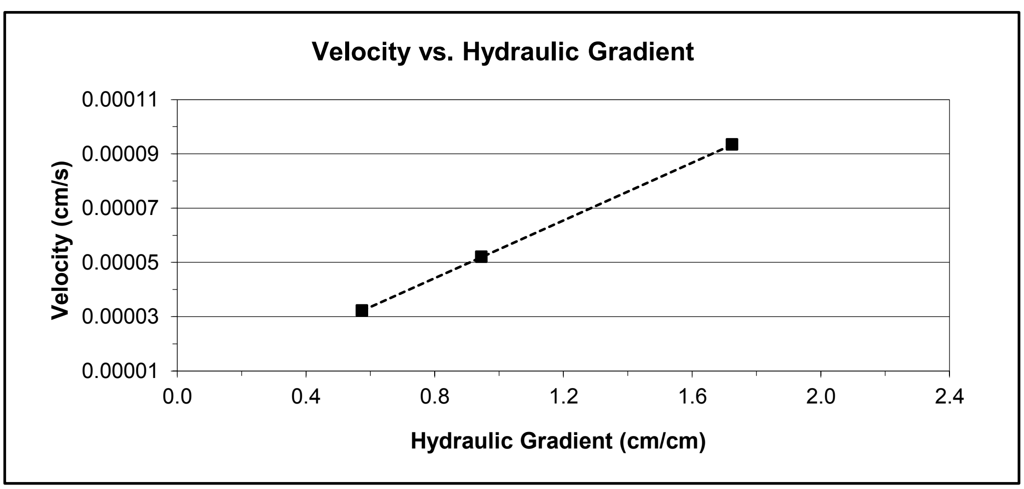
Average Ksat* (cm/sec)*: **5.2E-05**

Oversize Corrected Ksat* (cm/sec)*: **NA**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not applicable



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Falling Head Method

Job Name:	HDR	*Type of water used:*	TAP
Job Number:	DB17.1173.00	*Backpressure* (psi)*:*	0.0
Sample Number:	West Lysimeter Boring (42'-45')	*Offset* (cm)*:*	0.1
Project:	Lott, RWIS, Hawks Prarie Property	*Sample length* (cm)*:*	7.19
Depth (ft):	42'-45'	*Sample x-sectional area* (cm^2)*:*	62.21
		Reservoir x-sectional area (cm^2)*:*	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
13-Jul-17	10:06:23	23.0	18.5	18.4	163	1.4E-05	1.3E-05
13-Jul-17	10:09:06	23.0	18	17.9			
Test # 2:							
13-Jul-17	10:09:06	23.0	18	17.9	173	1.3E-05	1.2E-05
13-Jul-17	10:11:59	23.0	17.5	17.4			
Test # 3:							
13-Jul-17	10:11:59	23.0	17.5	17.4	183	1.3E-05	1.2E-05
13-Jul-17	10:15:02	23.0	17	16.9			

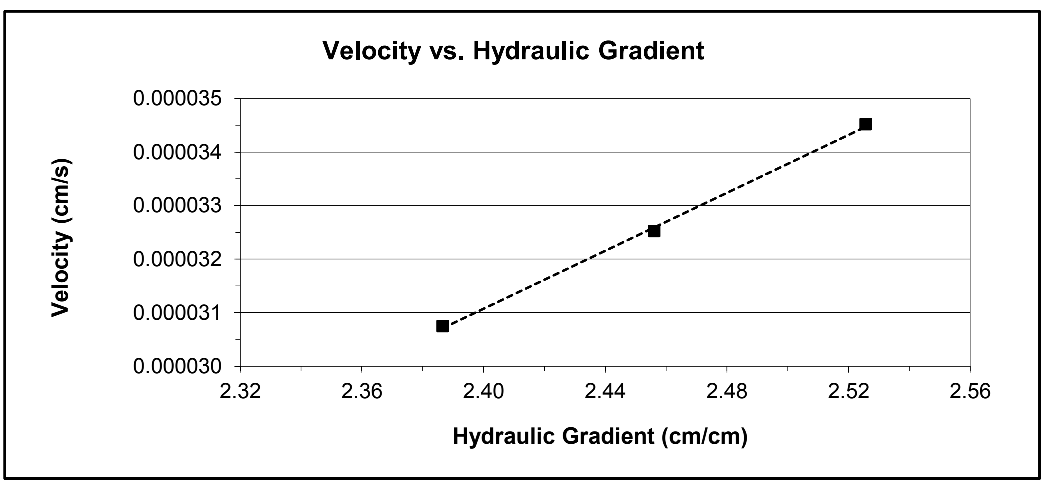
Average Ksat* (cm/sec)*: **1.2E-05**

Oversize Corrected Ksat* (cm/sec)*: **NA**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not applicable



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Falling Head Method

Job Name:	HDR	*Type of water used:*	TAP
Job Number:	DB17.1173.00	*Backpressure* (psi):	0.0
Sample Number:	East Lysimeter Boring (32'-35')	*Offset* (cm):	1.1
Project:	Lott, RWIS, Hawks Prarie Property	*Sample length* (cm):	8.37
Depth (ft):	32'-35'	*Sample x-sectional area* (cm^2):	62.30
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
13-Jul-17	8:39:47	23.2	50.3	49.2	728	2.7E-06	2.5E-06
13-Jul-17	8:51:55	23.2	49.3	48.2			
Test # 2:							
13-Jul-17	8:51:55	23.2	49.3	48.2	821	2.4E-06	2.2E-06
13-Jul-17	9:05:36	23.5	48.3	47.2			
Test # 3:							
13-Jul-17	9:05:36	23.5	48.3	47.2	883	2.3E-06	2.1E-06
13-Jul-17	9:20:19	23.5	47.3	46.2			

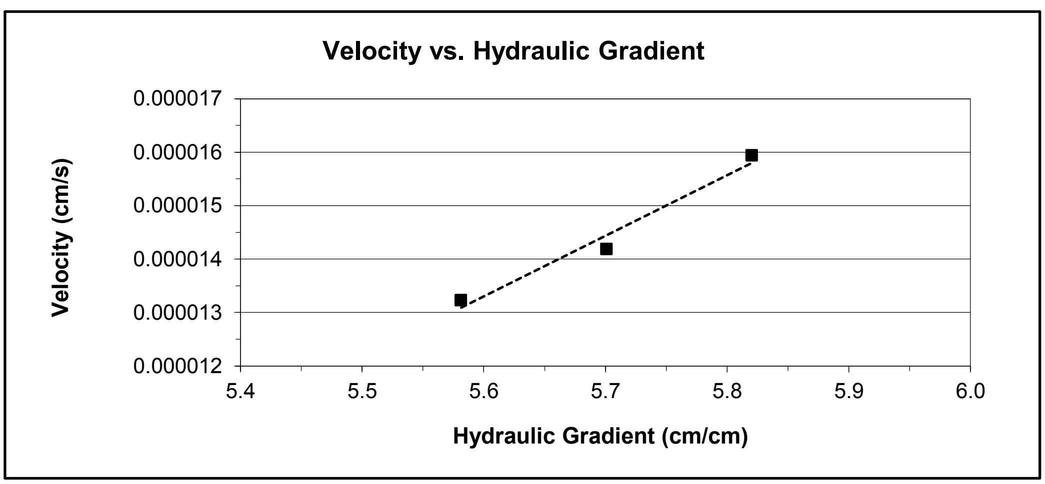
***Average Ksat* (cm/sec): 2.3E-06**

***Oversize Corrected Ksat* (cm/sec): NA**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not applicable



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Saturated Hydraulic Conductivity
Falling Head Method

Job Name:	HDR	*Type of water used:*	TAP
Job Number:	DB17.1173.00	*Backpressure* (psi):	0.0
Sample Number:	East Lysimeter Boring (42'-45')	*Offset* (cm):	0.1
Project:	Lott, RWIS, Hawks Prarie Property	*Sample length* (cm):	7.12
Depth (ft):	42'-45'	*Sample x-sectional area* (cm^2):	62.56
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
13-Jul-17	8:54:41	23.2	50.3	50.2	861	9.3E-07	8.5E-07
13-Jul-17	9:09:02	23.5	49.8	49.7			
Test # 2:							
13-Jul-17	9:09:02	23.5	49.8	49.7	928	8.7E-07	8.0E-07
13-Jul-17	9:24:30	23.5	49.3	49.2			
Test # 3:							
13-Jul-17	9:24:30	23.5	49.3	49.2	1020	8.0E-07	7.3E-07
13-Jul-17	9:41:30	23.5	48.8	48.7			

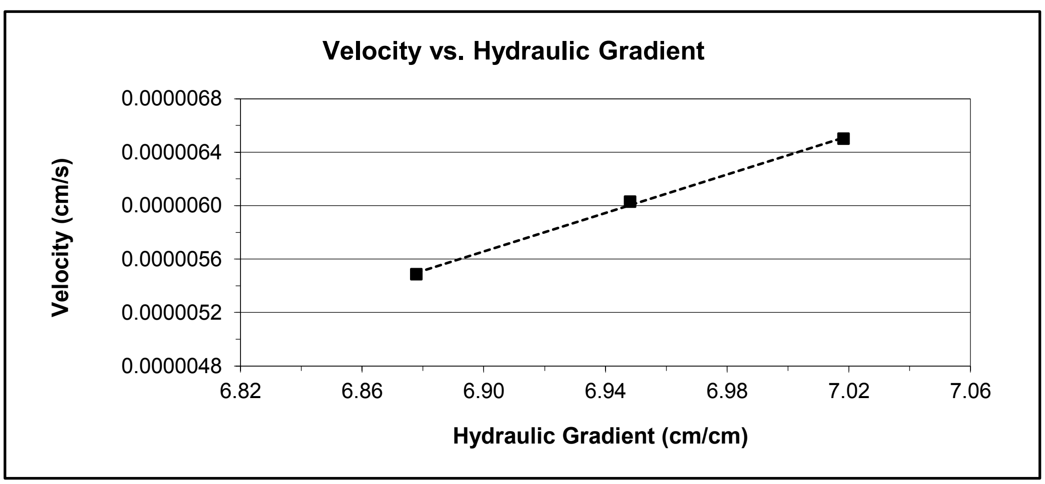
***Average Ksat* (cm/sec): 8.0E-07**

***Oversize Corrected Ksat* (cm/sec): NA**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not applicable



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Moisture Retention Characteristics

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
West Lysimeter Boring (22'-25')	0	24.6
	17	22.9
	49	19.8
	123	18.0
	337	12.7
	5609	7.5
	20396	5.3
	58027	4.2
	281465	3.5
	851293	1.8
West Lysimeter Boring (42'-45')	0	18.9
	17	18.4
	49	18.3
	123	18.1
	337	15.9
	6527	6.8
	23863	4.3
	65369	3.1
	261681	2.3
	851293	1.4
East Lysimeter Boring (32'-35')	0	15.8
	24	14.8
	69	14.5
	142	14.0
	337	12.6
	3059	5.6
	17745	2.7
	74955	1.3
	400883	0.8
	851293	0.6

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
East Lysimeter Boring (42'-45')	0	18.5
	51	17.8
	141	17.4
	337	16.9
	1530	15.9
	3365	11.6
	14379	6.4
	62004	3.2
	281261	1.9
	851293	1.3

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Calculated Unsaturated Hydraulic Properties

Sample Number	α (cm^{-1})	N (dimensionless)	θ_r (% vol)	θ_s (% vol)	Oversize Corrected θ_r (% vol)	Oversize Corrected θ_s (% vol)
West Lysimeter Boring (22'-25')	0.0335	1.2447	0.40	24.66	NA	NA
West Lysimeter Boring (42'-45')	0.0027	1.3435	0.00	18.74	NA	NA
East Lysimeter Boring (32'-35')	0.0029	1.4423	0.00	15.25	NA	NA
East Lysimeter Boring (42'-45')	0.0005	1.4831	0.00	17.90	NA	NA

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NR = Not requested
NA = Not applicable

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name:	HDR	*Dry wt. of sample (g):*	993.52
Job Number:	DB17.1173.00	*Tare wt., ring (g):*	88.01
Sample Number:	West Lysimeter Boring (22'-25')	*Tare wt., screen & clamp (g):*	32.17
Project:	Lott, RWIS, Hawks Prarie Property	*Initial sample volume (cm³):*	486.38
Depth (ft):	22'-25'	*Initial dry bulk density (g/cm³):*	2.04
		Assumed particle density (g/cm³):	2.68
		Initial calculated total porosity (%):	23.78

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	13-Jul-17	13:30	1233.40	0	24.61
	20-Jul-17	12:35	1225.30	16.5	22.94
	27-Jul-17	14:05	1209.89	49.0	19.78
	3-Aug-17	13:30	1201.13	123.0	17.98
Pressure plate:	17-Aug-17	12:20	1175.49	337	12.70

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	16.5	---	---	---	---
	49.0	---	---	---	---
	123.0	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: West Lysimeter Boring (22'-25')

Initial sample bulk density (g/cm^3)*:* 2.04
Fraction of bulk sample used (<2.00mm fraction) (%): 89.95

Dry weight of dew point potentiometer sample* (g)*:* 179.42
Tare weight, jar (g)*:* 116.42

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	2-Aug-17	10:00	181.98	5609	7.47
	28-Jul-17	10:35	181.25	20396	5.32
	26-Jul-17	10:30	180.86	58027	4.19
	20-Jul-17	9:45	180.62	281465	3.49

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	5609	---	---	---	---
	20396	---	---	---	---
	58027	---	---	---	---
	281465	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1).

Laboratory analysis by: J. Falance/A. Bland
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: West Lysimeter Boring (22'-25')

Initial sample bulk density (g/cm^3): 2.04
Fraction of bulk sample used (<2.00mm fraction) (%): 89.95

Dry weight of relative humidity box sample* (g): 62.67
Tare weight (g): 39.51

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	25-Jul-17	11:40	62.90	851293	1.85

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

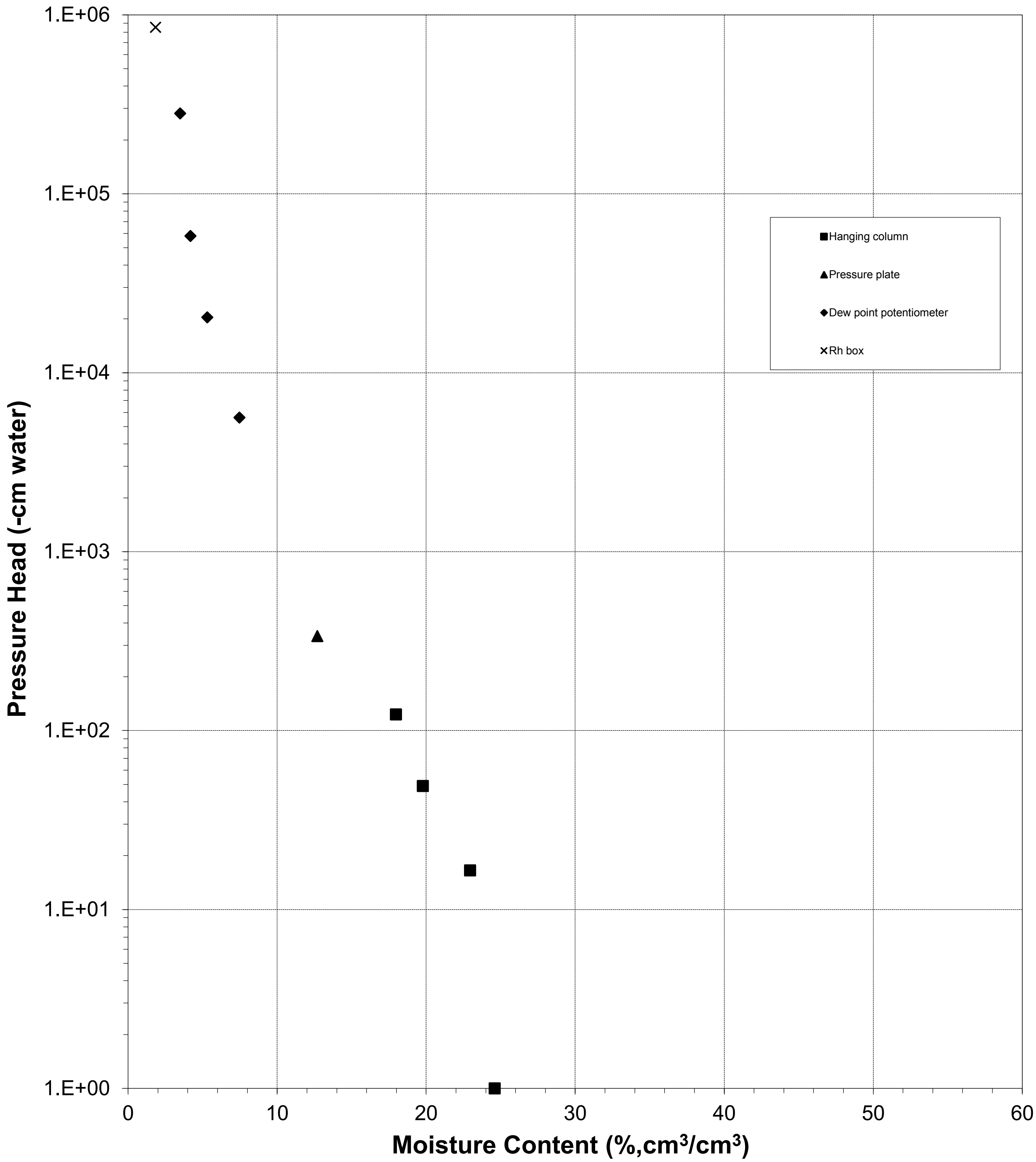
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: J. Falance/A. Bland
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

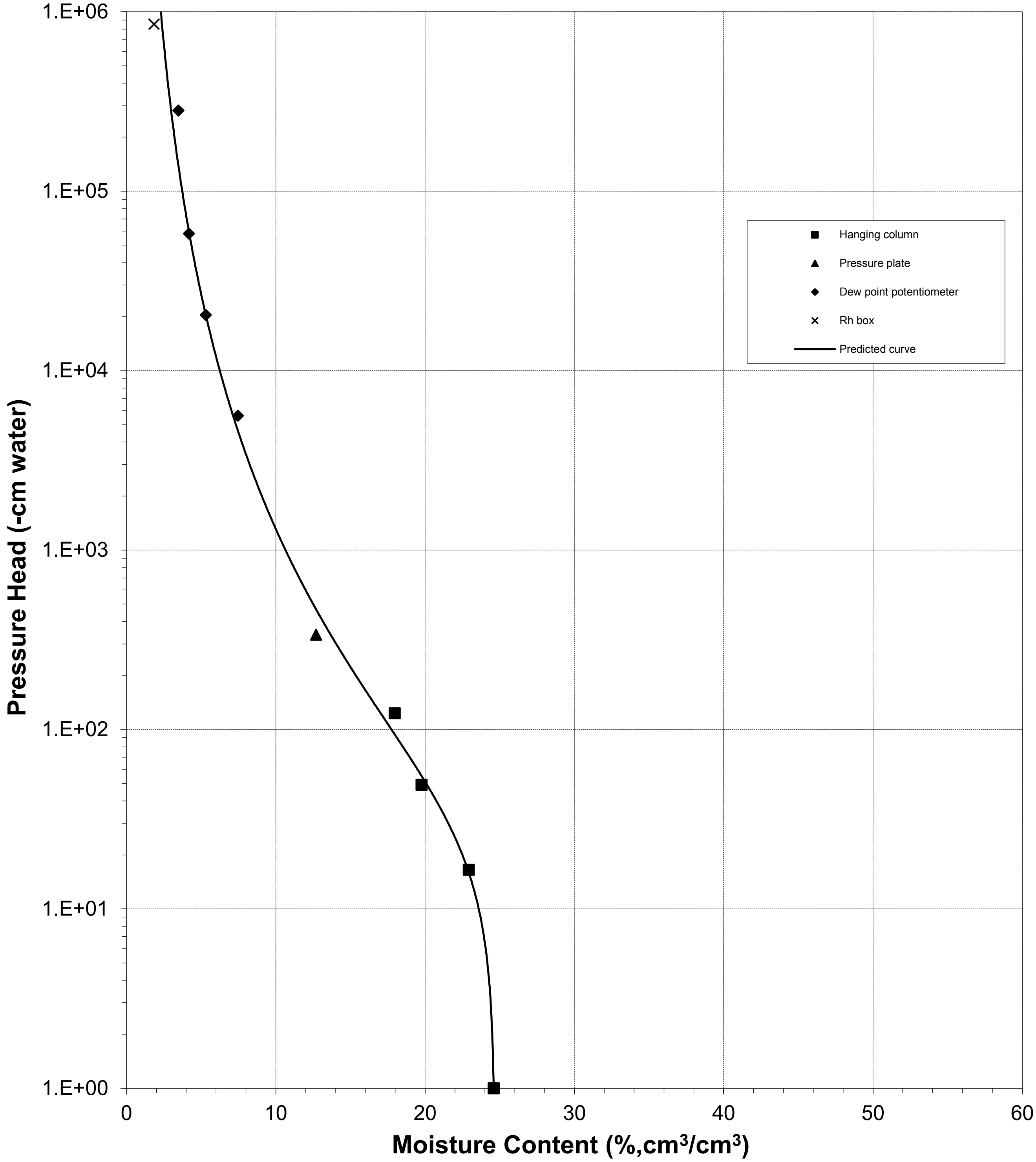
Water Retention Data Points

Sample Number: West Lysimeter Boring (22'-25')



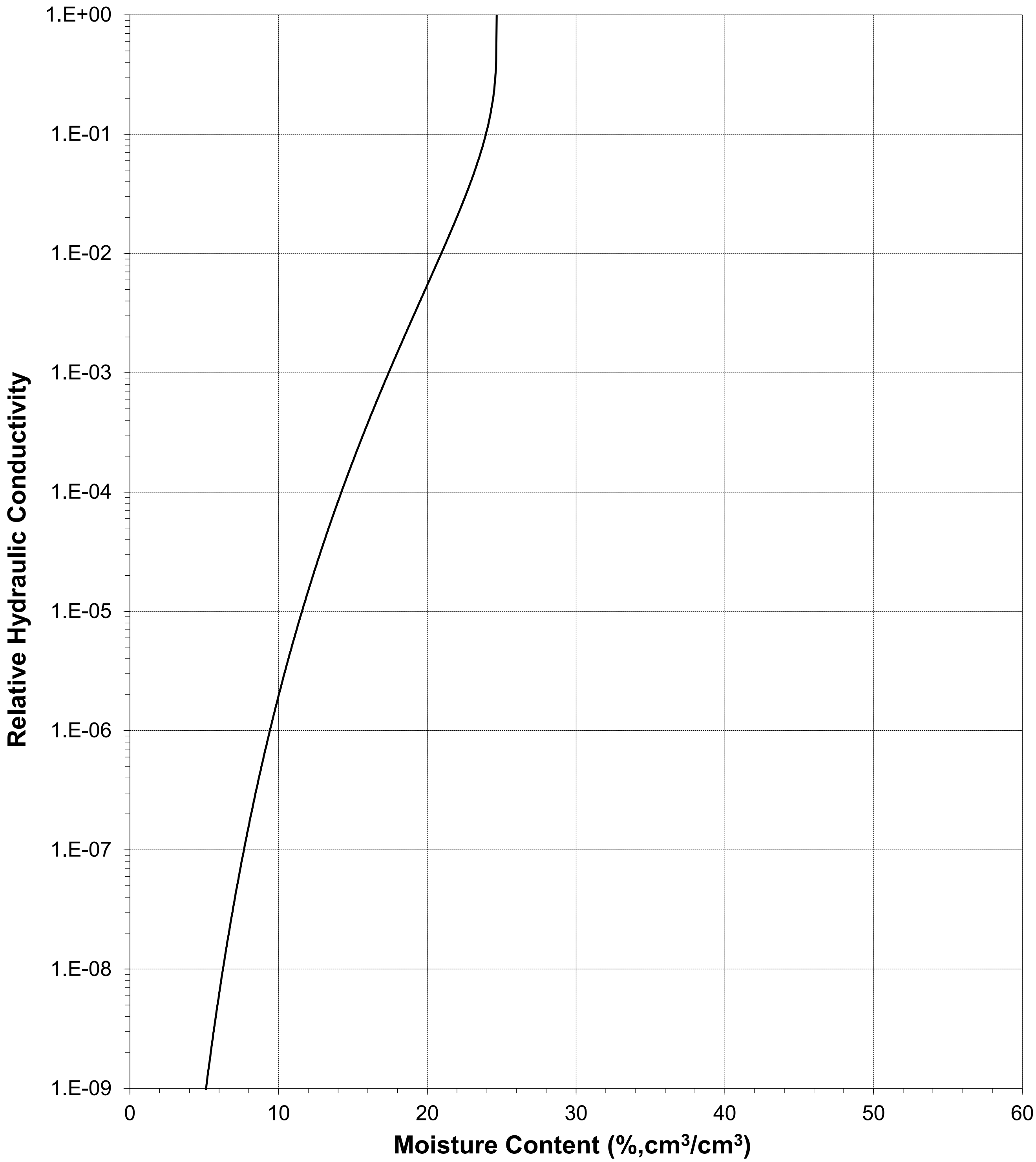
Predicted Water Retention Curve and Data Points

Sample Number: West Lysimeter Boring (22'-25')



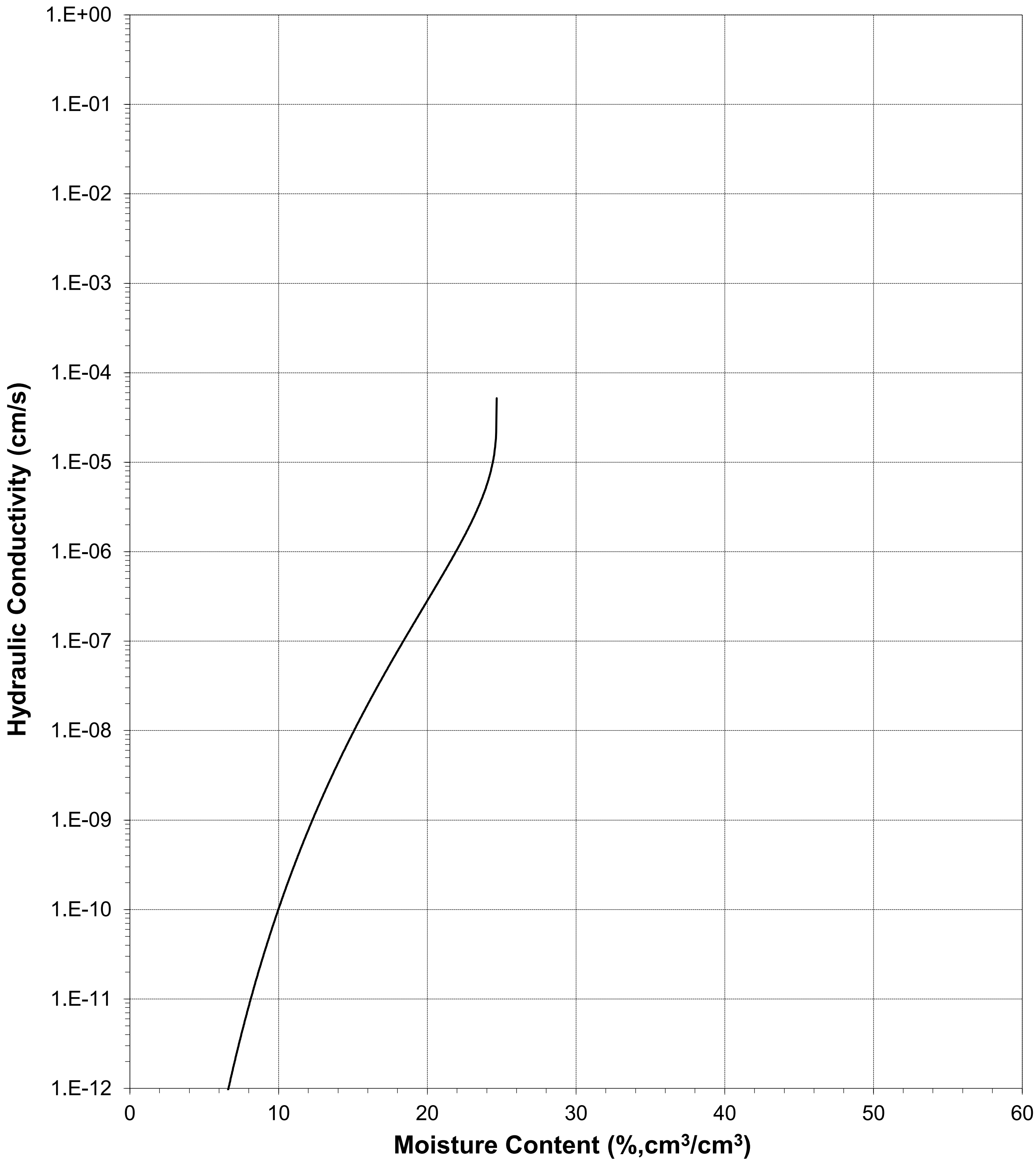
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: West Lysimeter Boring (22'-25')



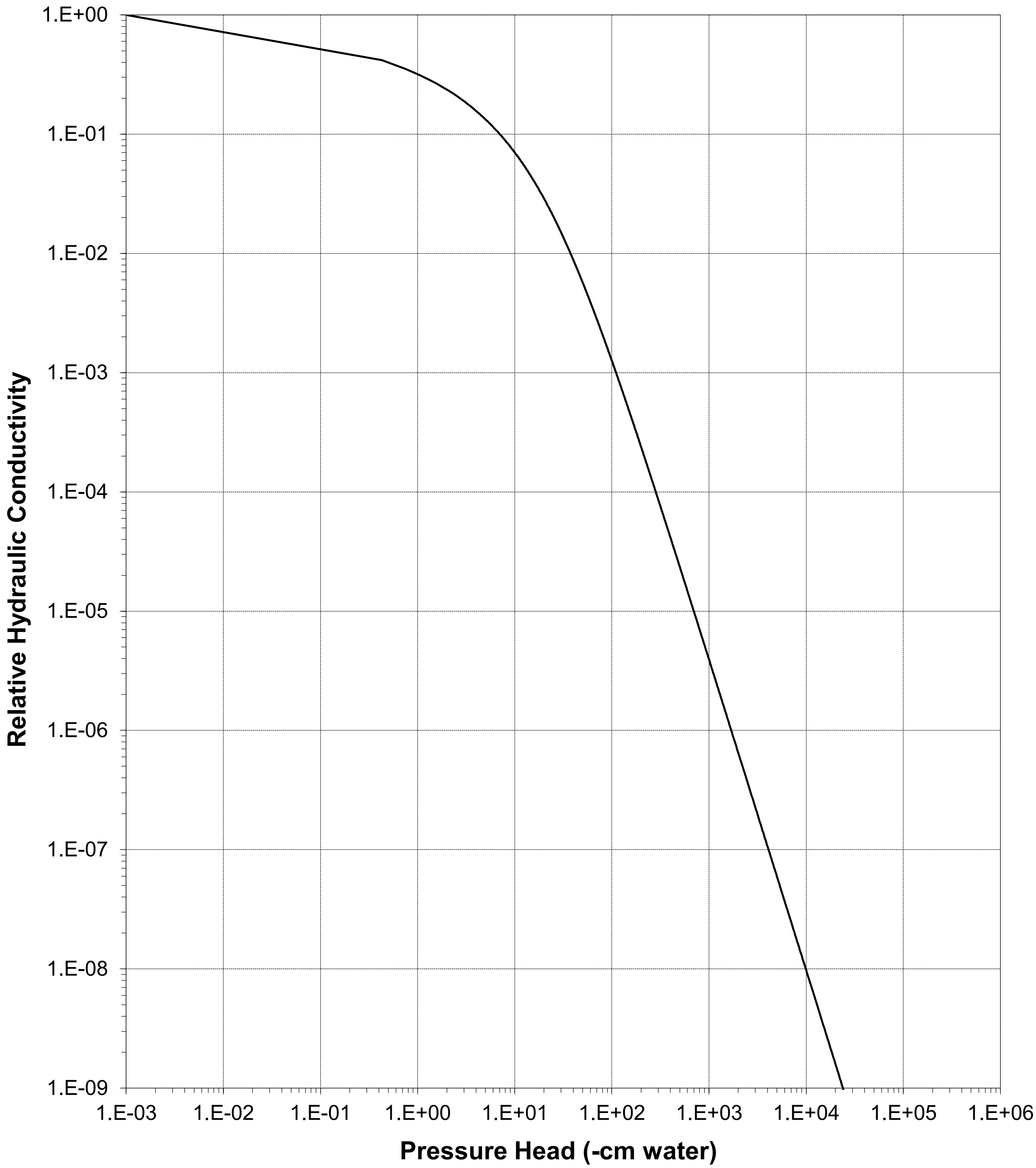
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: West Lysimeter Boring (22'-25')



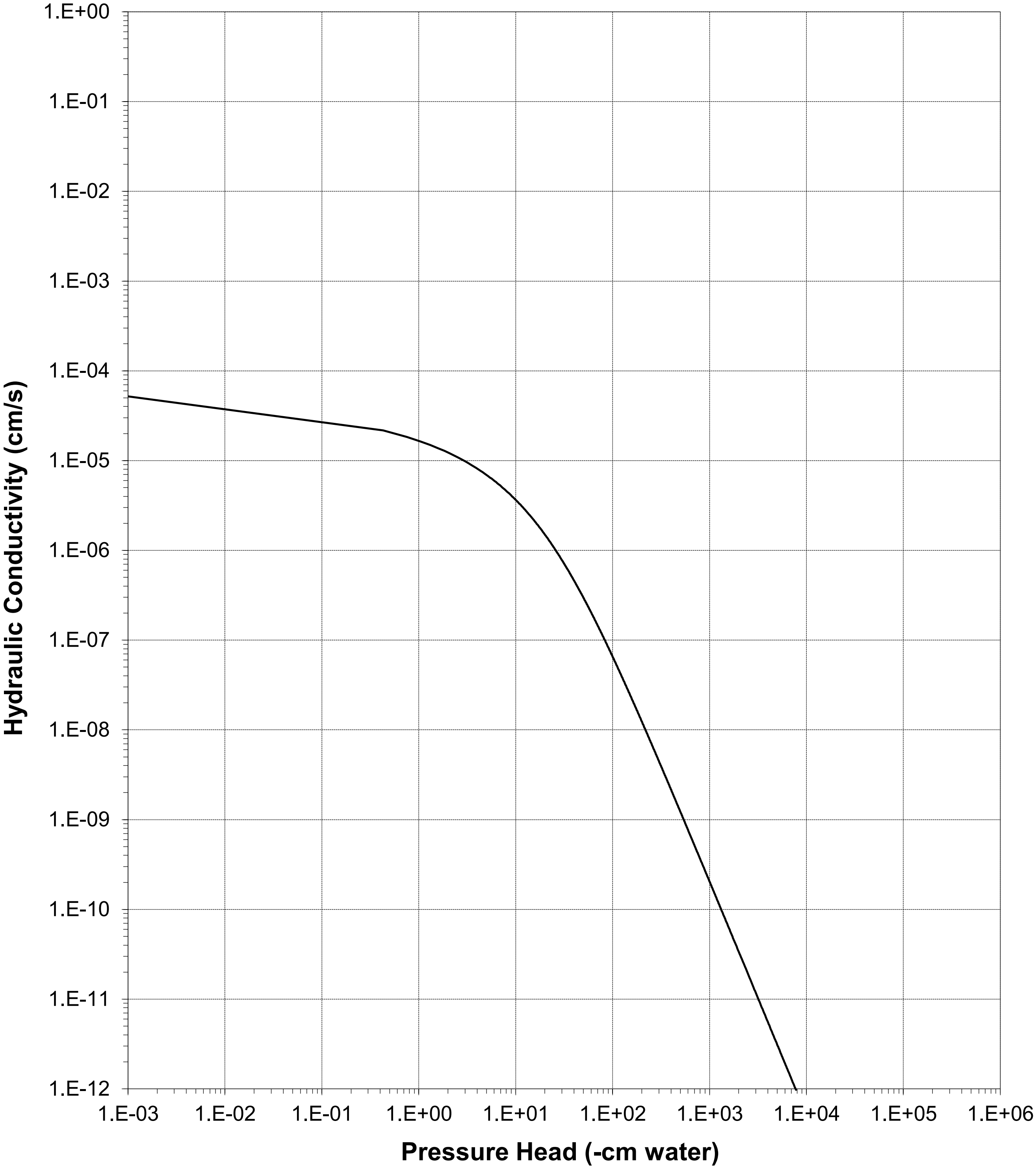
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: West Lysimeter Boring (22'-25')



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: West Lysimeter Boring (22'-25')



Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name:	HDR	*Dry wt. of sample (g):*	966.59
Job Number:	DB17.1173.00	*Tare wt., ring (g):*	81.30
Sample Number:	West Lysimeter Boring (42'-45')	*Tare wt., screen & clamp (g):*	32.15
Project:	Lott, RWIS, Hawks Prarie Property	*Initial sample volume (cm³):*	447.05
Depth (ft):	42'-45'	*Initial dry bulk density (g/cm³):*	2.16
		Assumed particle density (g/cm³):	2.68
		Initial calculated total porosity (%):	19.32

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	13-Jul-17	13:30	1164.49	0	18.89
	20-Jul-17	12:35	1162.21	16.5	18.38
	27-Jul-17	14:00	1161.78	49.0	18.28
	3-Aug-17	13:30	1161.07	123.0	18.13
Pressure plate:	17-Aug-17	12:20	1151.20	337	15.92

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	16.5	---	---	---	---
	49.0	---	---	---	---
	123.0	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: West Lysimeter Boring (42'-45')

Initial sample bulk density (g/cm^3)*:* 2.16
Fraction of bulk sample used (<2.00mm fraction) (%): 65.93

Dry weight of dew point potentiometer sample* (g)*:* 175.60
Tare weight, jar (g)*:* 114.25

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	1-Aug-17	9:45	178.52	6527	6.77
	28-Jul-17	10:40	177.47	23863	4.34
	26-Jul-17	10:35	176.93	65369	3.10
	20-Jul-17	9:55	176.61	261681	2.35

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	6527	---	---	---	---
	23863	---	---	---	---
	65369	---	---	---	---
	261681	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1).

Laboratory analysis by: J. Falance/A. Bland
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: West Lysimeter Boring (42'-45')

Initial sample bulk density (g/cm^3)*:* 2.16
Fraction of bulk sample used (<2.00mm fraction) (%): 65.93

Dry weight of relative humidity box sample* (g)*:* 66.05
Tare weight (g)*:* 40.79

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	25-Jul-17	11:40	66.30	851293	1.41

Volume Adjusted Data[1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change[2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

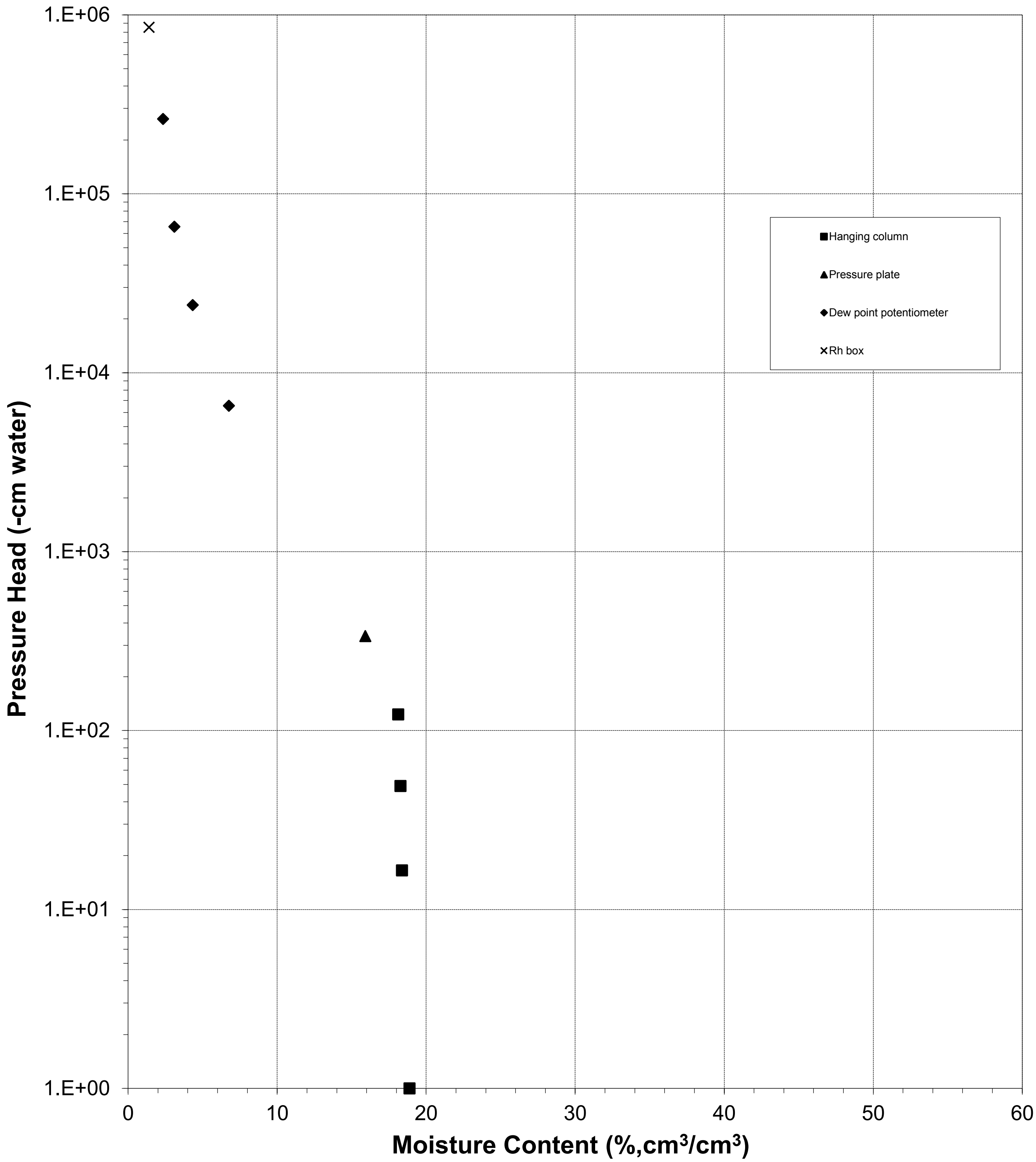
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: J. Falance/A. Bland
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

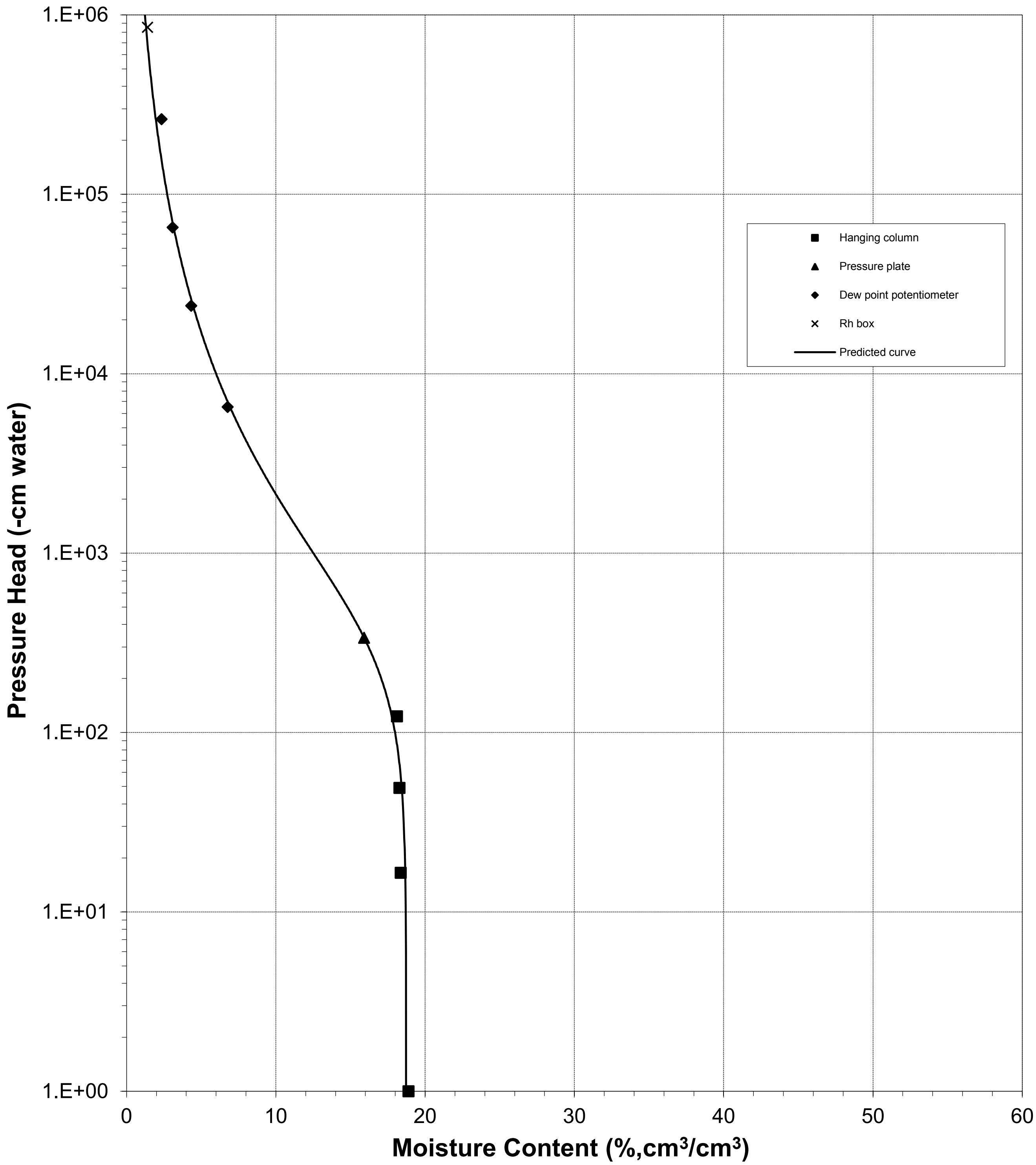
Water Retention Data Points

Sample Number: West Lysimeter Boring (42'-45')



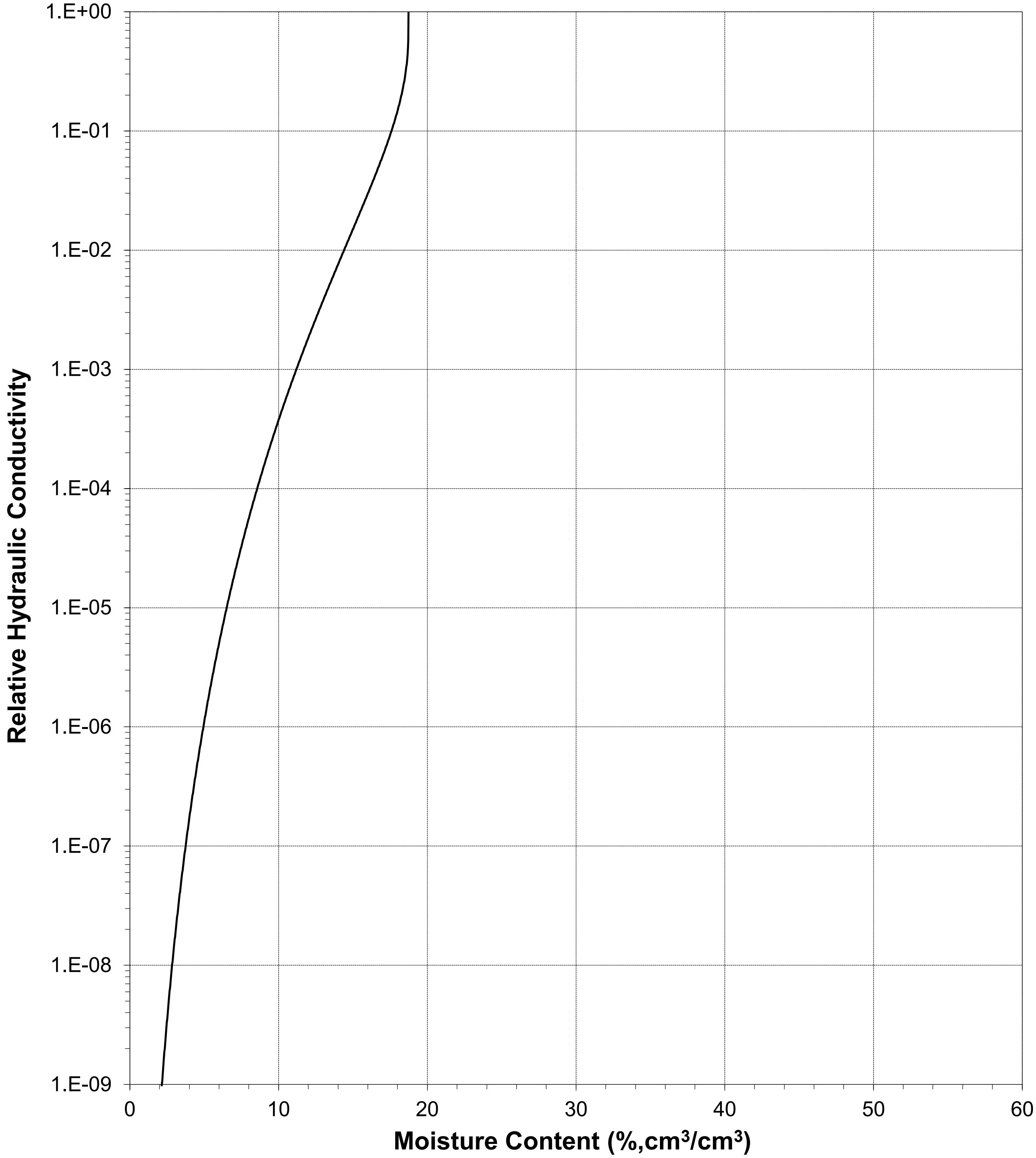
Predicted Water Retention Curve and Data Points

Sample Number: West Lysimeter Boring (42'-45')



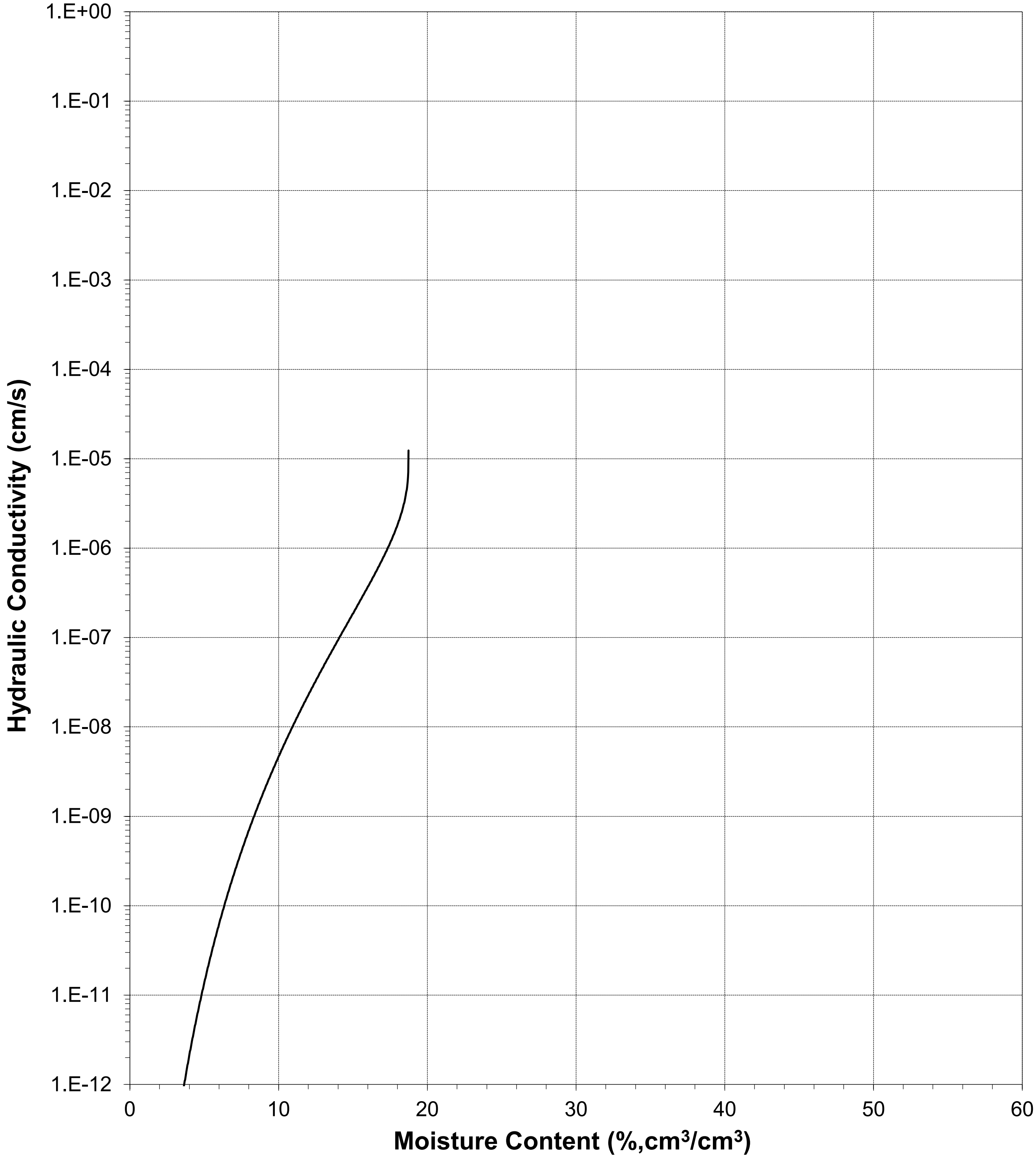
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: West Lysimeter Boring (42'-45')



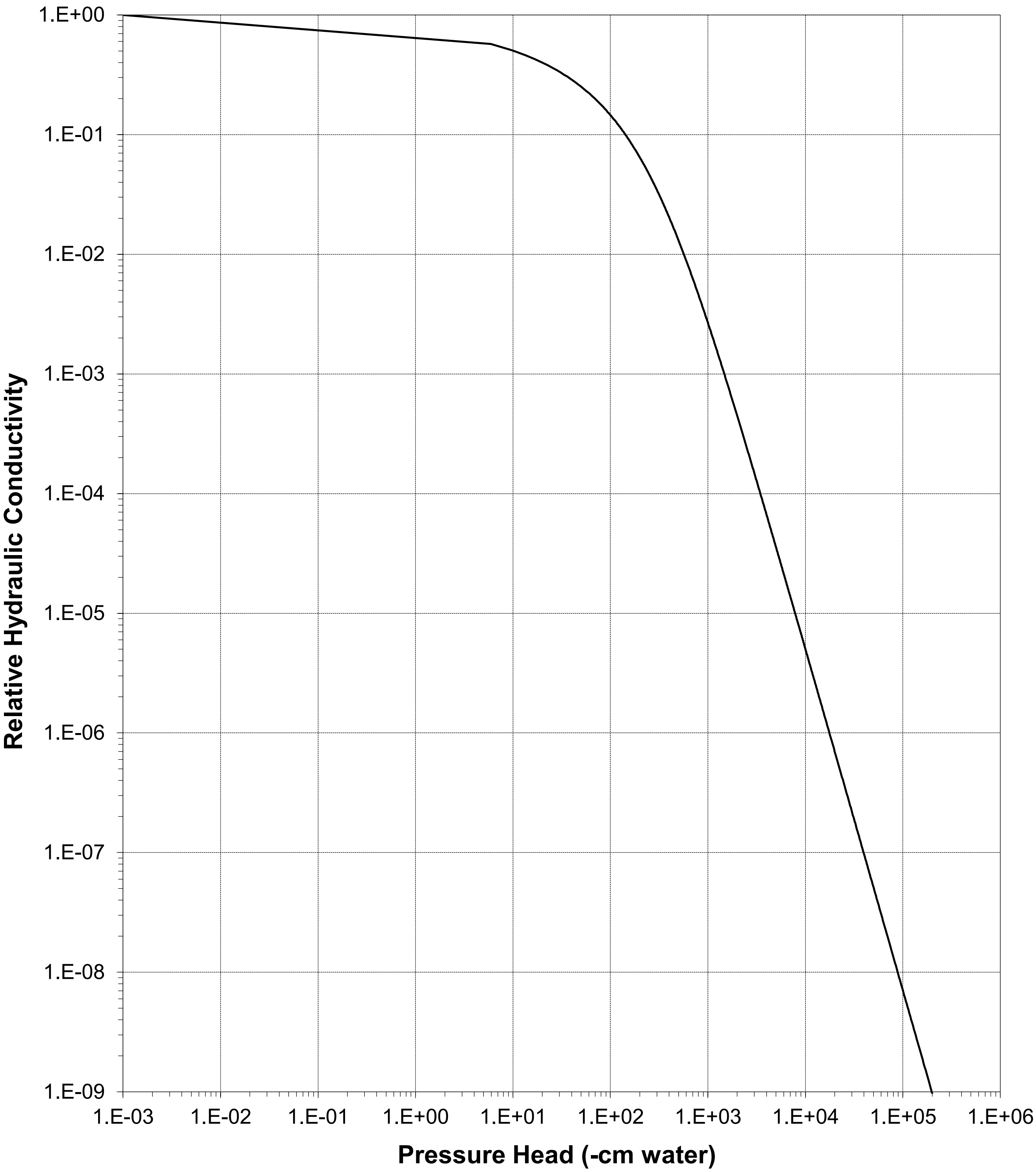
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: West Lysimeter Boring (42'-45')



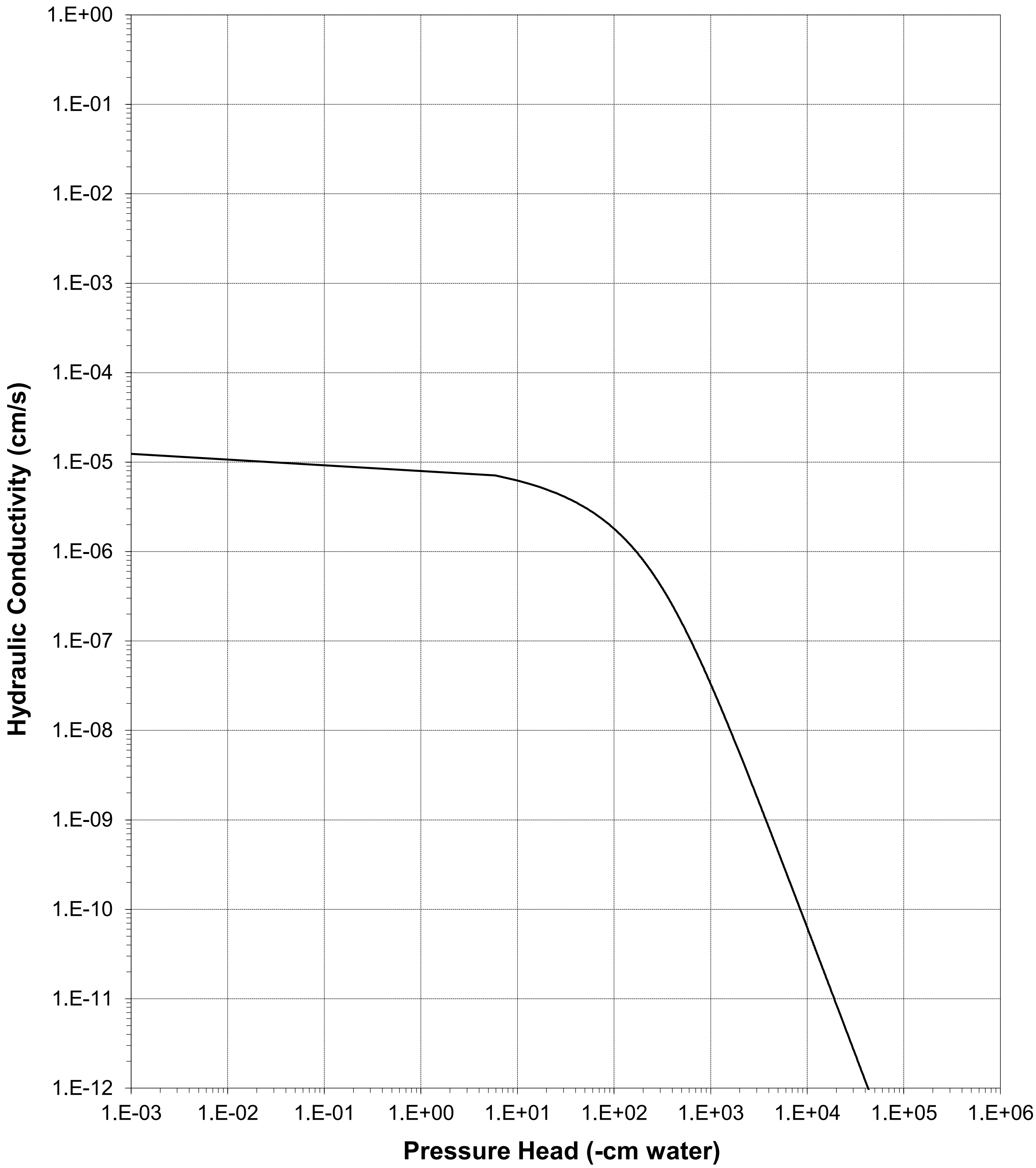
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: West Lysimeter Boring (42'-45')



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: West Lysimeter Boring (42'-45')



Moisture Retention Data
Hanging Column / Pressure Plate
(Soil-Water Characteristic Curve)

Job Name: HDR
Job Number: DB17.1173.00
Sample Number: East Lysimeter Boring (32'-35')
Project: Lott, RWIS, Hawks Prarie Property
Depth (ft): 32'-35'

Dry wt. of sample (g): 1185.04
Tare wt., ring (g): 94.90
Tare wt., screen & clamp (g): 46.47
Initial sample volume (cm^3): 521.22
Initial dry bulk density (g/cm^3): 2.27
Assumed particle density (g/cm^3): 2.68
Initial calculated total porosity (%): 15.17

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	13-Jul-17	13:30	1408.79	0	15.81
	20-Jul-17	12:40	1403.75	23.5	14.84
	27-Jul-17	14:10	1402.00	69.0	14.50
	3-Aug-17	13:40	1399.57	142.0	14.04
Pressure plate:	17-Aug-17	12:20	1392.26	337	12.63

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	23.5	---	---	---	---
	69.0	---	---	---	---
	142.0	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: East Lysimeter Boring (32'-35')

Initial sample bulk density (g/cm^3)*:* 2.27
Fraction of bulk sample used (<2.00mm fraction) (%): 26.51

Dry weight of dew point potentiometer sample* (g)*:* 178.66
Tare weight, jar (g)*:* 113.47

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	3-Aug-17	16:30	184.75	3059	5.63
	27-Jul-17	10:50	181.56	17745	2.68
	21-Jul-17	10:25	180.10	74955	1.33
	18-Jul-17	10:30	179.55	400883	0.82

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	3059	---	---	---	---
	17745	---	---	---	---
	74955	---	---	---	---
	400883	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1).

Laboratory analysis by: J. Falance/A. Bland
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: East Lysimeter Boring (32'-35')

Initial sample bulk density (g/cm^3)*:* 2.27
Fraction of bulk sample used (<2.00mm fraction) (%): 26.51

Dry weight of relative humidity box sample* (g)*:* 59.79
Tare weight (g)*:* 38.03

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	25-Jul-17	11:40	60.00	851293	0.58

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

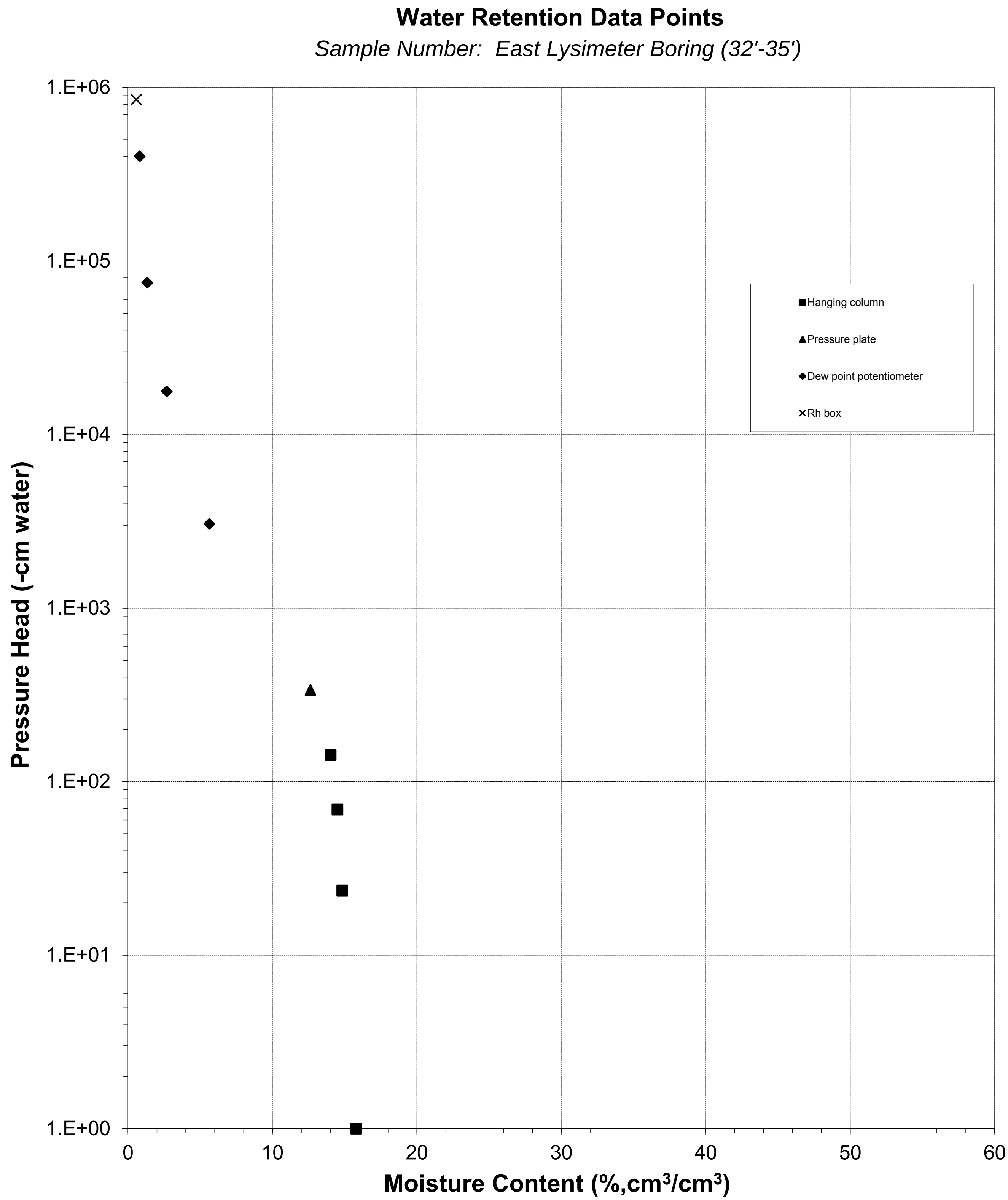
[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

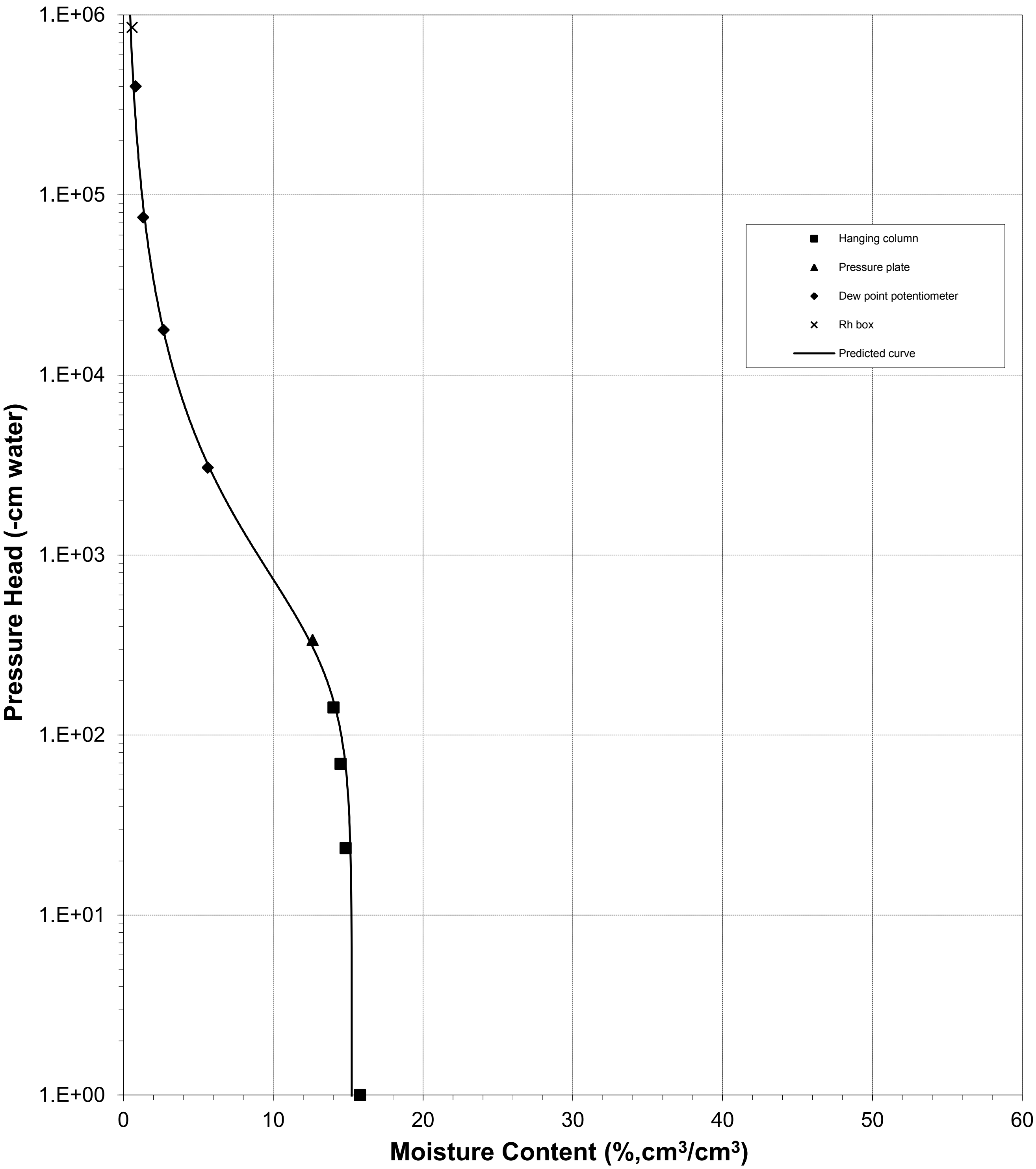
Laboratory analysis by: J. Falance/A. Bland
Data entered by: J. Hines/C. Krous
Checked by: J. Hines


Water Retention Data Points
Sample Number: East Lysimeter Boring (32'-35')
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
Pressure Head (-cm water)
0
10
20
30
40
50
60
Moisture Content (%,cm3/cm3)
Hanging column
Pressure plate
Dew point potentiometer
Rh box

Daniel B. Stephens & Associates, Inc.

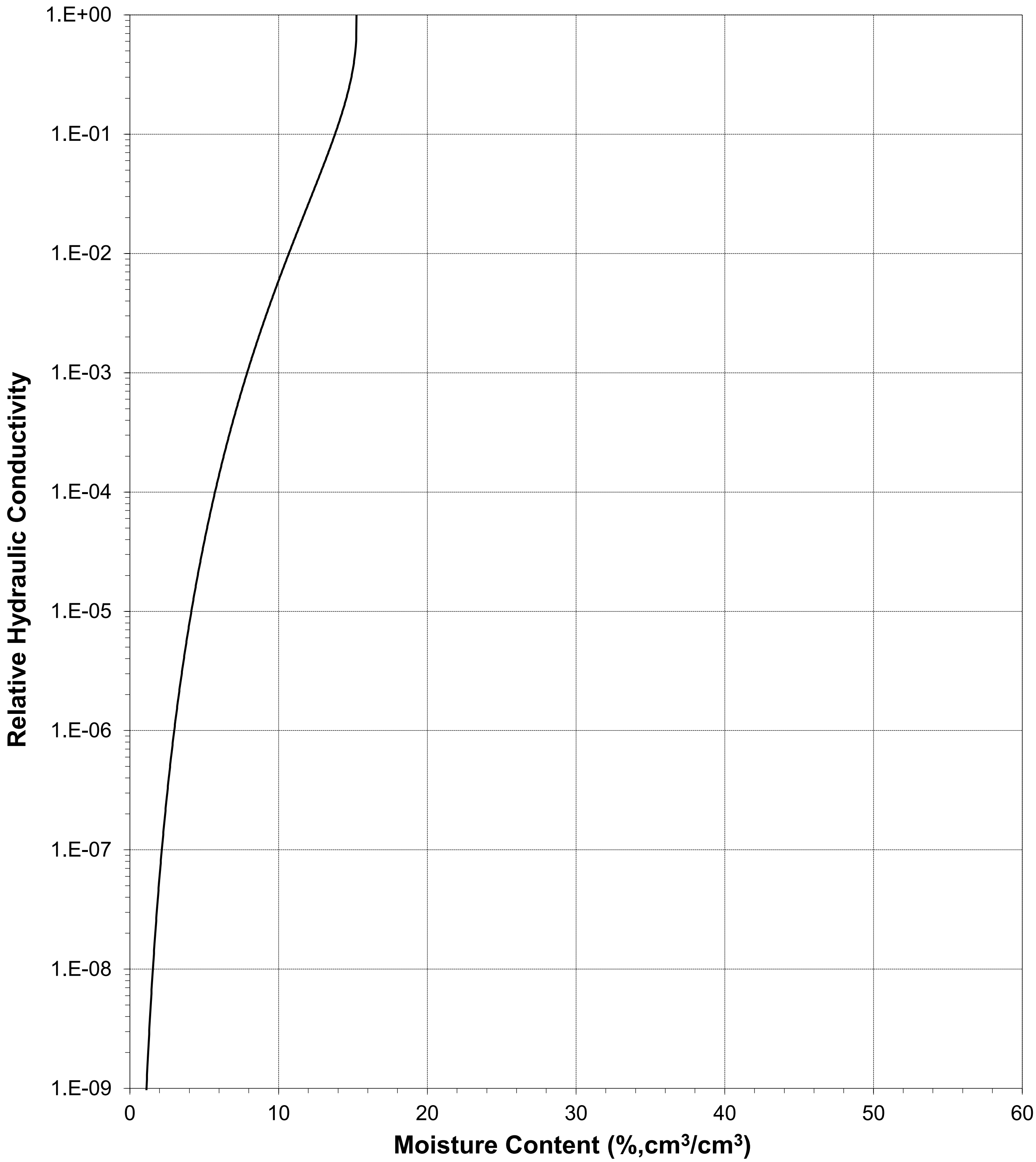
Predicted Water Retention Curve and Data Points

Sample Number: East Lysimeter Boring (32'-35')



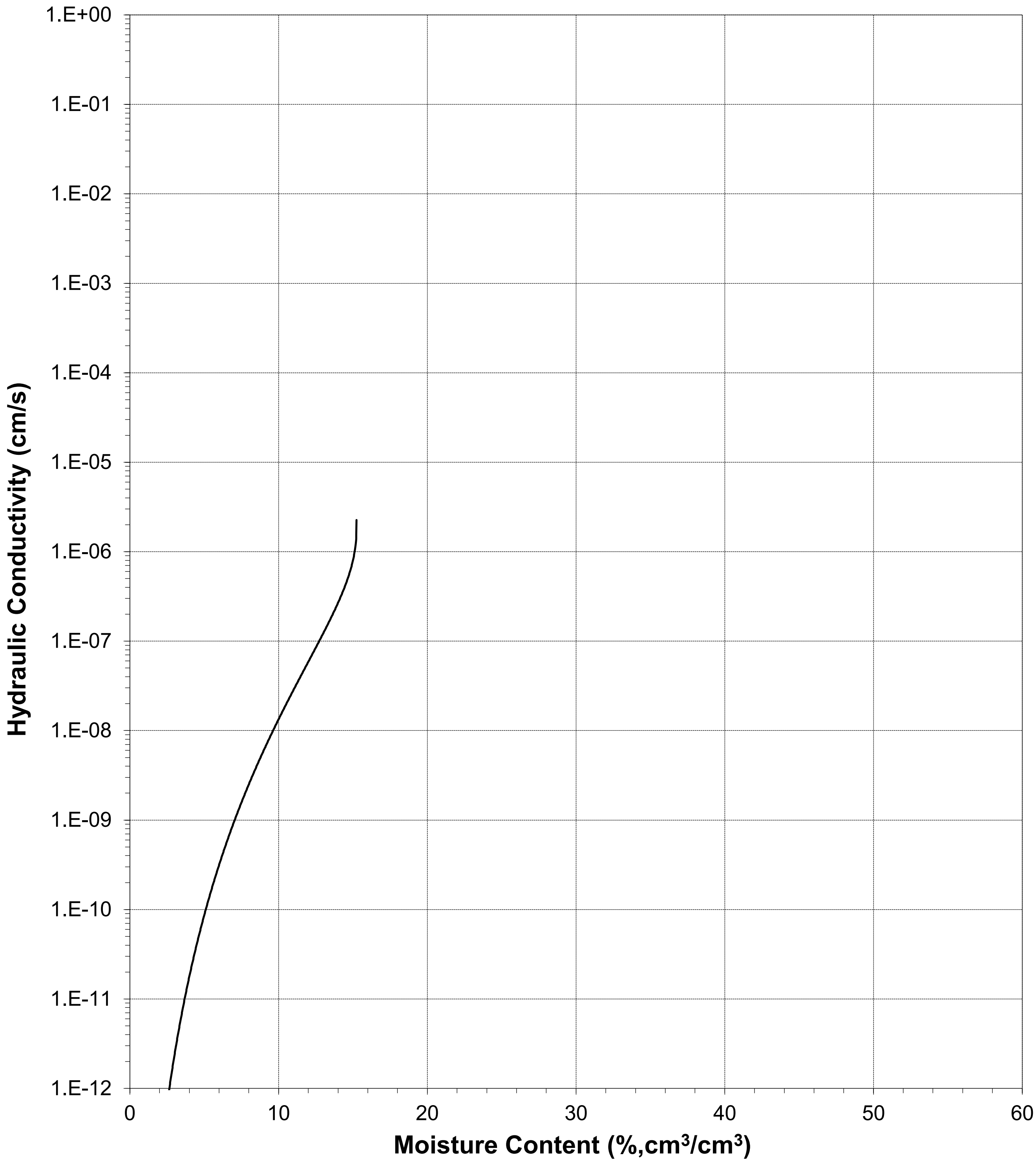
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: East Lysimeter Boring (32'-35')



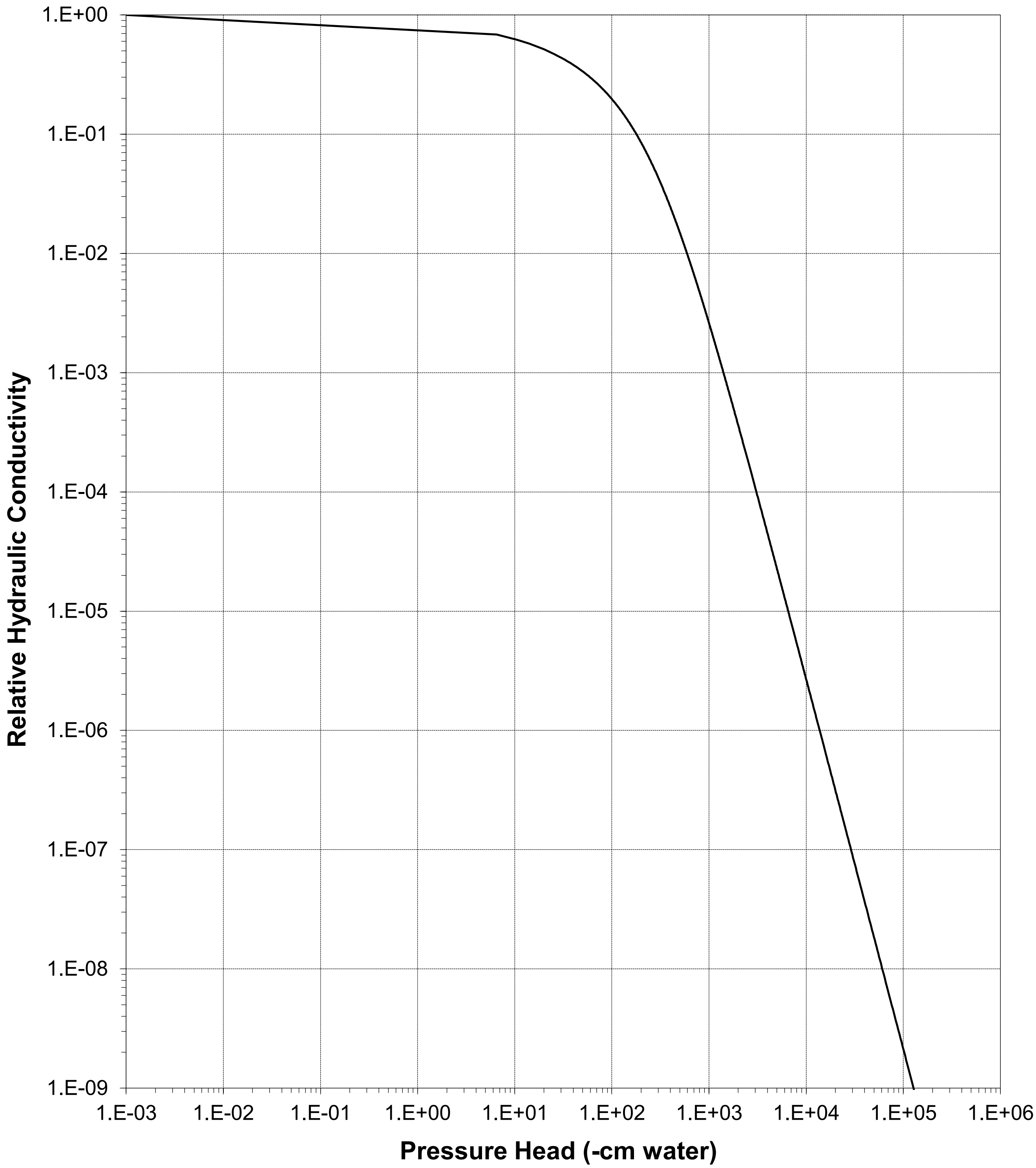
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: East Lysimeter Boring (32'-35')



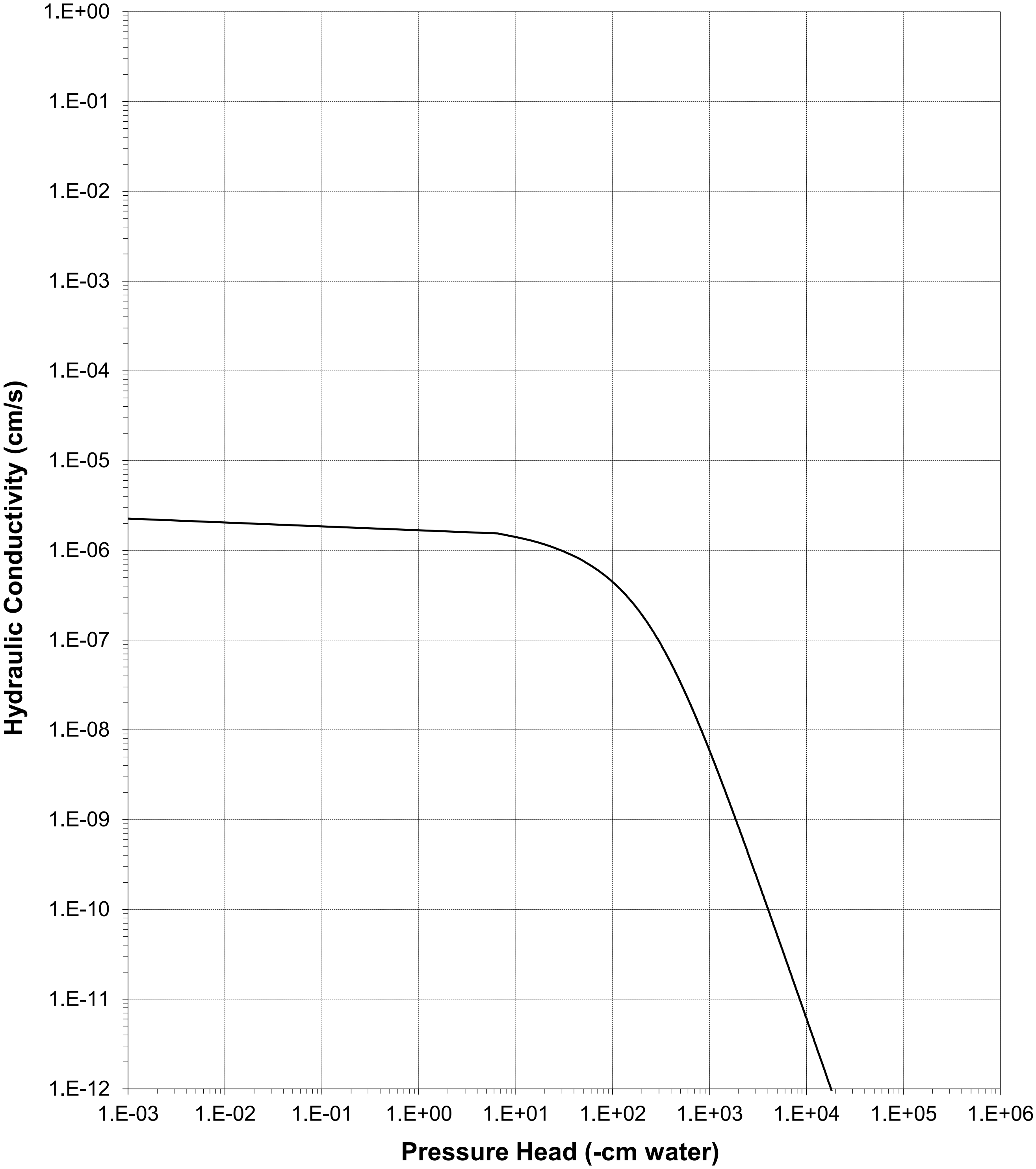
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: East Lysimeter Boring (32'-35')



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: East Lysimeter Boring (32'-35')



Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name:	HDR	*Dry wt. of sample (g):*	975.59
Job Number:	DB17.1173.00	*Tare wt., ring (g):*	80.10
Sample Number:	East Lysimeter Boring (42'-45')	*Tare wt., screen & clamp (g):*	31.70
Project:	Lott, RWIS, Hawks Prarie Property	*Initial sample volume (cm^3):*	445.25
Depth (ft):	42'-45'	*Initial dry bulk density (g/cm^3):*	2.19
		Assumed particle density (g/cm^3):	2.68
		Initial calculated total porosity (%):	18.24

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	13-Jul-17	12:00	1169.85	0	18.52
	20-Jul-17	12:45	1166.84	51.0	17.84
	27-Jul-17	14:10	1164.78	141.0	17.38
Pressure plate:	7-Aug-17	15:00	1162.60	337	16.89
	17-Aug-17	12:00	1158.01	1530	15.86

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	51.0	---	---	---	---
	141.0	---	---	---	---
Pressure plate:	337	---	---	---	---
	1530	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: East Lysimeter Boring (42'-45')

Initial sample bulk density (g/cm^3)*:* 2.19
Fraction of bulk sample used (<2.00mm fraction) (%): 54.09

Dry weight of dew point potentiometer sample* (g)*:* 170.82
Tare weight, jar (g)*:* 110.58

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	3-Aug-17	16:35	176.71	3365	11.59
	31-Jul-17	10:20	174.06	14379	6.37
	26-Jul-17	10:45	172.45	62004	3.20
	20-Jul-17	10:15	171.81	281261	1.94

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	3365	---	---	---	---
	14379	---	---	---	---
	62004	---	---	---	---
	281261	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1).

Laboratory analysis by: J. Falance/A. Bland
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: East Lysimeter Boring (42'-45')

Initial sample bulk density (g/cm^3)*:* 2.19
Fraction of bulk sample used (<2.00mm fraction) (%): 54.09

Dry weight of relative humidity box sample* (g)*:* 59.65
Tare weight (g)*:* 40.00

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	25-Jul-17	11:40	59.87	851293	1.33

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

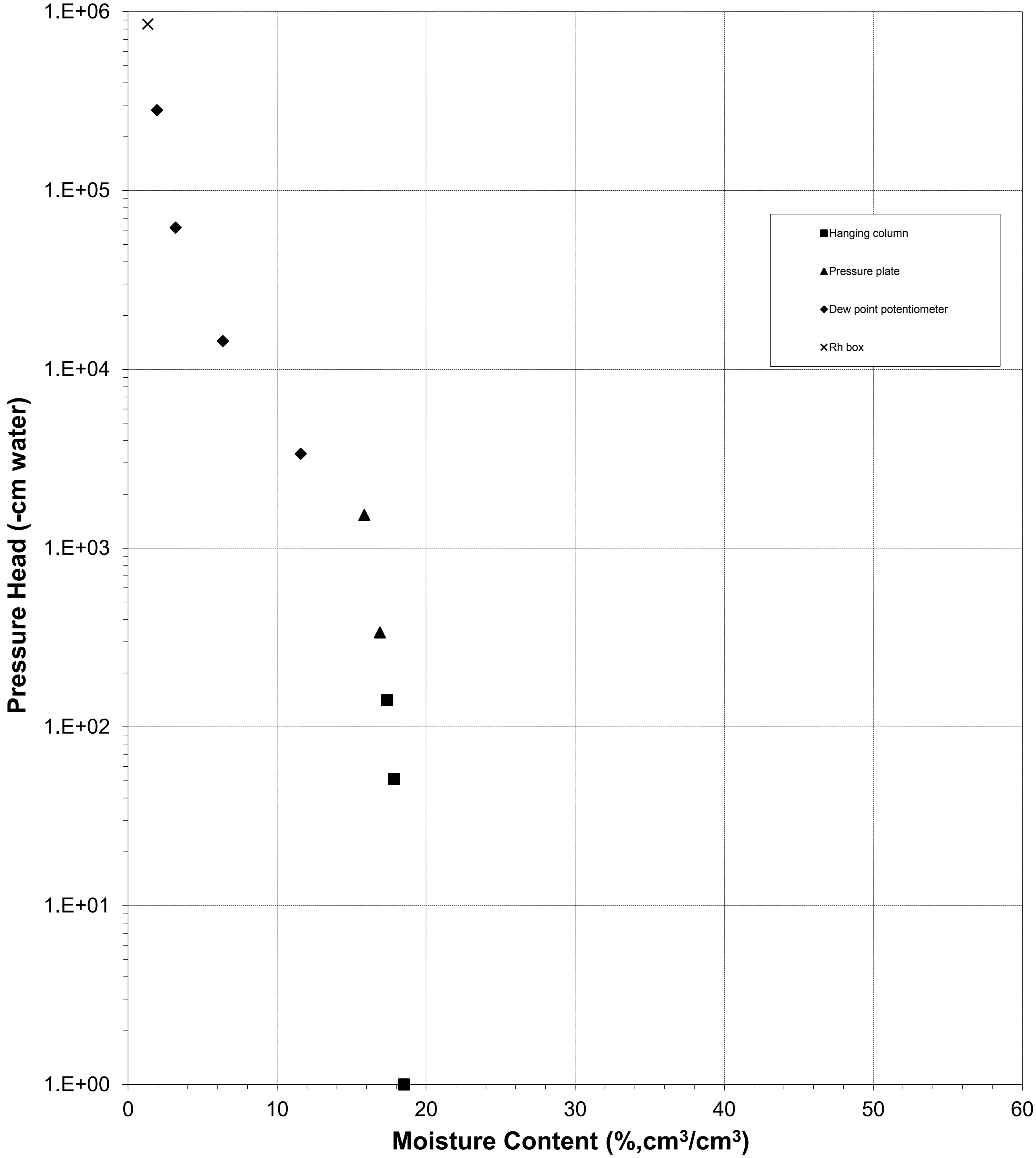
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: J. Falance/A. Bland
Data entered by: J. Hines/C. Krous
Checked by: J. Hines

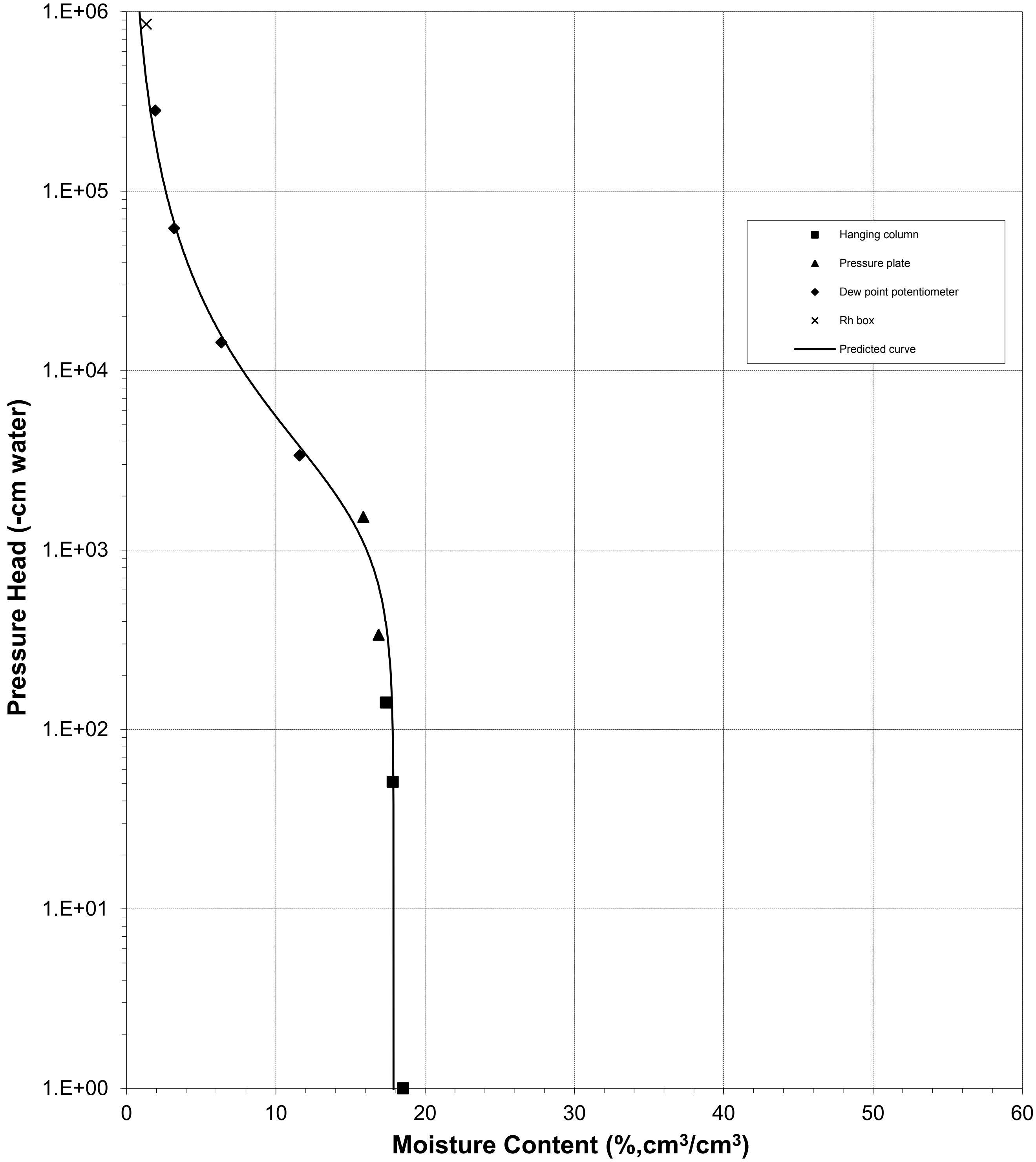
Water Retention Data Points

Sample Number: East Lysimeter Boring (42'-45')

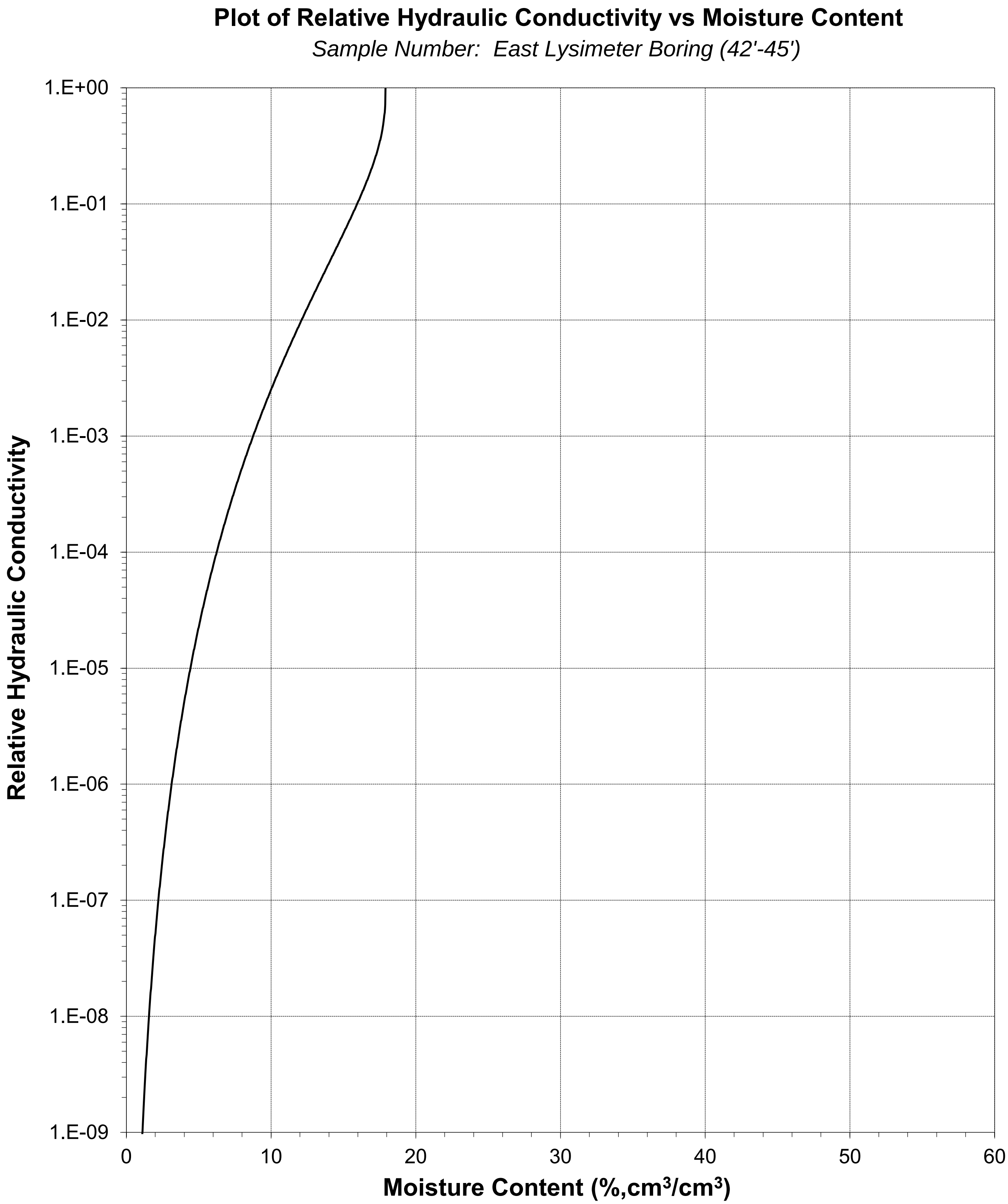


Predicted Water Retention Curve and Data Points

Sample Number: East Lysimeter Boring (42'-45')

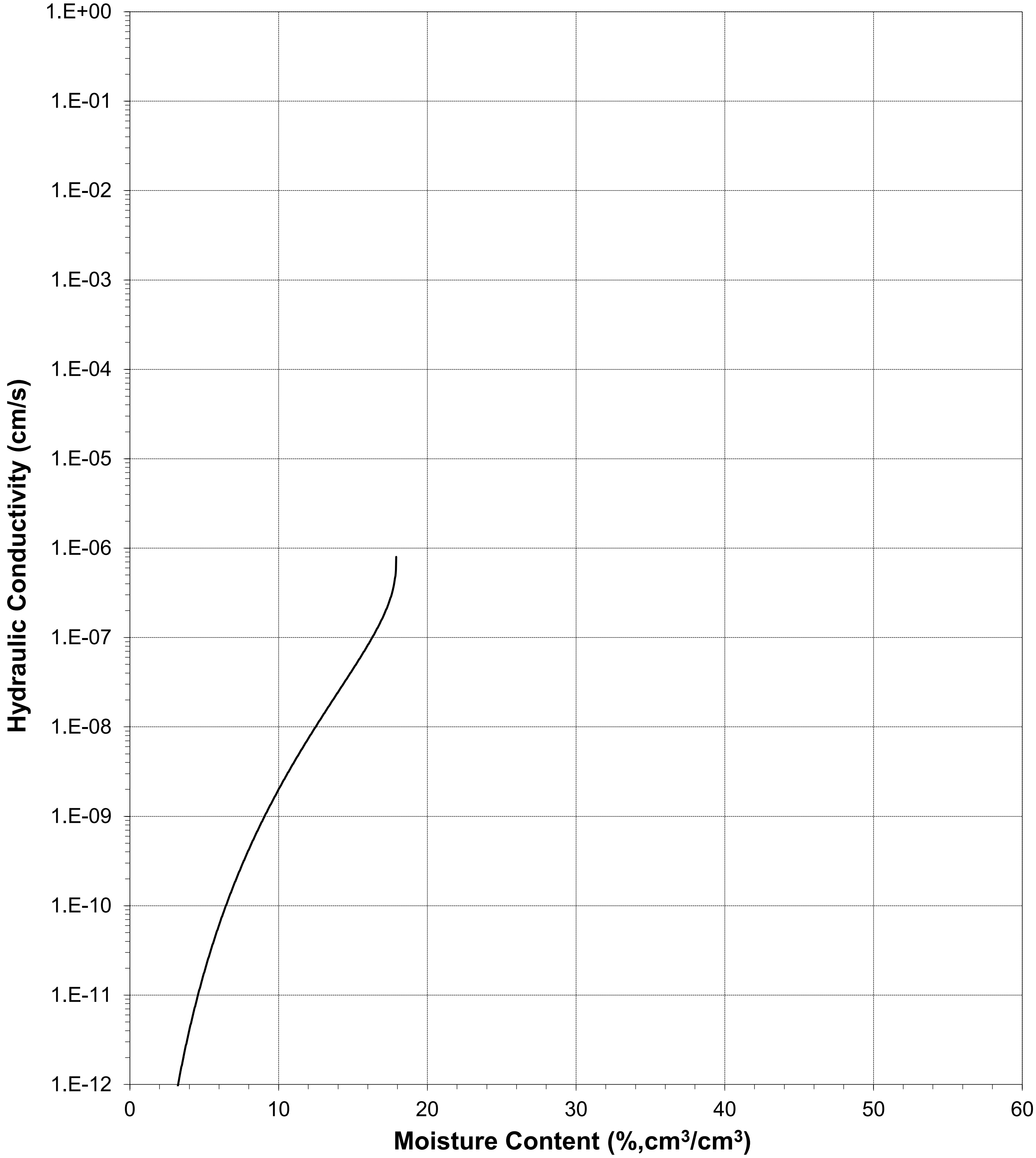


D a n i e l B . S t e p h e n s & A s s o c i a t e s , I n c .



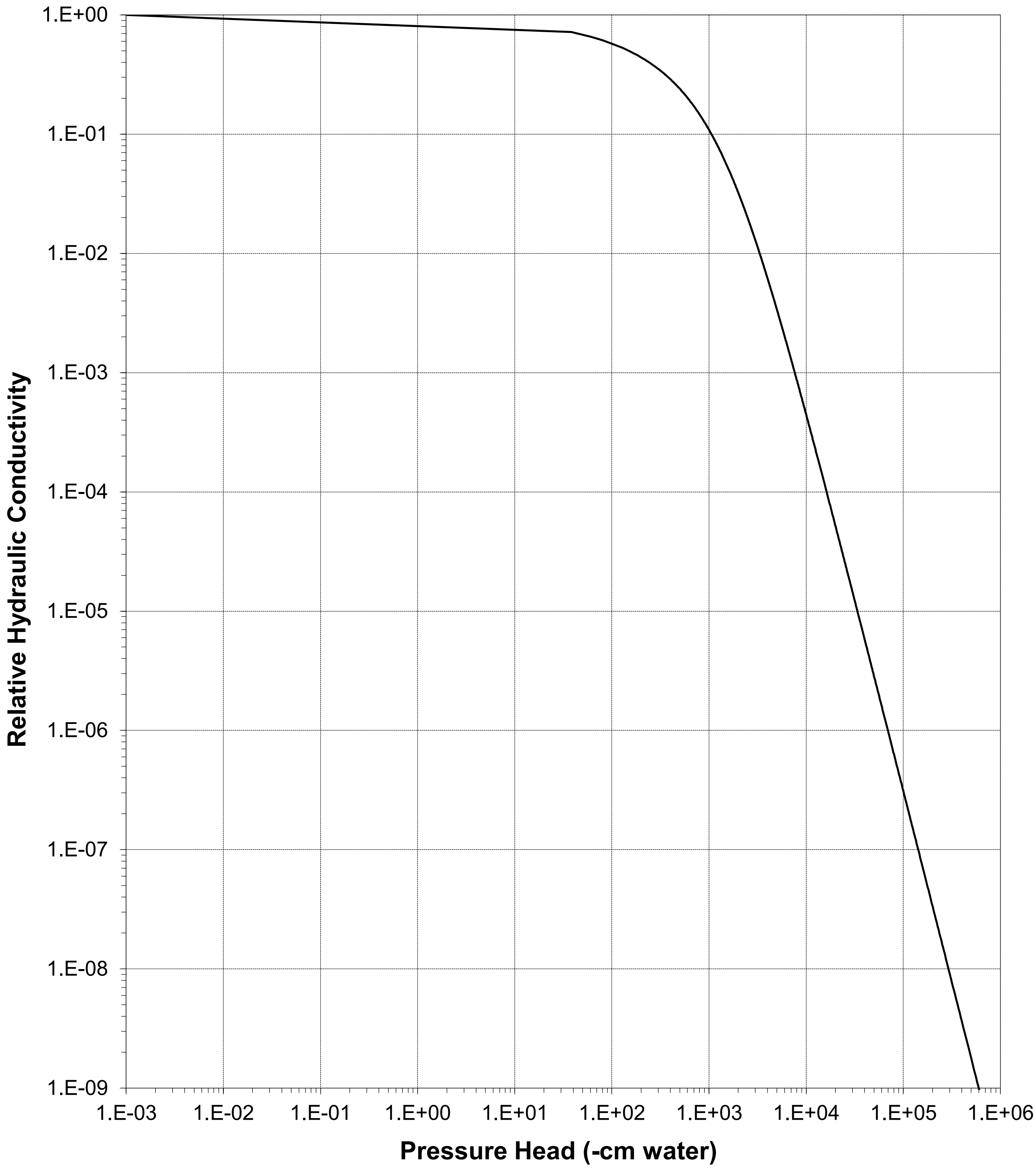
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: East Lysimeter Boring (42'-45')



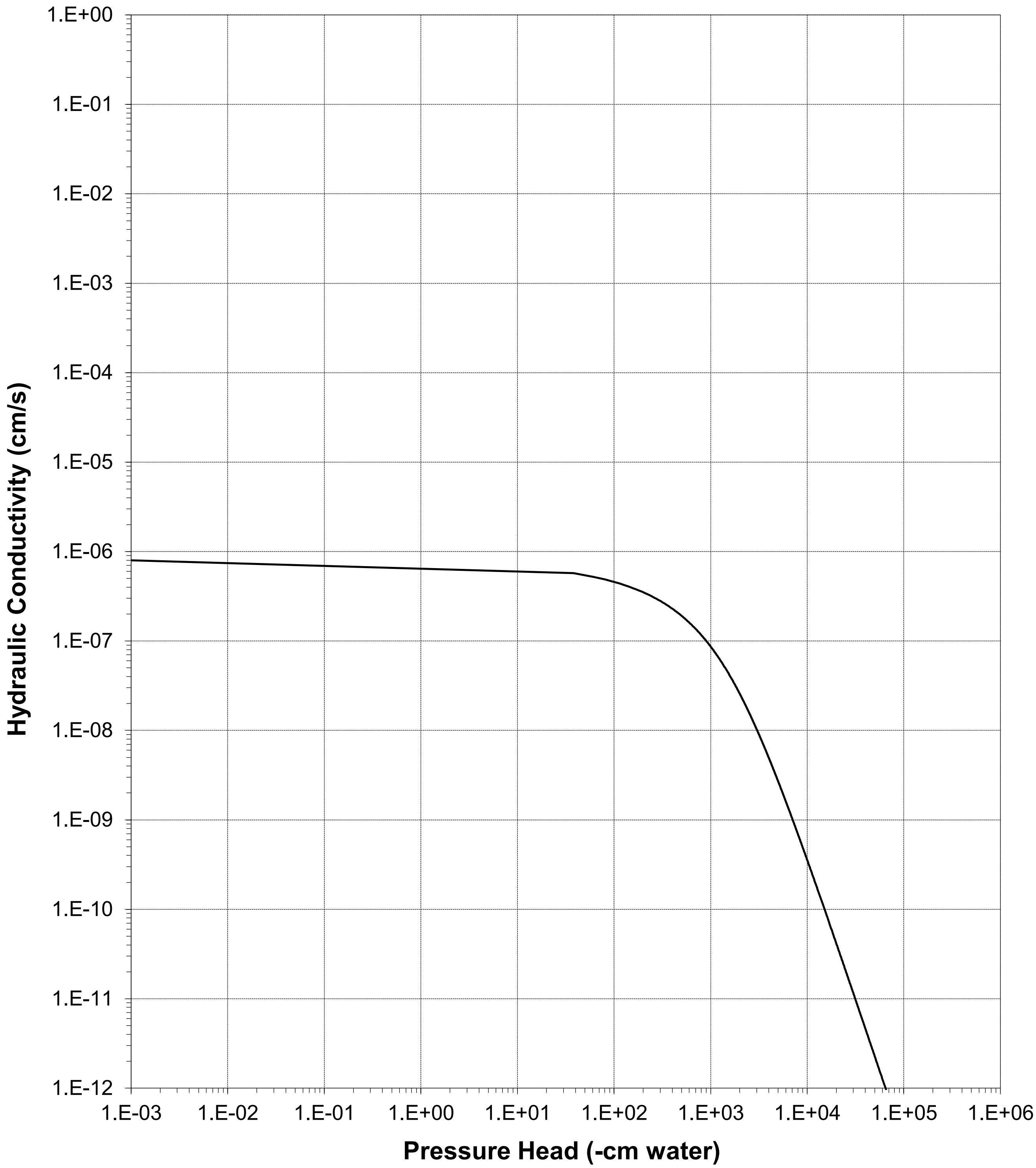
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: East Lysimeter Boring (42'-45')



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: East Lysimeter Boring (42'-45')



Particle Size Analysis

Daniel B. Stephens & Associates, Inc.

Summary of Particle Size Characteristics

Sample Number	d_{10} (mm)	d_{50} (mm)	d_{60} (mm)	C_u	C_c	Method	ASTM Classification	USDA Classification
West Lysimeter Boring (22'-25')	0.036	0.47	0.57	16	4.1	WS/H	Classification by ASTM 2487 requires Atterberg test	Sand †
West Lysimeter Boring (42'-45')	0.023	0.63	1.0	43	4.5	WS/H	Classification by ASTM 2487 requires Atterberg test	Loamy Sand †
East Lysimeter Boring (32'-35')	0.078	7.1	9.5	122	9.8	WS/H	Classification by ASTM 2487 requires Atterberg test	Sandy Loam †
East Lysimeter Boring (42'-45')	0.0038	1.2	3.5	921	1.5	WS/H	Classification by ASTM 2487 requires Atterberg test	Sandy Loam †
LOTT Hawks Prarie Lysimeter West, Upper 10 feet	0.30	6.9	10	33	2.1	WS/H	Classification by ASTM 2487 requires Atterberg test	Loamy Sand †
LOTT Hawks Prarie Lysimeter East, Upper 10 feet	0.30	2.4	3.6	12	1.3	WS/H	Classification by ASTM 2487 requires Atterberg test	Sand †

d_{50} = Median particle diameter

Est = Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

$$C_u = \frac{d_{60}}{d_{10}}$$

$$C_c = \frac{(d_{30})^2}{(d_{10})(d_{60})}$$

DS = Dry sieve

H = Hydrometer

WS = Wet sieve

† Greater than 10% of sample is coarse material

Percent Gravel, Sand, Silt and Clay*

Sample Number	% Gravel (>4.75mm)	% Sand (<4.75mm, >0.075mm)	% Silt (<0.075mm, >0.002mm)	% Clay (<0.002mm)
West Lysimeter Boring (22'-25')	6.0	79.6	11.3	3.2
West Lysimeter Boring (42'-45')	28.8	55.8	10.4	5.1
East Lysimeter Boring (32'-35')	63.3	26.8	7.0	2.9
East Lysimeter Boring (42'-45')	36.8	37.3	18.5	7.4
LOTT Hawks Prarie Lysimeter West, Upper 10 feet	59.0	35.1	4.7	1.1
LOTT Hawks Prarie Lysimeter East, Upper 10 feet	32.7	61.2	4.6	1.5

*USCS classification does not classify clay fraction based on particle size. USDA definition of clay (<0.002mm) used in this table.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#10 Split)

Job Name:	HDR	*Initial Dry Weight of Sample (g):*	1409.88
Job Number:	DB17.1173.00	*Weight Passing #10 (g):*	1268.25
Sample Number:	West Lysimeter Boring (22'-25')	*Weight Retained #10 (g):*	141.63
Project:	Lott, RWIS, Hawks Prarie Property	*Weight of Hydrometer Sample (g):*	79.34
Depth (ft):	22'-25'	*Calculated Weight of Sieve Sample (g):*	88.20
Test Date:	19-Jul-17	*Shape:*	Angular
		Hardness:	Soft

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+10						
	3"	75	0.00	0.00	1409.88	100.00
	2"	50	0.00	0.00	1409.88	100.00
	1.5"	38.1	0.00	0.00	1409.88	100.00
	1"	25	0.00	0.00	1409.88	100.00
	3/4"	19.0	0.00	0.00	1409.88	100.00
	3/8"	9.5	43.17	43.17	1366.71	96.94
	4	4.75	40.84	84.01	1325.87	94.04
	10	2.00	57.62	141.63	1268.25	89.95
-10			(Based on calculated sieve wt.)			
	20	0.85	7.41	16.27	71.93	81.55
	40	0.425	32.65	48.92	39.28	44.54
	60	0.250	18.53	67.45	20.75	23.53
	140	0.106	6.82	74.27	13.93	15.79
	200	0.075	1.15	75.42	12.78	14.49
	dry pan		0.06	75.48	12.72	
	wet pan			12.72	0.00	

d_{10} (mm):	0.036	d_{50} (mm):	0.47
d_{16} (mm):	0.11	d_{60} (mm):	0.57
d_{30} (mm):	0.29	d_{84} (mm):	1.1

Median Particle Diameter --d_{50} (mm): 0.47

Uniformity Coefficient, Cu --[d_{60}/d_{10}] (mm): 16

Coefficient of Curvature, Cc --[$(d_{30})^2/(d_{10}*d_{60})$] (mm): 4.1

Mean Particle Diameter --[$(d_{16}+d_{50}+d_{84})/3$] (mm): 0.56

ASTM Soil Classification: Classification by ASTM 2487 requires Atterberg test

USDA Soil Classification: Sand †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Falance

Data entered by: A. Bland

Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

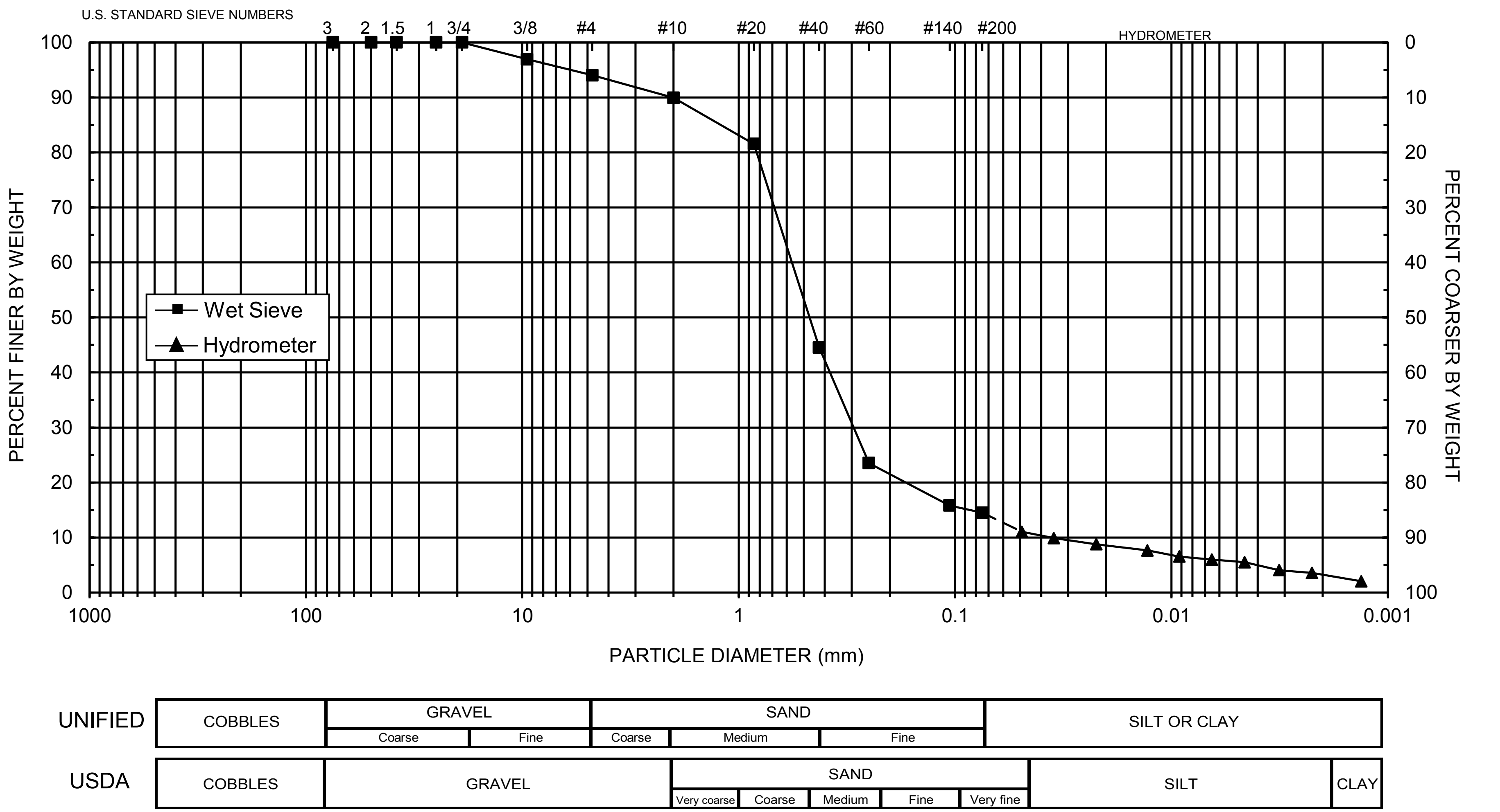
Job Name:	HDR	*Type of Water Used:*	DISTILLED
Job Number:	DB17.1173.00	*Reaction with* H_2O_2*:*	NA
Sample Number:	West Lysimeter Boring (22'-25')	*Dispersant*:*	$(NaPO_3)_6$
Project:	Lott, RWIS, Hawks Prarie Property	*Assumed particle density:*	2.68
Depth (ft):	22'-25'	*Initial Wt. (g):*	79.34
Test Date:	14-Jul-17	*Total Sample Wt. (g):*	1409.88
Start Time:	9:00	*Wt. Passing #10 (g):*	1268.25

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
14-Jul-17	1	21.4	16.0	6.2	9.8	13.7	0.04909	12.2	11.0
	2	21.4	15.0	6.2	8.8	13.8	0.03492	11.0	9.9
	5	21.4	14.0	6.2	7.8	14.0	0.02221	9.7	8.8
	15	21.4	13.0	6.2	6.8	14.2	0.01290	8.5	7.6
	30	21.4	12.0	6.2	5.8	14.3	0.00917	7.2	6.5
	60	21.5	11.5	6.2	5.3	14.4	0.00650	6.7	6.0
	120	21.8	11.0	6.1	4.9	14.5	0.00459	6.1	5.5
	250	22.7	9.5	5.9	3.6	14.7	0.00317	4.5	4.0
	502	23.0	9.0	5.8	3.2	14.8	0.00224	4.0	3.6
15-Jul-17	1505	21.4	8.0	6.2	1.8	15.0	0.00132	2.3	2.0

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: A. Bland
Data entered by: A. Bland
Checked by: J. Hines



d_{10} = **0.036**	d_{30} = **0.29**	d_{50} = **0.47**	d_{60} = **0.57**	C_u = **16**	C_c = **4.1**

SAMPLE NUMBER	DEPTH (FT)	ASTM CLASSIFICATION	USDA CLASSIFICATION
West Lysimeter Boring (22'-25')	**22'-25'**	**Classification by ASTM 2487 requires Atterberg test**	**Sand** †

† Greater than 10% of sample is coarse material

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#10 Split)

Job Name: HDR
Job Number: DB17.1173.00
Sample Number: West Lysimeter Boring (42'-45')
Project: Lott, RWIS, Hawks Prarie Property
Depth (ft): 42'-45'

Test Date: 19-Jul-17

Initial Dry Weight of Sample (g): 1926.31
Weight Passing #10 (g): 1270.10
Weight Retained #10 (g): 656.21
Weight of Hydrometer Sample (g): 78.80
Calculated Weight of Sieve Sample (g): 119.51

Shape: Angular
Hardness: Soft

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+10						
	3"	75	0.00	0.00	1926.31	100.00
	2"	50	0.00	0.00	1926.31	100.00
	1.5"	38.1	0.00	0.00	1926.31	100.00
	1"	25	303.32	303.32	1622.99	84.25
	3/4"	19.0	62.16	365.48	1560.83	81.03
	3/8"	9.5	114.33	479.81	1446.50	75.09
	4	4.75	74.80	554.61	1371.70	71.21
	10	2.00	101.60	656.21	1270.10	65.93
-10			(Based on calculated sieve wt.)			
	20	0.85	8.89	49.60	69.91	58.50
	40	0.425	24.05	73.65	45.86	38.37
	60	0.250	18.49	92.14	27.37	22.90
	140	0.106	7.37	99.51	20.00	16.73
	200	0.075	1.57	101.08	18.43	15.42
	dry pan		0.15	101.23	18.28	
	wet pan			18.28	0.00	

d_{10} (mm): 0.023 d_{50} (mm): 0.63
d_{16} (mm): 0.087 d_{60} (mm): 1.0
d_{30} (mm): 0.32 d_{84} (mm): 24

Median Particle Diameter --d_{50} (mm): 0.63
Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 43
Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 4.5
Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 8.2

ASTM Soil Classification: Classification by ASTM 2487 requires Atterberg test
USDA Soil Classification: Loamy Sand †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Falance
Data entered by: A. Bland
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

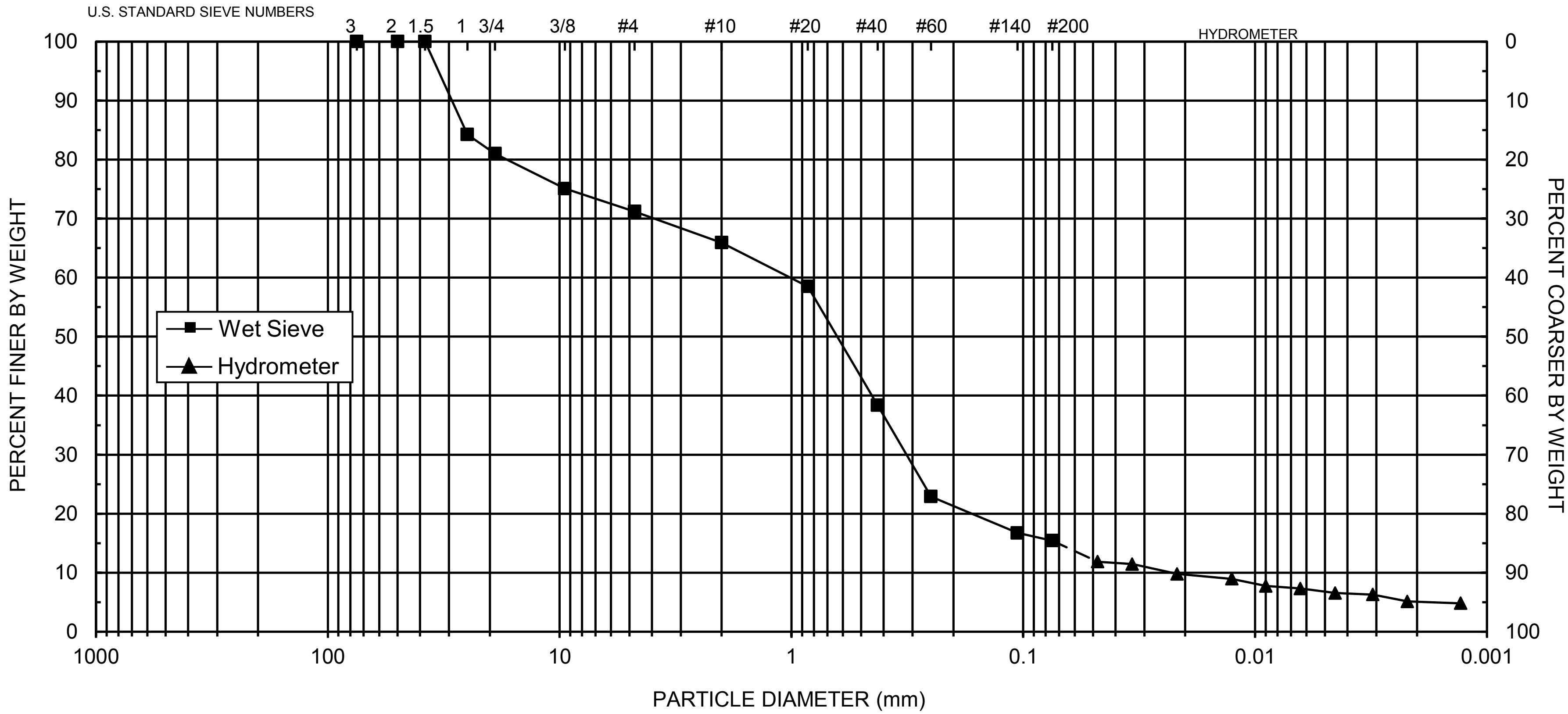
Job Name:	HDR	*Type of Water Used:*	DISTILLED
Job Number:	DB17.1173.00	*Reaction with* H_2O_2*:*	NA
Sample Number:	West Lysimeter Boring (42'-45')	*Dispersant*:*	$(NaPO_3)_6$
Project:	Lott, RWIS, Hawks Prarie Property	*Assumed particle density:*	2.68
Depth (ft):	42'-45'	*Initial Wt. (g):*	78.80
Test Date:	14-Jul-17	*Total Sample Wt. (g):*	1926.31
Start Time:	9:06	*Wt. Passing #10 (g):*	1270.10

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
14-Jul-17	1	21.4	20.5	6.2	14.3	12.9	0.04774	18.0	11.9
	2	21.4	20.0	6.2	13.8	13.0	0.03387	17.4	11.4
	5	21.4	18.0	6.2	11.8	13.3	0.02169	14.8	9.8
	15	21.4	17.0	6.2	10.8	13.5	0.01260	13.6	9.0
	30	21.5	15.5	6.2	9.3	13.8	0.00898	11.7	7.7
	60	21.5	15.0	6.2	8.8	13.8	0.00637	11.1	7.3
	120	21.8	14.0	6.1	7.9	14.0	0.00451	9.9	6.5
	250	22.7	13.5	5.9	7.6	14.1	0.00310	9.5	6.3
	502	23.0	12.0	5.8	6.2	14.3	0.00220	7.8	5.1
15-Jul-17	1501	21.4	12.0	6.2	5.8	14.3	0.00130	7.3	4.8

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: A. Bland
Data entered by: C. Krous
Checked by: C. Krous



UNIFIED	COBBLES	GRAVEL		SAND			SILT OR CLAY	
		Coarse	Fine	Coarse	Medium	Fine		

USDA	COBBLES	GRAVEL	SAND					SILT	CLAY
			Very coarse	Coarse	Medium	Fine	Very fine		

d_{10} = **0.023**	d_{30} = **0.32**	d_{50} = **0.63**	d_{60} = **1.0**	C_u = **43**	C_c = **4.5**

SAMPLE NUMBER	DEPTH (FT)	ASTM CLASSIFICATION	USDA CLASSIFICATION
West Lysimeter Boring (42'-45')	**42'-45'**	**Classification by ASTM 2487 requires Atterberg test**	**Loamy Sand †**

† Greater than 10% of sample is coarse material

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#10 Split)

Job Name:	HDR	*Initial Dry Weight of Sample (g):*	1915.39
Job Number:	DB17.1173.00	*Weight Passing #10 (g):*	507.68
Sample Number:	East Lysimeter Boring (32'-35')	*Weight Retained #10 (g):*	1407.71
Project:	Lott, RWIS, Hawks Prarie Property	*Weight of Hydrometer Sample (g):*	77.29
Depth (ft):	32'-35'	*Calculated Weight of Sieve Sample (g):*	291.60
Test Date:	19-Jul-17	*Shape:*	Angular
		Hardness:	Soft

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+10						
	3"	75	0.00	0.00	1915.39	100.00
	2"	50	0.00	0.00	1915.39	100.00
	1.5"	38.1	0.00	0.00	1915.39	100.00
	1"	25	0.00	0.00	1915.39	100.00
	3/4"	19.0	112.66	112.66	1802.73	94.12
	3/8"	9.5	658.30	770.96	1144.43	59.75
	4	4.75	440.60	1211.56	703.83	36.75
	10	2.00	196.15	1407.71	507.68	26.51
-10			(Based on calculated sieve wt.)			
	20	0.85	15.33	229.64	61.96	21.25
	40	0.425	12.40	242.04	49.56	17.00
	60	0.250	9.72	251.76	39.84	13.66
	140	0.106	8.66	260.42	31.18	10.69
	200	0.075	2.30	262.72	28.88	9.90
	dry pan		0.24	262.96	28.64	
	wet pan			28.64	0.00	

d_{10} (mm):	0.078	d_{50} (mm):	7.1
d_{16} (mm):	0.36	d_{60} (mm):	9.5
d_{30} (mm):	2.7	d_{84} (mm):	15

Median Particle Diameter --d_{50} (mm): 7.1

Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 122

Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 9.8

Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 7.5

ASTM Soil Classification: Classification by ASTM 2487 requires Atterberg test

USDA Soil Classification: Sandy Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Falance

Data entered by: A. Bland

Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

Job Name: HDR
Job Number: DB17.1173.00
Sample Number: East Lysimeter Boring (32'-35')
Project: Lott, RWIS, Hawks Prarie Property
Depth (ft): 32'-35'

Test Date: 14-Jul-17
Start Time: 9:12

Type of Water Used: DISTILLED
Reaction with H_2O_2*:* NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.68

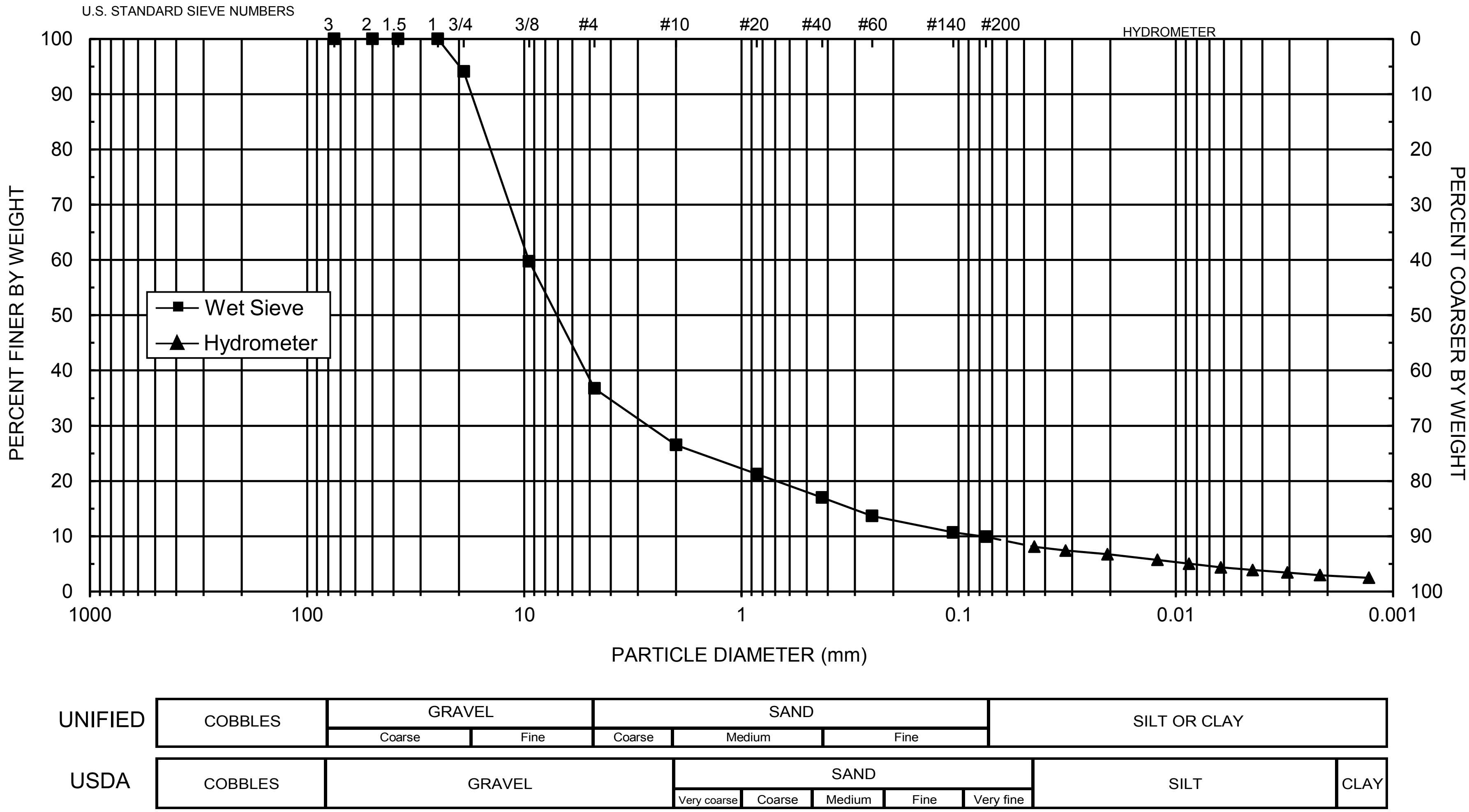
Initial Wt. (g): 77.29
Total Sample Wt. (g): 1915.39
Wt. Passing #10 (g): 507.68

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
14-Jul-17	1	21.4	30.0	6.2	23.8	11.4	0.04478	30.5	8.1
	2	21.4	28.0	6.2	21.8	11.7	0.03212	27.9	7.4
	5	21.4	26.0	6.2	19.8	12.0	0.02059	25.4	6.7
	15	21.4	23.0	6.2	16.8	12.5	0.01213	21.5	5.7
	30	21.5	21.0	6.2	14.8	12.9	0.00868	19.0	5.0
	60	21.6	19.0	6.1	12.9	13.2	0.00621	16.5	4.4
	120	21.8	17.5	6.1	11.4	13.4	0.00442	14.6	3.9
	250	22.7	16.0	5.9	10.1	13.7	0.00306	12.9	3.4
	502	23.0	14.5	5.8	8.7	13.9	0.00217	11.1	2.9
15-Jul-17	1496	21.4	13.5	6.2	7.3	14.1	0.00129	9.4	2.5

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: A. Bland
Data entered by: A. Bland
Checked by: J. Hines



d_{10} = **0.078**	d_{30} = **2.7**	d_{50} = **7.1**	d_{60} = **9.5**	C_u = **122**	C_c = **9.8**

SAMPLE NUMBER	DEPTH (FT)	ASTM CLASSIFICATION	USDA CLASSIFICATION
East Lysimeter Boring (32'-35')	**32'-35'**	**Classification by ASTM 2487 requires Atterberg test**	**Sandy Loam †**

† Greater than 10% of sample is coarse material

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#10 Split)

Job Name:	HDR	*Initial Dry Weight of Sample (g):*	2174.14
Job Number:	DB17.1173.00	*Weight Passing #10 (g):*	1176.08
Sample Number:	East Lysimeter Boring (42'-45')	*Weight Retained #10 (g):*	998.06
Project:	Lott, RWIS, Hawks Prarie Property	*Weight of Hydrometer Sample (g):*	65.54
Depth (ft):	42'-45'	*Calculated Weight of Sieve Sample (g):*	121.16
Test Date:	19-Jul-17	*Shape:*	Angular
		Hardness:	Soft

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+10						
	3"	75	0.00	0.00	2174.14	100.00
	2"	50	0.00	0.00	2174.14	100.00
	1.5"	38.1	0.00	0.00	2174.14	100.00
	1"	25	129.77	129.77	2044.37	94.03
	3/4"	19.0	126.63	256.40	1917.74	88.21
	3/8"	9.5	294.82	551.22	1622.92	74.65
	4	4.75	249.90	801.12	1373.02	63.15
	10	2.00	196.94	998.06	1176.08	54.09
-10			(Based on calculated sieve wt.)			
	20	0.85	8.88	64.50	56.66	46.76
	40	0.425	7.20	71.70	49.46	40.82
	60	0.250	8.20	79.90	41.26	34.05
	140	0.106	7.70	87.60	33.56	27.70
	200	0.075	2.21	89.81	31.35	25.88
	dry pan		0.20	90.01	31.15	
	wet pan			31.15	0.00	

d_{10} (mm):	0.0038	d_{50} (mm):	1.2
d_{16} (mm):	0.016	d_{60} (mm):	3.5
d_{30} (mm):	0.14	d_{84} (mm):	15

Median Particle Diameter --d_{50} (mm): 1.2

Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 921

Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 1.5

Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 5.4

ASTM Soil Classification: Classification by ASTM 2487 requires Atterberg test

USDA Soil Classification: Sandy Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Falance

Data entered by: A. Bland

Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

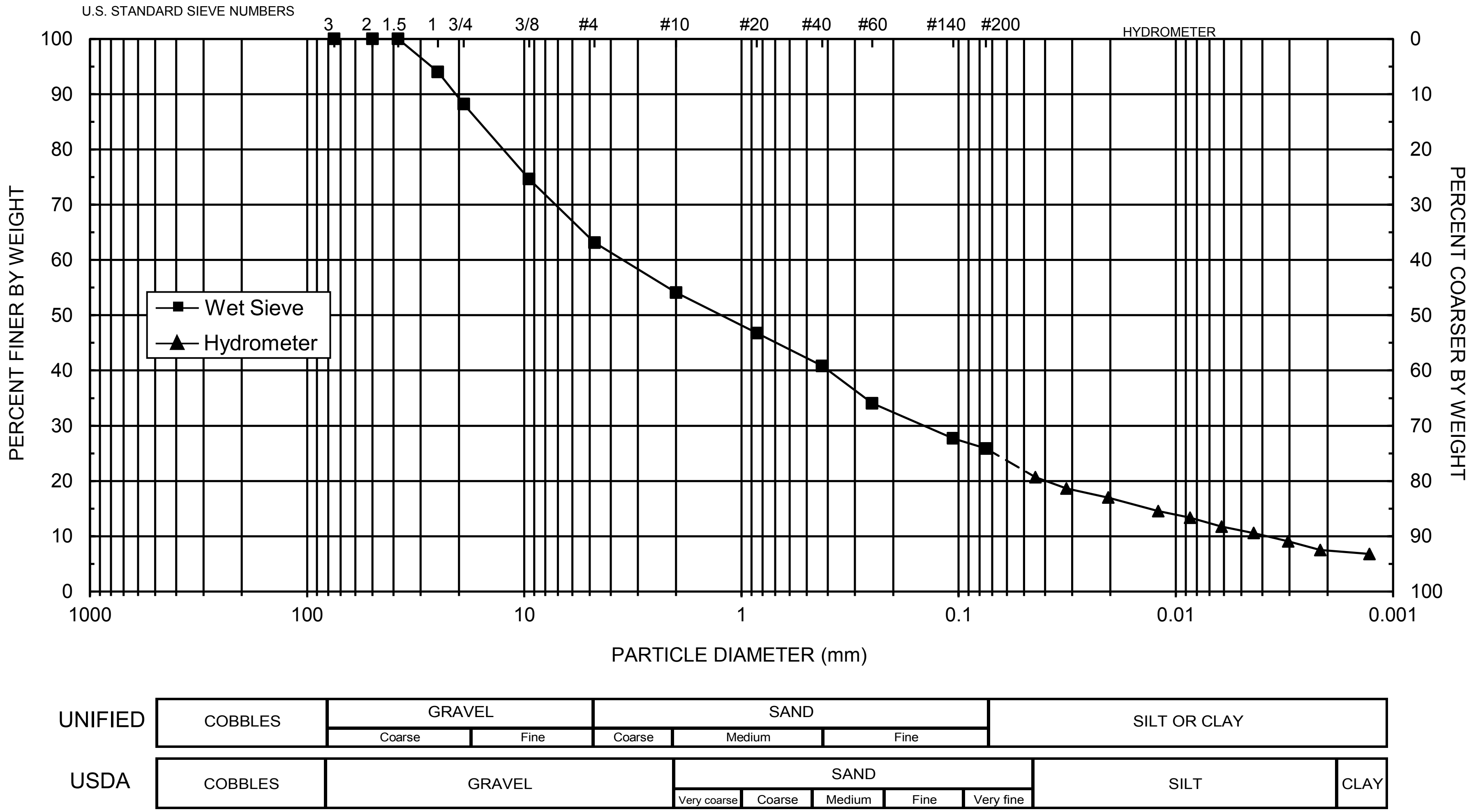
Job Name:	HDR	*Type of Water Used:*	DISTILLED
Job Number:	DB17.1173.00	*Reaction with H_2O_2:*	NA
Sample Number:	East Lysimeter Boring (42'-45')	*Dispersant*:*	$(NaPO_3)_6$
Project:	Lott, RWIS, Hawks Prarie Property	*Assumed particle density:*	2.68
Depth (ft):	42'-45'	*Initial Wt. (g):*	65.54
Test Date:	14-Jul-17	*Total Sample Wt. (g):*	2174.14
Start Time:	9:18	*Wt. Passing #10 (g):*	1176.08

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
14-Jul-17	1	21.4	31.5	6.2	25.3	11.1	0.04429	38.2	20.7
	2	21.4	29.0	6.2	22.8	11.5	0.03189	34.5	18.6
	5	21.4	27.0	6.2	20.8	11.9	0.02045	31.4	17.0
	15	21.4	24.0	6.2	17.8	12.4	0.01205	26.9	14.6
	30	21.5	22.5	6.2	16.3	12.6	0.00860	24.7	13.3
	60	21.6	20.5	6.1	14.4	12.9	0.00615	21.7	11.7
	120	21.9	19.0	6.1	12.9	13.2	0.00437	19.5	10.6
	250	22.7	17.0	5.9	11.1	13.5	0.00304	16.8	9.1
	502	23.0	15.0	5.8	9.2	13.8	0.00216	13.9	7.5
15-Jul-17	1491	21.4	14.5	6.2	8.3	13.9	0.00128	12.6	6.8

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: A. Bland
Data entered by: A. Bland
Checked by: J. Hines



d_{10} = **0.0038**	d_{30} = **0.14**	d_{50} = **1.2**	d_{60} = **3.5**	C_u = **921**	C_c = **1.5**

SAMPLE NUMBER	DEPTH (FT)	ASTM CLASSIFICATION	USDA CLASSIFICATION
East Lysimeter Boring (42'-45')	**42'-45'**	**Classification by ASTM 2487 requires Atterberg test**	**Sandy Loam †**

† Greater than 10% of sample is coarse material

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#10 Split)

Job Name: HDR
Job Number: DB17.1173.00
Sample Number: LOTT Hawks Prarie Lysimeter West, Upper 10 feet
Project: Lott, RWIS, Hawks Prarie Property
Depth (ft): 10'

Test Date: 2-Aug-17

Initial Dry Weight of Sample (g): 1163.36
Weight Passing #10 (g): 299.61
Weight Retained #10 (g): 863.74
Weight of Hydrometer Sample (g): 60.47
Calculated Weight of Sieve Sample (g): 234.80

Shape: Rounded
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+10						
	3"	75	0.00	0.00	1163.36	100.00
	2"	50	0.00	0.00	1163.36	100.00
	1.5"	38.1	0.00	0.00	1163.36	100.00
	1"	25	126.70	126.70	1036.66	89.11
	3/4"	19.0	92.06	218.76	944.60	81.20
	3/8"	9.5	273.40	492.16	671.20	57.69
	4	4.75	194.02	686.18	477.18	41.02
	10	2.00	177.56	863.74	299.61	25.75
-10			(Based on calculated sieve wt.)			
	20	0.85	21.76	196.09	38.71	16.49
	40	0.425	11.42	207.51	27.29	11.62
	60	0.250	5.64	213.15	21.65	9.22
	140	0.106	6.18	219.33	15.47	6.59
	200	0.075	1.68	221.01	13.79	5.87
	dry pan		0.23	221.24	13.56	
	wet pan			13.56	0.00	

d_{10} (mm): 0.30　　d_{50} (mm): 6.9
d_{16} (mm): 0.79　　d_{60} (mm): 10
d_{30} (mm): 2.5　　d_{84} (mm): 21

Median Particle Diameter --d_{50} (mm): 6.9
Uniformity Coefficient, Cu --[d_{60}/d_{10}] (mm): 33
Coefficient of Curvature, Cc --[$(d_{30})^2/(d_{10}*d_{60})$] (mm): 2.1
Mean Particle Diameter --[$(d_{16}+d_{50}+d_{84})/3$] (mm): 9.6

ASTM Soil Classification: Classification by ASTM 2487 requires Atterberg test
USDA Soil Classification: Loamy Sand †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Falance/A. Bland
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

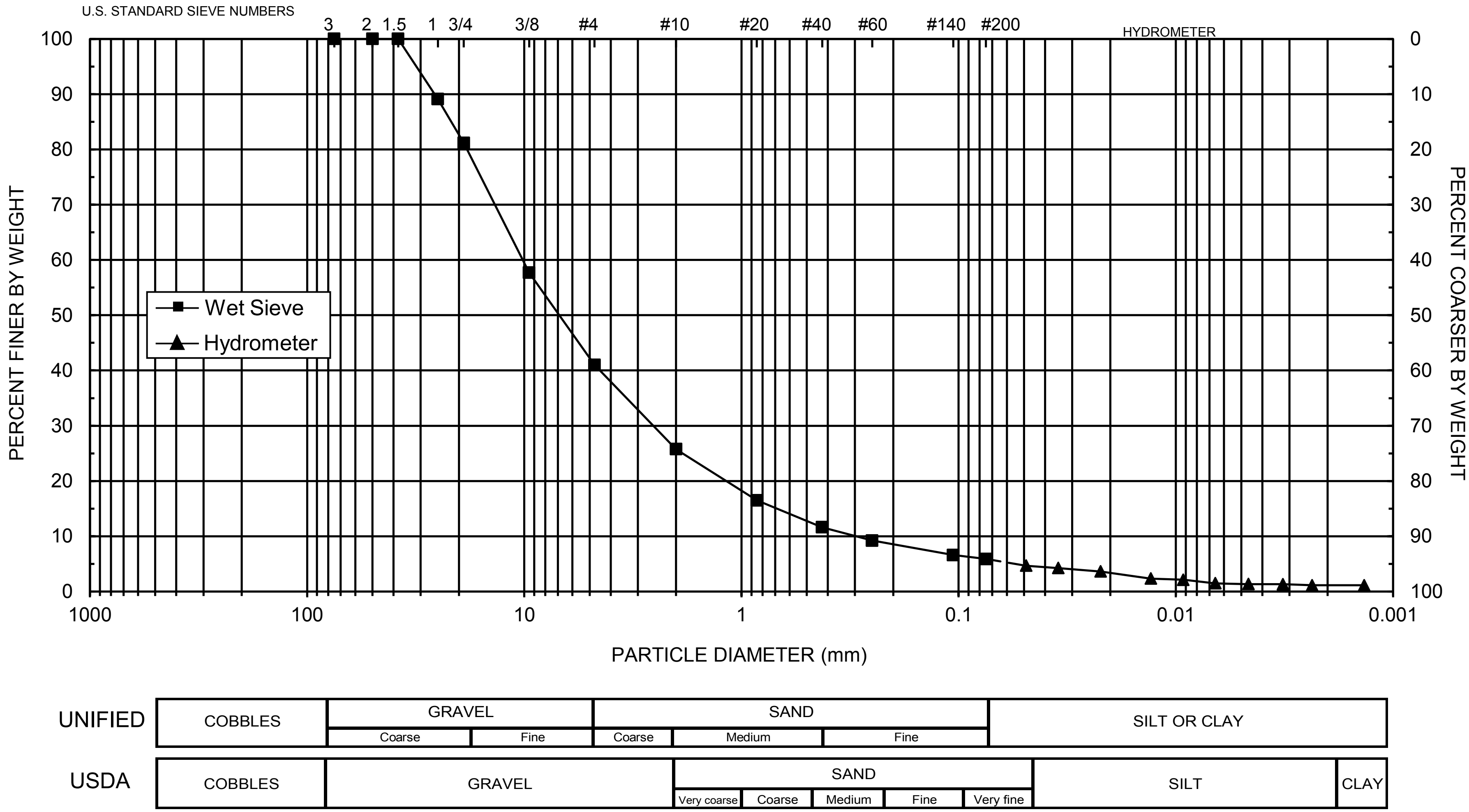
Job Name:	HDR	*Type of Water Used:*	DISTILLED
Job Number:	DB17.1173.00	*Reaction with* H_2O_2*:*	NA
Sample Number:	LOTT Hawks Prarie Lysimeter West, Upper 10 feet	*Dispersant*:*	$(NaPO_3)_6$
Project:	Lott, RWIS, Hawks Prarie Property	*Assumed particle density:*	2.65
Depth (ft):	10'	*Initial Wt. (g):*	60.47
Test Date:	27-Jul-17	*Total Sample Wt. (g):*	1163.36
Start Time:	9:00	*Wt. Passing #10 (g):*	299.61

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
27-Jul-17	1	22.1	17.0	6.0	11.0	13.5	0.04882	18.1	4.7
	2	22.1	16.0	6.0	10.0	13.7	0.03473	16.5	4.2
	5	22.1	14.5	6.0	8.5	13.9	0.02216	14.0	3.6
	15	22.1	11.5	6.0	5.5	14.4	0.01302	9.0	2.3
	30	22.1	11.0	6.0	5.0	14.5	0.00923	8.2	2.1
	60	22.2	9.5	6.0	3.5	14.7	0.00658	5.8	1.5
	120	22.8	9.0	5.9	3.1	14.8	0.00463	5.2	1.3
	250	22.7	9.0	5.9	3.1	14.8	0.00321	5.1	1.3
	466	22.9	8.5	5.9	2.6	14.9	0.00235	4.4	1.1
28-Jul-17	1450	21.6	8.5	5.9	2.6	14.9	0.00135	4.4	1.1

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: A. Bland
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.30**	d_{30} = **2.5**	d_{50} = **6.9**	d_{60} = **10**	C_u = **33**	C_c = **2.1**

SAMPLE NUMBER	DEPTH (FT)	ASTM CLASSIFICATION	USDA CLASSIFICATION
LOTT Hawks Prarie Lysimeter West, Upper 10 feet	**10'**	**Classification by ASTM 2487 requires Atterberg test**	**Loamy Sand †**

† Greater than 10% of sample is coarse material

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#10 Split)

Job Name: HDR
Job Number: DB17.1173.00
Sample Number: LOTT Hawks Prarie Lysimeter East, Upper 10 feet
Project: Lott, RWIS, Hawks Prarie Property
Depth (ft): 10'

Test Date: 2-Aug-17

Initial Dry Weight of Sample (g): 1349.83
Weight Passing #10 (g): 604.49
Weight Retained #10 (g): 745.35
Weight of Hydrometer Sample (g): 59.04
Calculated Weight of Sieve Sample (g): 131.84

Shape: Rounded
Hardness: Weathered and friable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+10						
	3"	75	0.00	0.00	1349.83	100.00
	2"	50	0.00	0.00	1349.83	100.00
	1.5"	38.1	0.00	0.00	1349.83	100.00
	1"	25	96.55	96.55	1253.28	92.85
	3/4"	19.0	82.47	179.02	1170.81	86.74
	3/8"	9.5	113.87	292.89	1056.94	78.30
	4	4.75	148.62	441.51	908.32	67.29
	10	2.00	303.84	745.35	604.49	44.78
-10			(Based on calculated sieve wt.)			
	20	0.85	31.46	104.26	27.58	20.92
	40	0.425	11.41	115.67	16.17	12.27
	60	0.250	4.38	120.05	11.79	8.94
	140	0.106	3.06	123.11	8.73	6.62
	200	0.075	0.70	123.81	8.03	6.09
	dry pan		0.01	123.82	8.02	
	wet pan			8.02	0.00	

d_{10} (mm): 0.30 d_{50} (mm): 2.4
d_{16} (mm): 0.57 d_{60} (mm): 3.6
d_{30} (mm): 1.2 d_{84} (mm): 15

Median Particle Diameter --d_{50} (mm): 2.4
Uniformity Coefficient, Cu --[d_{60}/d_{10}] (mm): 12
Coefficient of Curvature, Cc --[$(d_{30})^2/(d_{10}*d_{60})$] (mm): 1.3
Mean Particle Diameter --[$(d_{16}+d_{50}+d_{84})/3$] (mm): 6.0

ASTM Soil Classification: Classification by ASTM 2487 requires Atterberg test
USDA Soil Classification: Sand †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Falance/A. Bland
Data entered by: C. Krous
Checked by: J. Hines

Particle Size Analysis
Hydrometer Data

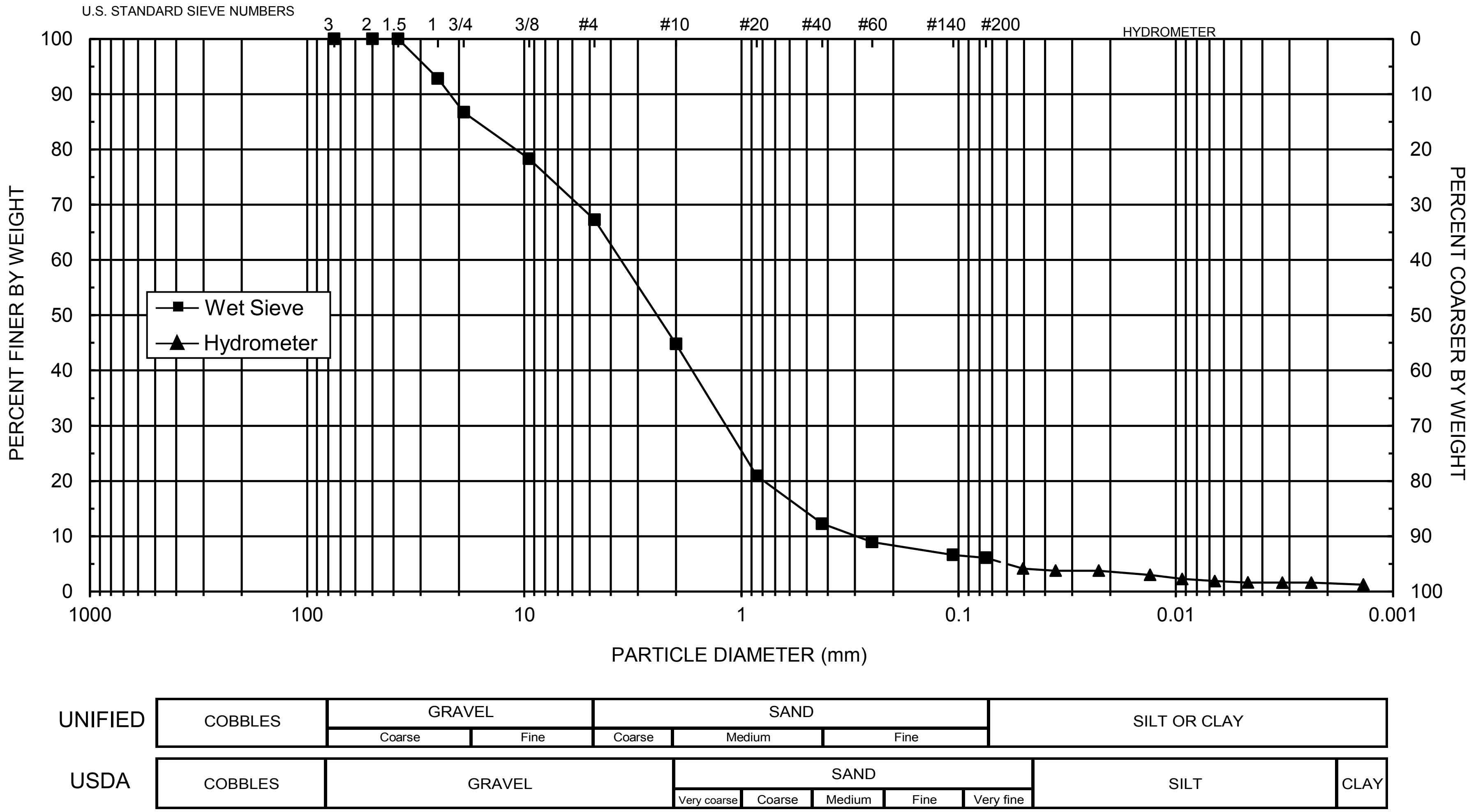
Job Name:	HDR	*Type of Water Used:*	DISTILLED
Job Number:	DB17.1173.00	*Reaction with* H_2O_2*:*	NA
Sample Number:	LOTT Hawks Prarie Lysimeter East, Upper 10 feet	*Dispersant*:*	$(NaPO_3)_6$
Project:	Lott, RWIS, Hawks Prarie Property	*Assumed particle density:*	2.65
Depth (ft):	10'	*Initial Wt. (g):*	59.04
Test Date:	27-Jul-17	*Total Sample Wt. (g):*	1349.83
Start Time:	9:06	*Wt. Passing #10 (g):*	604.49

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
27-Jul-17	1	22.1	11.5	6.0	5.5	14.4	0.05043	9.3	4.1
	2	22.1	11.0	6.0	5.0	14.5	0.03576	8.4	3.8
	5	22.1	11.0	6.0	5.0	14.5	0.02262	8.4	3.8
	15	22.1	10.0	6.0	4.0	14.7	0.01313	6.7	3.0
	30	22.1	9.0	6.0	3.0	14.8	0.00934	5.0	2.3
	60	22.2	8.5	6.0	2.5	14.9	0.00661	4.2	1.9
	120	22.8	8.0	5.9	2.1	15.0	0.00466	3.6	1.6
	250	22.7	8.0	5.9	2.1	15.0	0.00323	3.6	1.6
	461	22.9	8.0	5.9	2.1	15.0	0.00237	3.6	1.6
28-Jul-17	1446	21.6	7.0	5.4	1.6	15.2	0.00137	2.8	1.2

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: A. Bland
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.30**	d_{30} = **1.2**	d_{50} = **2.4**	d_{60} = **3.6**	C_u = **12**	C_c = **1.3**

SAMPLE NUMBER	DEPTH (FT)	ASTM CLASSIFICATION	USDA CLASSIFICATION
LOTT Hawks Prarie Lysimeter East, Upper 10 feet	**10'**	**Classification by ASTM 2487 requires Atterberg test**	**Sand** †

† Greater than 10% of sample is coarse material

Percent Organic Matter

Summary of Percent Organic Matter

Sample Number	Organic Matter* (%, g/g)
West Lysimeter Boring (22'-25')	0.6
West Lysimeter Boring (42'-45')	0.6
East Lysimeter Boring (32'-35')	0.7
East Lysimeter Boring (42'-45')	1.0
LOTT Hawks Prarie Lysimeter West, Upper 10 feet	0.7
LOTT Hawks Prarie Lysimeter East, Upper 10 feet	0.7

*Correction for oversize material applied, if necessary

Data for Percent Organic Matter

Job Name:	HDR
Job Number:	DB17.1173.00
Sample Number:	West Lysimeter Boring (22'-25')
Project:	Lott, RWIS, Hawks Prarie Property
Depth (ft):	22'-25'
Test Date:	13-Jul-17

Fraction of bulk sample used (<2.00 mm fraction) (%)*:*	89.95
Tare weight, pan (g)*:*	79.18
Oven Dry (105 °C) weight of sample* (g)*:*	148.48
Muffle Furnace Dry (440 °C) weight of sample* (g)*:*	148.04
Organic Matter of <2.00 mm fraction (%, g/g)*:*	0.63
Organic Matter of Bulk Sample* (%, g/g)*:	**0.57**

Comments:

* Weight including tares

Laboratory analysis by:	D. O'Dowd
Data entered by:	C. Krous
Checked by:	J. Hines

Data for Percent Organic Matter

Job Name:	HDR
Job Number:	DB17.1173.00
Sample Number:	West Lysimeter Boring (42'-45')
Project:	Lott, RWIS, Hawks Prarie Property
Depth (ft):	42'-45'
Test Date:	13-Jul-17

Fraction of bulk sample used (<2.00 mm fraction) (%):	65.93
Tare weight, pan (g):	79.19
Oven Dry (105 °C) weight of sample* (g):	151.20
Muffle Furnace Dry (440 °C) weight of sample* (g):	150.77
Organic Matter of <2.00 mm fraction (%, g/g):	0.60
***Organic Matter of Bulk Sample* (%, g/g):**	**0.39**

Comments:

* Weight including tares

Laboratory analysis by:	D. O'Dowd
Data entered by:	C. Krous
Checked by:	J. Hines

Daniel B. Stephens & Associates, Inc.

Data for Percent Organic Matter

Job Name:	HDR
Job Number:	DB17.1173.00
Sample Number:	East Lysimeter Boring (32'-35')
Project:	Lott, RWIS, Hawks Prarie Property
Depth (ft):	32'-35'
Test Date:	13-Jul-17

Fraction of bulk sample used (<2.00 mm fraction) (%):	26.51
Tare weight, pan (g):	83.67
Oven Dry (105 °C) weight of sample* (g):	147.63
Muffle Furnace Dry (440 °C) weight of sample* (g):	147.17
Organic Matter of <2.00 mm fraction (%, g/g):	0.72
***Organic Matter of Bulk Sample* (%, g/g):**	**0.19**

Comments:

* Weight including tares

Laboratory analysis by:	D. O'Dowd
Data entered by:	C. Krous
Checked by:	J. Hines

Data for Percent Organic Matter

Job Name:	HDR
Job Number:	DB17.1173.00
Sample Number:	East Lysimeter Boring (42'-45')
Project:	Lott, RWIS, Hawks Prarie Property
Depth (ft):	42'-45'
Test Date:	13-Jul-17

Fraction of bulk sample used (<2.00 mm fraction) (%):	54.09
Tare weight, pan (g):	84.43
Oven Dry (105°C) weight of sample* (g):	146.57
Muffle Furnace Dry (440°C) weight of sample* (g):	145.92
Organic Matter of <2.00 mm fraction (%, g/g):	1.05
***Organic Matter of Bulk Sample* (%, g/g):**	**0.57**

Comments:

* Weight including tares

Laboratory analysis by:	D. O'Dowd
Data entered by:	C. Krous
Checked by:	J. Hines

Data for Percent Organic Matter

Job Name: HDR
Job Number: DB17.1173.00
Sample Number: LOTT Hawks Prarie Lysimeter West, Upper 10 feet
Project: Lott, RWIS, Hawks Prarie Property
Depth (ft): 10'

Test Date: 24-Jul-17

Fraction of bulk sample used (<4.75mm fraction) (%): 41.02

Tare weight, pan (g): 79.15
Oven Dry (105°C) weight of sample* (g): 167.71

Muffle Furnace Dry (440°C) weight of sample* (g): 167.11

Organic Matter of <4.75 mm fraction (%, g/g): 0.68
***Organic Matter of Bulk Sample* (%, g/g): 0.28**

Comments:

* Weight including tares

Laboratory analysis by: A. Bland
Data entered by: C. Krous
Checked by: J. Hines

Data for Percent Organic Matter

Job Name: HDR
Job Number: DB17.1173.00
Sample Number: LOTT Hawks Prarie Lysimeter East, Upper 10 feet
Project: Lott, RWIS, Hawks Prarie Property
Depth (ft): 10'

Test Date: 24-Jul-17

Fraction of bulk sample used (<4.75mm fraction) (%): 67.29

Tare weight, pan (g):	79.19
Oven Dry (105 °C) weight of sample* (g):	195.68
Muffle Furnace Dry (440 °C) weight of sample* (g):	194.91

Organic Matter of <4.75 mm fraction (%, g/g): 0.66
***Organic Matter of Bulk Sample* (%, g/g): 0.44**

Comments:

* Weight including tares

Laboratory analysis by: A. Bland
Data entered by: C. Krous
Checked by: J. Hines

Cation Exchange Capacity

Summary of Cation Exchange Capacity

Sample Number	CEC (meq/100g)	Reporting Detection Limit
West Lysimeter Boring (22'-25')	4.86	0.09
West Lysimeter Boring (42'-45')	5.61	0.09
East Lysimeter Boring (32'-35')	6.84	0.09
East Lysimeter Boring (42'-45')	7.10	0.09
LOTT Hawks Prarie Lysimeter West, Upper 10 feet	3.43	0.09
LOTT Hawks Prarie Lysimeter East, Upper 10 feet	3.04	0.09

"<" Indicates value is less than the detection limit.
Analysis performed by Hall Environmental Analysis Laboratory

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Hall Environmental
Project: Not Indicated
Report Date: 07/27/17

Lab ID: B17071432-001
Client Sample ID: 1707673-001A, W Lysmeter Boring (22-25 Feet)
Collection Date: 07/12/17 10:00
DateReceived: 07/18/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Cation Exchange Capacity	4.86	meq/100g		0.09		SW6010B	07/26/17 19:58 / rlh

Lab ID: B17071432-002
Client Sample ID: 1707673-002A, W Lysmeter Boring (42-45 Feet)
Collection Date: 07/12/17 10:00
DateReceived: 07/18/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Cation Exchange Capacity	5.61	meq/100g		0.09		SW6010B	07/26/17 20:09 / rlh

Lab ID: B17071432-003
Client Sample ID: 1707673-003A, E Lysmeter Boring (32-35 Feet)
Collection Date: 07/12/17 10:00
DateReceived: 07/18/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Cation Exchange Capacity	6.84	meq/100g		0.09		SW6010B	07/26/17 20:13 / rlh

Lab ID: B17071432-004
Client Sample ID: 1707673-004A, E Lysmeter Boring (42-45 Feet)
Collection Date: 07/12/17 10:00
DateReceived: 07/18/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Cation Exchange Capacity	7.10	meq/100g		0.09		SW6010B	07/26/17 20:19 / rlh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Hall Environmental
Project: Not Indicated
Report Date: 08/07/17

Lab ID: B17072402-001
Client Sample ID: 1707D95-001A, Hawks Prarie West Upper 10 Feet
Collection Date: 07/24/17 10:00
DateReceived: 07/28/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Cation Exchange Capacity	3.43	meq/100g		0.09		SW6010B	08/04/17 16:08 / slf

Lab ID: B17072402-002
Client Sample ID: 1797D95-002A, Hawks Prarie East Upper 10 Feet
Collection Date: 07/24/17 10:00
DateReceived: 07/28/17
Matrix: Soil

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
CHEMICAL CHARACTERISTICS							
Cation Exchange Capacity	3.04	meq/100g		0.09		SW6010B	08/04/17 16:15 / slf

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Hall Environmental **Report Date:** 07/27/17
Project: Not Indicated **Work Order:** B17071432

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B								Batch: 111919	
Lab ID: LCS-111919	Laboratory Control Sample				Run: ICP203-B_170726A			07/26/17 18:02	
Cation Exchange Capacity	13.2	meq/100g	0.087	73	50	150			
Lab ID: B17071432-003AMS2	Sample Matrix Spike				Run: ICP203-B_170726A			07/26/17 20:16	
Cation Exchange Capacity	50.5	meq/100g	0.087	100	50	150			
Lab ID: B17071432-004A DUP	Sample Duplicate				Run: ICP203-B_170726A			07/26/17 20:23	
Cation Exchange Capacity	6.79	meq/100g	0.087				4.4	30	

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Hall Environmental
Project: Not Indicated

Report Date: 08/07/17
Work Order: B17072402

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: SW6010B									Batch: 112233
Lab ID: LCS-112233	Laboratory Control Sample				Run: ICP203-B_170804A				08/04/17 16:04
Cation Exchange Capacity	11.2	meq/100g	0.087	81	50	150			
Lab ID: B17072402-001A DUP	Sample Duplicate				Run: ICP203-B_170804A				08/04/17 16:11
Cation Exchange Capacity	3.07	meq/100g	0.087				11	30	
Lab ID: B17072402-002AMS2	Sample Matrix Spike				Run: ICP203-B_170804A				08/04/17 16:18
Cation Exchange Capacity	40.8	meq/100g	0.087	87	50	150			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263, ASTM D2216
Calculated Porosity:	ASTM D7263
Saturated Hydraulic Conductivity:	
Constant Head: (Rigid Wall)	ASTM D 5856 (modified apparatus)
Falling Head: (Rigid Wall)	Klute, A. and C. Dirkson. 1986. Hydraulic Conductivity and Diffusivity: Laboratory Methods.Chp. 28, pp. 700-703, in A. Klute (ed.), Methods of Soil Analysis, Part 1, American Society of Agronomy, Madison, WI
Hanging Column Method:	ASTM D6836 (modified apparatus)
Pressure Plate Method:	ASTM D6836 (modified apparatus)
Water Potential (Dewpoint Potentiometer) Method:	ASTM D6836
Relative Humidity (Box) Method:	Campbell, G. and G. Gee. 1986. Water Potential: Miscellaneous Methods. Chp. 25, pp. 631-632, in A. Klute (ed.), Methods of Soil Analysis. Part 1. American Society of Agronomy, Madison, WI; Karathanasis & Hajek. 1982. Quantitative Evaluation of Water Adsorption on Soil Clays. SSA Journal 46:1321-1325
Moisture Retention Characteristics & Calculated Unsaturated Hydraulic Conductivity:	ASTM D6836; van Genuchten, M.T. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. SSSAJ 44:892-898; van Genuchten, M.T., F.J. Leij, and S.R. Yates. 1991. The RETC code for quantifying the hydraulic functions of unsaturated soils. Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Ada, Oklahoma. EPA/600/2091/065. December 1991
Particle Size Analysis:	ASTM D7928, ASTM D6913
USCS (ASTM) Classification:	ASTM D7928, ASTM D6913, ASTM D2487
USDA Classification:	ASTM D7928, ASTM D6913, USDA Soil Textural Triangle
Percent Organic Matter:	ASTM D2974
Cation exchange capacity (CEC)	EPA 6010B, USDA Handbook 60

tm TECHNOLOGY OF MATERIALS

4020 N. Palm Street, # 202
Fullerton, CA 92835

Sam Iyengar Ph.D.
Technical Director

John Koreny
Ida Fischer
HDR
500, 108th Avenue, NE Suite 1200
Bellevue, WA 98004-5549

August 04, 2017

Dear John:
Enclosed please find a report on the XRD, clay analysis of soil samples. Please call me if you have any questions or concerns.

Sincerely,

Sam Iyengar

X-ray and Clay Analysis of Samples

Introduction:

Two soil samples were received at the laboratory for analysis. It was requested that all samples be analyzed by X-ray powder diffraction (XRD). The soil sample was analyzed by XRD to determine the presence of crystalline components in both the bulk and clay fractions. This report summarizes the findings.

Materials and Method:

Soils from Lott –Hawks Prarie were analyzed:

1) **Composite Sample East Lysimeter Boring 50 ft.**
2) **Composite Sample West Lysimeter Boring 50 ft.**

X-ray Diffraction (XRD):

Analysis was carried out on a Phillips Diffractometer at 30 Kv and 20 ma using Cu K-alpha radiation and a scintillation detector. Bulk soil sample was run after grinding it to pass through a 325 mesh (44 um) sieve and it was scanned from 2 to 50 degrees two-theta. The resulting patterns collected on a computer were matched with the reference standards for various inorganic minerals stored in the JCPDS database. Semi-quantitative estimation of mineral components was carried out from the peak intensities.

Clay analysis:

Samples were analyzed by Laboratory Standard Operating Procedure-100. The samples were gently ground to break up the aggregates and were air-dried. They were then suspended and shaken in distilled water to promote dispersion. They were initially treated with dilute HCl to destroy any carbonate cementing agents. The time required to separate **< 5 um fraction** was calculated from the Stocks law and the suspension was allowed to stand for appropriate time. The supernatant (with colloids) solution was decanted into a separate beaker. The process of adding water and settling was continued till the supernatant became clear.

A portion of the clay suspension in the beaker was used to make oriented clay mounts on a Millipore filter. The suspensions were filtered through a 45 um filter paper on a Millipore filter set-up using vacuum. They were then washed thoroughly with distilled water to remove excess salts. The clay cake on the filter paper was transferred, while still wet, onto a glass slide and kept in an ethylene glycol chamber for 24 hours. A drop of glycol was placed on the edge of each slide before placing them in the chamber.

To confirm the presence of smectite clay, oriented and glycolated mounts of the clay sample was prepared and analyzed. Upon glycolation, smectite, if present, will expand to ~17 A

Results and Discussion:

XRD patterns for soil samples are shown in Figures 1-2. Stick patterns for applicable reference minerals from the Powder Diffraction File (PDF) database are also shown.

Overall Mineralogy of Soil Samples:

The mineralogy of the soil is shown in Table 1. A semi-quantitative estimation of various minerals is shown. It is accurate to +/- 8 -10 wt. %.

Table 1: Mineralogical Composition of Soil Sample (wt. %)

ID	Smectite	Chlorite	Mica/ Illite	Kaolin	Quartz	Ca-Na Feldspars
East Lysimeter	**~3**	**~4**	**~3**	**~5**	**~65**	**~20**
West Lysimeter	**~2**	**~3**	**~2**	**~5**	**~68**	**~20**

The following comments describe some of the minerals that are present in these samples.

Quartz is usually the major constituent of most rocks and sediments, and is one of the common crystalline forms of silicon dioxide (SiO_2). This is a fairly *hard and non-reactive mineral.* **Cristobalite** is another form of SiO_2.

Feldspar is a group name for a large number of aluminum silicate minerals of variable composition. The general formula is **X** $Al(Al,Si)Si_2O_8$, where **X** may be Na, K, Ca or Ba. The most common mineral names mentioned from this group include K-feldspars (orthoclase, adularia, microcline) and plagioclase (Na-Ca) feldspars (albite, anorthite). These minerals *are softer than quartz and slightly reactive.*

Clays: The clays are fine-grained (< 0.002 or 0.005 mm) hydrous aluminum silicate phyllosilicate minerals with a layered structure. They consist of sheets of SiO_2 tetrahedra linked to sheets of Al or Mg octohedra forming a layer. When the ratio of silica tetrahedra to Al or Mg octohedra is 1 : 1, it forms **kaolin** group of minerals; when the ratio is 2 : 1, one octohedra sandwiched between two sheets of silica tetrahedra, it forms **mica**, **smectite**, **vermiculite** or **chlorite**, The space between layers is called interlayer space. **Montmorillonite or Bentonite (Smectite group of minerals)** is an expandable *clay mineral* with Ca, Mg, Na, etc. in the interlayer region. These ions are surrounded by water molecules.

They expand upon intercalation with water or organic compounds such as ethylene glycol and glycerol. They have large surface area and are highly reactive. *Bentonite is widely used as a drilling mud*. Mica/Illite is a non-expandable mineral (with K ion in the interlayer space holding the layers together) and is slightly reactive. **Vermiculite** is a non-expandable mineral with Mg ions (with water) or islands of partially developed hydroxy-Al polymers in the inter-layer region. They also have a large surface area and are highly reactive. **Chlorite** is a non-expandable mineral with a fully developed brucite ($Mg(OH)_2$) in-between the layers preventing any separation. They are moderately reactive.

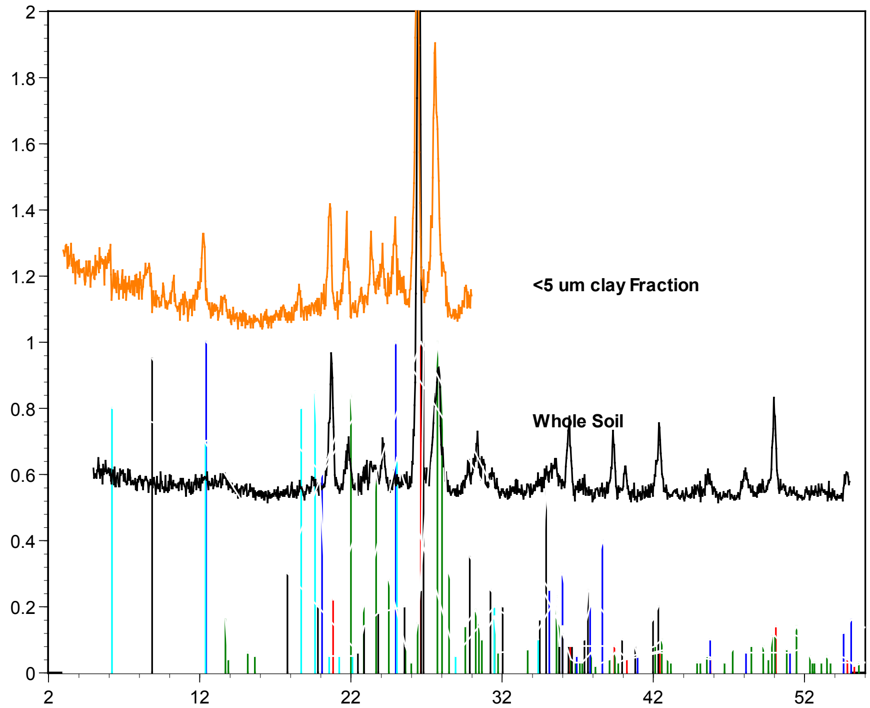


Figure 1: XRD patterns for **East Lysimeter** sample w/ stick patterns for **quartz (red), feldspars (green), kaolinite (blue), mica (black) and chlorite (Cyan)**

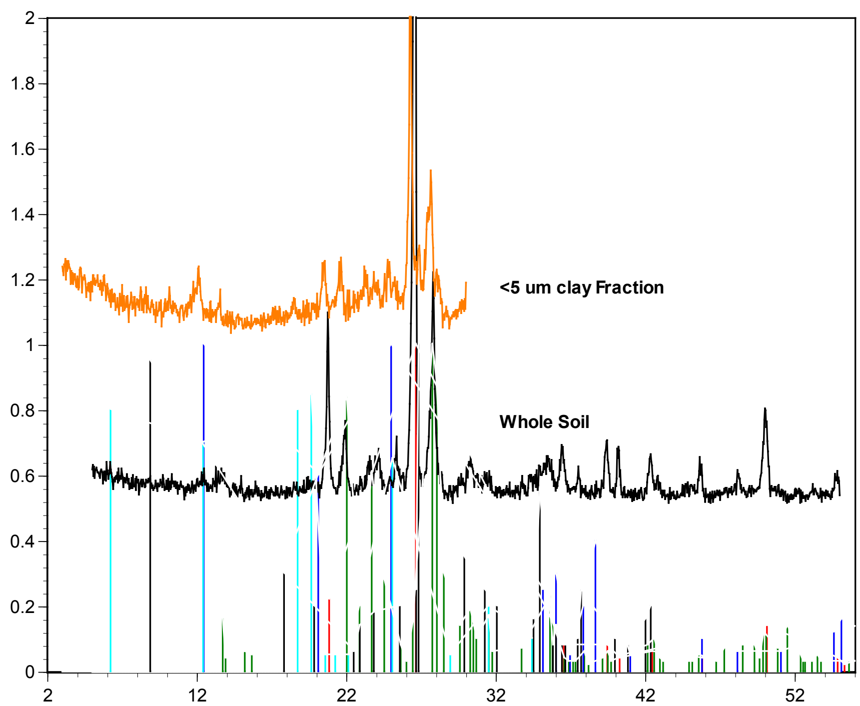


Figure 2: XRD patterns for **West Lysimeter** sample w/ stick patterns for **quartz (red), feldspars (green), kaolinite (blue), mica (black) and chlorite (Cyan)**

This page intentionally left blank.

Appendix E – Analytical Reports - Monitoring Well Boring Soil Samples

This page intentionally left blank.

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project:	NA	**Date Received:**	June 12, 2017
Project #:	17T028	**Sampled By:**	Client
Client :	HDR	**Date Reported:**	July 10, 2017
Source:	Multiple	**Tested By:**	B. Goble, K. DeChurch
MTC Sample#:	Multiple		

CASE NARRATIVE

1. Seven samples were submitted for grain size distribution according to ASTM D422. The samples were prepared according to ASTM D421.
2. One sample from this job was chosen for triplicate analysis.
3. An assumed specific gravity of 2.65 was used in the hydrometer calculations.
4. A standard milkshake mixer type device was used to disperse the fine fraction sample for one minute.
5. The data is provided in summary tables and plots.
6. There were no noted anomalies in this project.

Reviewed by: EGoble Goble

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980

Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974

Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: NA **Client:** HDR
Project #: 17T028
Date Received: June 12, 2017 **Sampled by:** Client
Date Tested: July 5, 2017 **Tested by:** B. Goble, K. DeChurch

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
MW-12(O) 148-150'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	98.9	89.9	67.7	43.4	25.7	19.0	14.0	11.2	8.9	5.6	4.5
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	98.9	89.8	67.6	44.7	26.8	20.4	14.5	11.8	10.2	5.9	5.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.0	90.0	67.8	43.7	26.2	18.6	13.6	10.9	8.7	5.5	4.4
MW-12(O) 56-58'	100.0	100.0	100.0	100.0	92.4	76.1	67.6	55.0	41.4	24.5	7.7	3.6	2.9	2.6	2.1	1.8	1.4	1.4	1.4	1.4	1.4
MW-12(O) 88-90'	100.0	100.0	100.0	76.3	71.8	58.8	54.3	42.6	31.4	19.2	11.3	7.0	5.4	4.4	3.7	3.1	2.9	2.6	2.1	1.6	1.6
MW-12(O) 185-187'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	96.0	64.1	27.1	10.3	6.2	4.8	4.4	3.5	3.1	2.2	2.2
MW-12(O) 234-236'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.9	99.0	94.8	86.4	74.2	54.9	43.9	34.5	28.2	21.9	12.5	6.3
MW-12(O) 295-297'	100.0	100.0	100.0	96.3	86.5	68.0	59.5	39.2	19.1	11.0	8.3	7.2	6.2	4.6	3.7	3.4	3.0	2.7	2.3	1.7	1.7
MW-12(O) 335-337'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.2	95.1	79.6	38.1	17.7	13.1	10.5	9.0	8.4	6.3	5.8	5.3	4.2	4.2

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: NA
Project #: 17T028
Date Received: June 12, 2017
Date Tested: July 5, 2017

Client: HDR
Sampled by: Client
Tested by: B. Goble, K. DeChurch

Percent Retained in Each Size Fraction

Description	% Coarse Gravel				% Gravel			% Coarse Sand	% Medium Sand		% Fine Sand			% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay	
Particle Size (microns)	3-2"	2-1 1/2"	1 1/2"-1"	1-3/4"	3/4-1/2"	1/2-3/8"	3/8"-4750	4750-2000	2000-850	850-425	425-250	250-150	150-75	75-32	32-22	22-13	13-9	9-7	7-3.2	3.2-1.3	<1.3
MW-12(O) 148-150'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	9.0	22.2	24.3	17.6	6.7	5.0	2.8	2.2	3.4	1.1	4.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	9.1	22.2	22.9	17.8	6.4	5.9	2.7	1.6	4.3	0.5	5.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	9.0	22.2	24.1	17.5	7.6	4.9	2.7	2.2	3.3	1.1	4.4
MW-12(O) 56-58'	0.0	0.0	0.0	7.6	16.3	8.6	12.5	13.6	17.0	16.8	4.1	0.7	0.3	0.5	0.4	0.4	0.0	0.0	0.0	0.0	1.4
MW-12(O) 88-90'	0.0	0.0	23.7	4.5	13.0	4.5	11.7	11.2	12.2	7.9	4.3	1.6	1.0	0.8	0.5	0.3	0.3	0.5	0.5	0.0	1.6
MW-12(O) 185-187'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	4.0	31.9	37.0	16.8	4.1	1.3	0.4	0.9	0.4	0.9	0.0	2.2
MW-12(O) 234-236'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.9	4.2	8.3	12.3	19.3	11.0	9.4	6.3	6.3	9.4	6.3	6.3
MW-12(O) 295-297'	0.0	0.0	3.7	9.8	18.5	8.4	20.3	20.2	8.1	2.7	1.1	1.0	1.6	0.9	0.3	0.3	0.3	0.3	0.7	0.0	1.7
MW-12(O) 335-337'	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.1	15.5	41.5	20.5	4.5	2.7	1.5	0.5	2.1	0.5	0.5	1.1	0.0	4.2

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: NA **Client:** HDR
Project #: 17T028
Date Received: June 12, 2017 **Sampled by:** Client
Date Tested: July 5, 2017 **Tested by:** B. Goble, K. DeChurch

Relative Standard Deviation, By Size

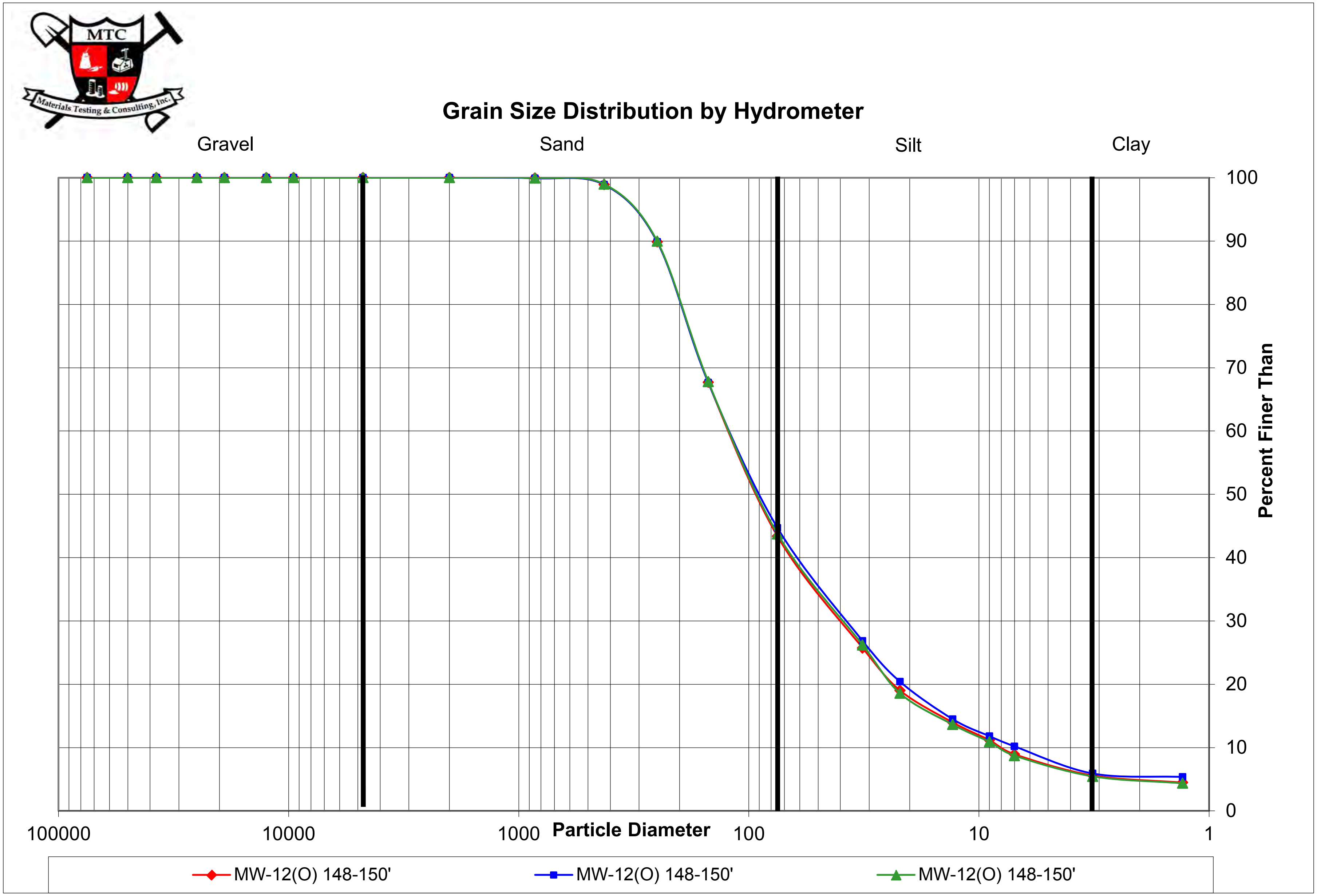
Sample ID	75000	50000	37500	25000	19000	12500	9500	4750	2000	850	425	250	150	75	32	22	13	9	7	3.2	1.3
MW-12(O) 148-150'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	98.9	89.9	67.7	43.4	25.7	19.0	14.0	11.2	8.9	5.6	4.5
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	98.9	89.8	67.6	44.7	26.8	20.4	14.5	11.8	10.2	5.9	5.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.0	90.0	67.8	43.7	26.2	18.6	13.6	10.9	8.7	5.5	4.4
AVE	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	98.9	89.9	67.7	43.9	26.3	19.3	14.0	11.3	9.3	5.7	4.7
STDEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.6	0.5	0.8	0.3	0.4	0.6	0.2	0.4
%RSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	1.3	1.7	4.1	2.5	3.3	7.0	3.3	9.5

This Triplicate applies to the Batch Containing the Following Samples

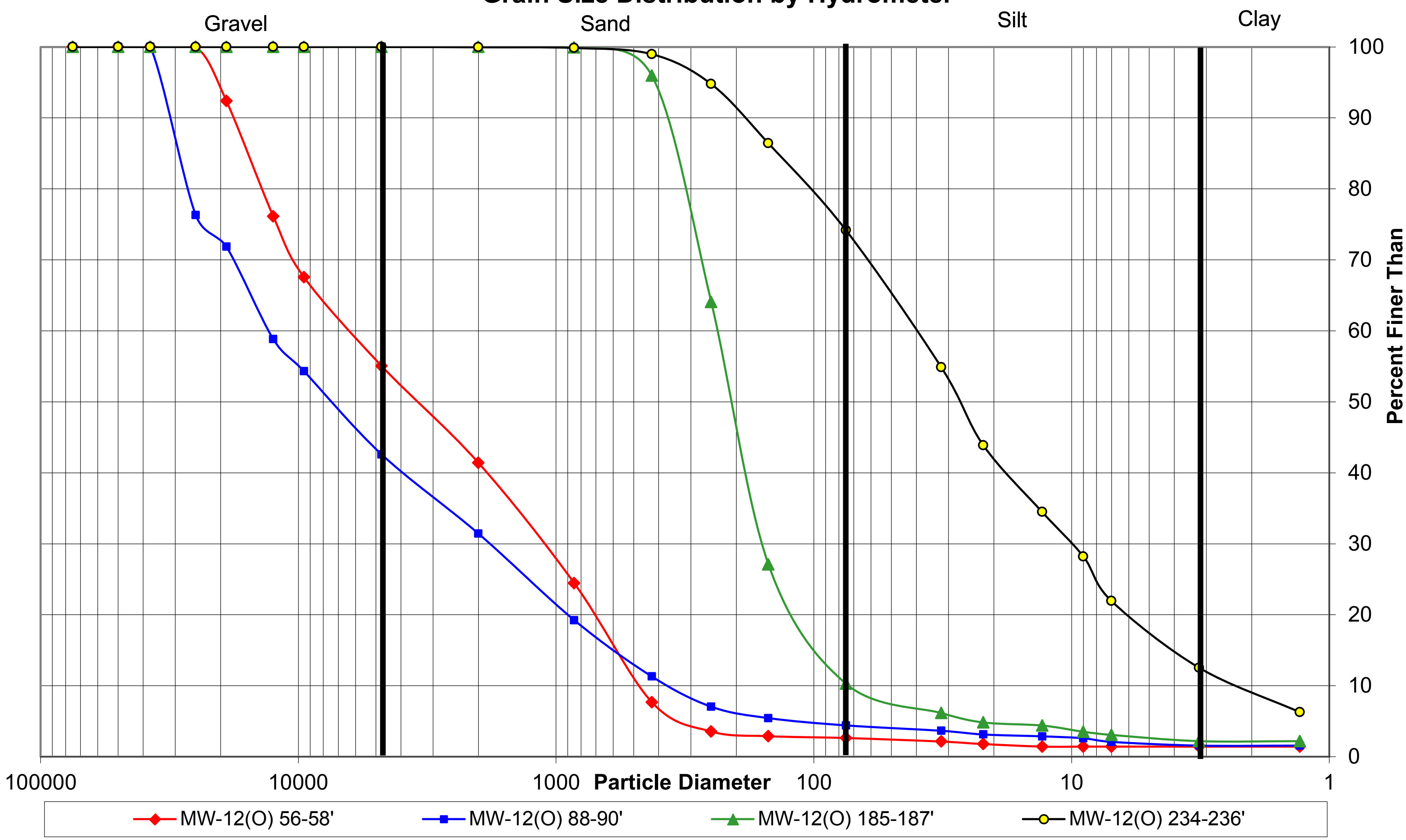
Sample ID	Date Sampled	Date Set up	Date Started	Date Complete	Data Qualifiers
MW-12(O) 148-150'	6/6/2017	6/24/2017	7/3/2017	7/5/2017	
	6/6/2017	6/24/2017	7/3/2017	7/5/2017	
	6/6/2017	6/24/2017	7/3/2017	7/5/2017	
MW-12(O) 56-58'	6/5/2017	6/24/2017	7/3/2017	7/5/2017	
MW-12(O) 88-90'	6/5/2017	6/24/2017	7/3/2017	7/5/2017	
MW-12(O) 185-187'	6/6/2017	6/24/2017	7/3/2017	7/5/2017	
MW-12(O) 234-236'	6/8/2017	6/24/2017	7/3/2017	7/5/2017	
MW-12(O) 295-297'	6/8/2017	6/24/2017	7/3/2017	7/5/2017	
MW-12(O) 335-337'	6/9/2017	6/24/2017	7/3/2017	7/5/2017	

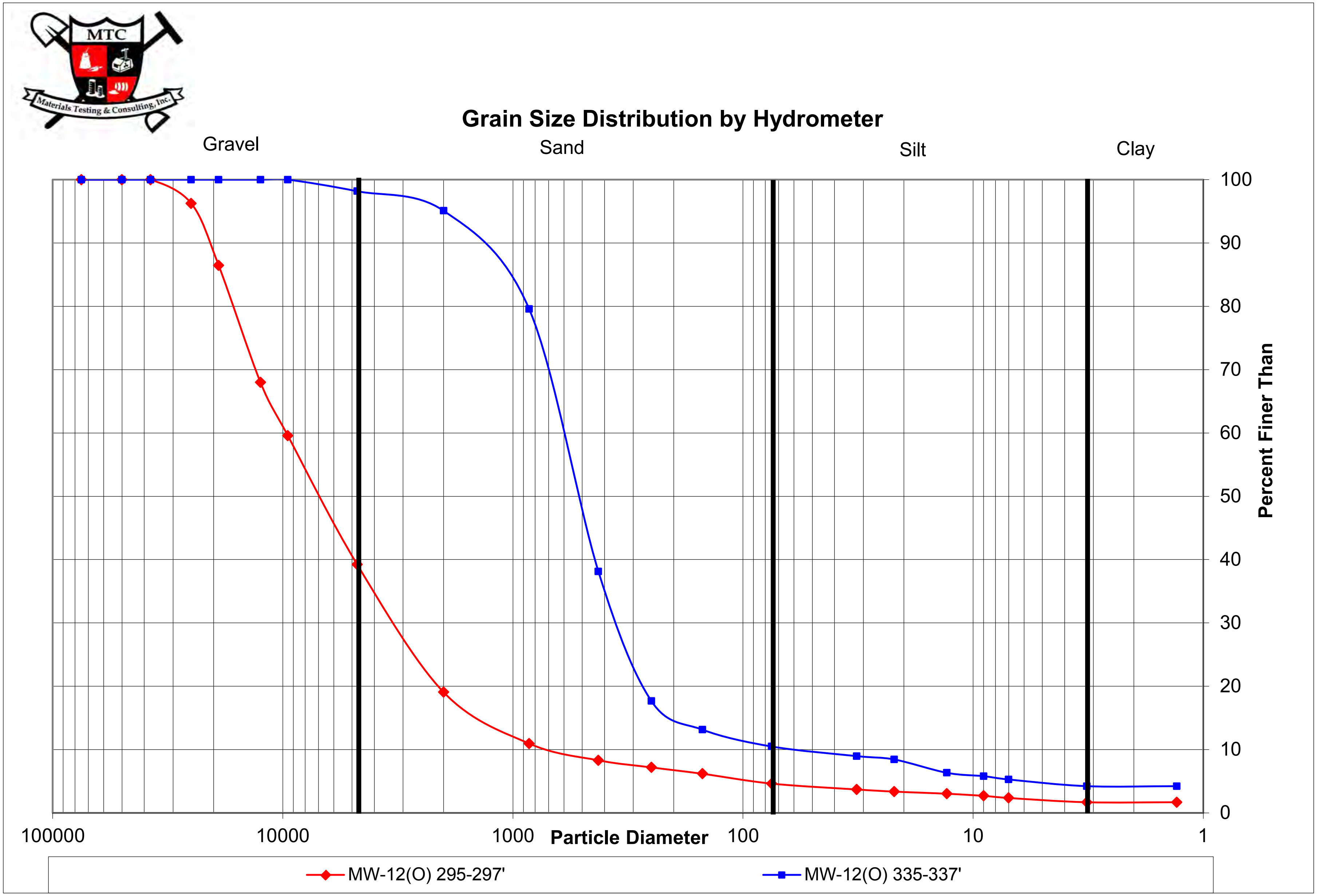
Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________


MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-12(O) 148-150'
MW-12(O) 148-150'
MW-12(O) 148-150'

Grain Size Distribution by Hydrometer




MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-12(O) 295-297'
MW-12(O) 335-337'

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project:	LOTT RWIS	**Date Received:**	July 17, 2017
Project #:	17T028	**Sampled By:**	Others
Client :	HDR	**Date Reported:**	August 2, 2017
Source:	Multiple	**Tested By:**	B. Goble, K. DeChurch
MTC Sample#:	Multiple		

CASE NARRATIVE

1. Twelve samples were submitted for loss on ignition determination according to ASTM D2974, Method A and C.
2. Fourteen samples were submitted for grain size distribution according to ASTM D422. The samples were prepared according to ASTM D421. One sample from this job was chosen for triplicate analysis. An assumed specific gravity of 2.65 was used in the hydrometer calculations. A standard milkshake mixer type device was used to disperse the fine fraction sample for one minute.
3. The data is provided in summary tables and plots.
4. There were no noted anomalies in this project.

Reviewed by: E Gabe Goble

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT RWIS
Project #: 17T028
Date Received: July 17, 2017
Date Tested: July 31, 2017

Client: HDR
Sampled by: Others
Tested by: B. Goble, K. DeChurch

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
MW-14(R) 130'-132'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7	99.0	97.1	63.4	44.8	24.5	16.9	11.8	6.8	4.2
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.6	98.5	96.4	65.0	46.4	26.2	17.7	12.7	5.1	5.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.9	99.7	99.1	97.1	65.5	44.3	25.5	17.0	12.8	5.1	5.1
MW-14(R) 50'	100.0	100.0	100.0	90.1	86.5	81.7	80.1	72.7	66.0	54.3	33.8	10.0	6.2	5.1	4.3	3.5	2.9	2.6	2.6	1.4	1.4
MW-14(R) 88'	100.0	100.0	100.0	95.5	86.5	72.5	64.0	48.2	34.2	21.0	10.7	6.3	4.3	3.3	3.0	2.7	2.1	2.0	1.5	1.1	1.1
MW-14(R) 310'	100.0	100.0	100.0	100.0	100.0	100.0	96.7	93.0	81.4	45.7	19.2	13.3	10.7	8.3	6.2	5.5	4.4	3.3	2.6	0.7	0.7
MW-14(R) 340'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	75.5	27.9	19.5	15.8	12.4	10.2	8.4	7.5	6.2	4.0	2.7
MW-14(R) 380'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6	99.4	99.0	92.5	59.7	47.0	36.5	29.5	24.6	14.0	9.8
MW-23(Q) 74'	100.0	100.0	100.0	100.0	100.0	95.9	95.4	94.8	93.2	81.8	36.2	9.7	4.7	3.5	2.1	2.1	1.7	1.7	1.3	1.3	0.8
MW-23(Q) 97'	100.0	100.0	100.0	100.0	97.1	95.1	91.9	80.1	72.5	64.2	30.5	13.4	7.7	5.7	4.3	3.6	3.0	2.7	2.0	1.3	1.3
MW-23(Q) 109'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.4	95.0	86.1	81.7	79.2	59.9	55.2	45.9	38.4	31.4	18.6	12.8
MW-23(Q) 162'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.7	99.3	89.2	58.6	33.2	21.2	15.5	12.7	8.5	5.6
MW-23(Q) 249'	100.0	100.0	100.0	100.0	89.3	87.5	83.8	68.6	52.1	39.3	30.8	26.9	24.4	22.0	18.0	15.8	12.9	11.0	9.0	6.4	3.9
MW-23(Q) 275'	100.0	100.0	100.0	82.6	75.9	65.8	64.2	56.2	47.2	32.4	18.9	10.4	8.5	5.6	3.9	3.1	2.5	2.1	1.4	1.0	0.8
MW-23(Q) 307'	100.0	100.0	100.0	100.0	100.0	98.0	96.8	93.2	84.3	51.0	22.5	14.6	11.6	9.1	6.8	5.6	4.5	3.8	3.0	2.3	1.5
MW-23(Q) 316'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.5	98.3	94.1	66.9	28.9	20.0	11.1	8.9	5.9	4.4	3.0

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by:

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT RWIS
Project #: 17T028
Date Received: July 17, 2017
Date Tested: July 31, 2017

Client: HDR

Sampled by: Others
Tested by: B. Goble, K. DeChurch

Percent Retained in Each Size Fraction

Description	% Coarse Gravel				% Gravel			% Coarse Sand	% Medium Sand		% Fine Sand			% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay	
Particle Size (microns)	3-2"	2-1 1/2"	1 1/2"-1"	1-3/4"	3/4-1/2"	1/2-3/8"	3/8"-4750	4750-2000	2000-850	850-425	425-250	250-150	150-75	75-32	32-22	22-13	13-9	9-7	7-3.2	3.2-1.3	<1.3
MW-14(R) 130'-132'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	1.9	33.7	18.6	20.3	7.6	5.1	5.1	2.5	4.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.1	2.1	31.4	18.6	20.3	8.4	5.1	7.6	0.0	5.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6	2.0	31.5	21.3	18.7	8.5	4.3	7.7	0.0	5.1
MW-14(R) 50'	0.0	0.0	9.9	3.6	4.8	1.6	7.4	6.7	11.7	20.5	23.8	3.9	1.1	0.8	0.9	0.6	0.3	0.0	1.2	0.0	1.4
MW-14(R) 88'	0.0	0.0	4.5	9.0	14.1	8.5	15.8	14.0	13.2	10.3	4.4	1.9	1.0	0.3	0.3	0.6	0.2	0.5	0.5	0.0	1.1
MW-14(R) 310'	0.0	0.0	0.0	0.0	0.0	3.3	3.8	11.5	35.8	26.5	5.9	2.6	2.4	2.1	0.7	1.1	1.1	0.7	1.8	0.0	0.7
MW-14(R) 340'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	23.9	47.6	8.5	3.7	3.4	2.2	1.8	0.9	1.3	2.2	1.3	2.7
MW-14(R) 380'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.5	6.5	32.8	12.6	10.5	7.0	4.9	10.5	4.2	9.8
MW-23(Q) 74'	0.0	0.0	0.0	0.0	4.1	0.5	0.5	1.6	11.4	45.6	26.5	5.0	1.2	1.4	0.0	0.4	0.0	0.4	0.0	0.4	0.8
MW-23(Q) 97'	0.0	0.0	0.0	2.9	2.0	3.2	11.7	7.7	8.3	33.6	17.1	5.7	2.0	1.4	0.7	0.7	0.3	0.7	0.7	0.0	1.3
MW-23(Q) 109'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	4.3	8.9	4.4	2.5	19.3	4.7	9.3	7.6	7.0	12.8	5.8	12.8
MW-23(Q) 162'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.4	10.1	30.6	25.4	12.0	5.6	2.8	4.2	2.8	5.6
MW-23(Q) 249'	0.0	0.0	0.0	10.7	1.7	3.8	15.2	16.5	12.8	8.5	3.9	2.4	2.5	4.0	2.3	2.9	1.9	1.9	2.6	2.6	3.9
MW-23(Q) 275'	0.0	0.0	17.4	6.6	10.1	1.7	8.0	9.0	14.8	13.5	8.5	1.9	2.9	1.6	0.8	0.6	0.4	0.6	0.4	0.2	0.8
MW-23(Q) 307'	0.0	0.0	0.0	0.0	2.0	1.2	3.6	8.9	33.3	28.6	7.9	3.0	2.4	2.4	1.1	1.1	0.8	0.8	0.8	0.8	1.5
MW-23(Q) 316'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	1.2	4.2	27.2	38.0	8.9	8.9	2.2	3.0	1.5	1.5	3.0

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT RWIS
Client: HDR
Project #: 17T028
Date Received: July 17, 2017
Sampled by: Others
Date Tested: July 31, 2017
Tested by: B. Goble, K. DeChurch

Relative Standard Deviation, By Size

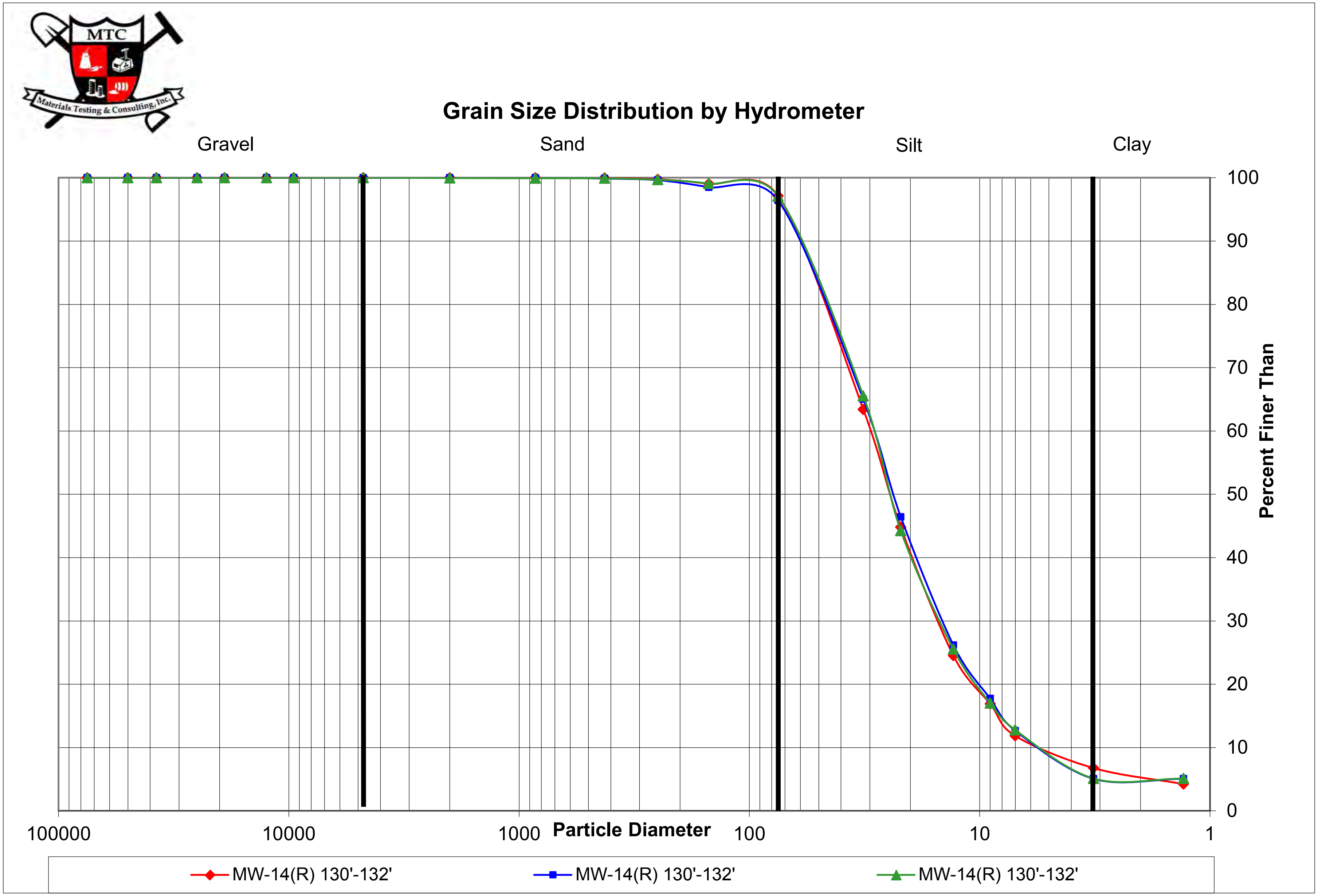
Sample ID	75000	50000	37500	25000	19000	12500	9500	4750	2000	850	425	250	150	75	32	22	13	9	7	3.2	1.3
MW-14(R) 130'-132'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7	99.0	97.1	63.4	44.8	24.5	16.9	11.8	6.8	4.2
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.6	98.5	96.4	65.0	46.4	26.2	17.7	12.7	5.1	5.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.9	99.7	99.1	97.1	65.5	44.3	25.5	17.0	12.8	5.1	5.1
AVE	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.7	98.9	96.9	64.6	45.2	25.4	17.2	12.4	5.6	4.8
STDEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.9	0.9	0.7	0.4	0.4	0.8	0.4
%RSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	1.4	2.0	2.7	2.1	3.4	14.0	8.4

This Triplicate applies to the Batch Containing the Following Samples

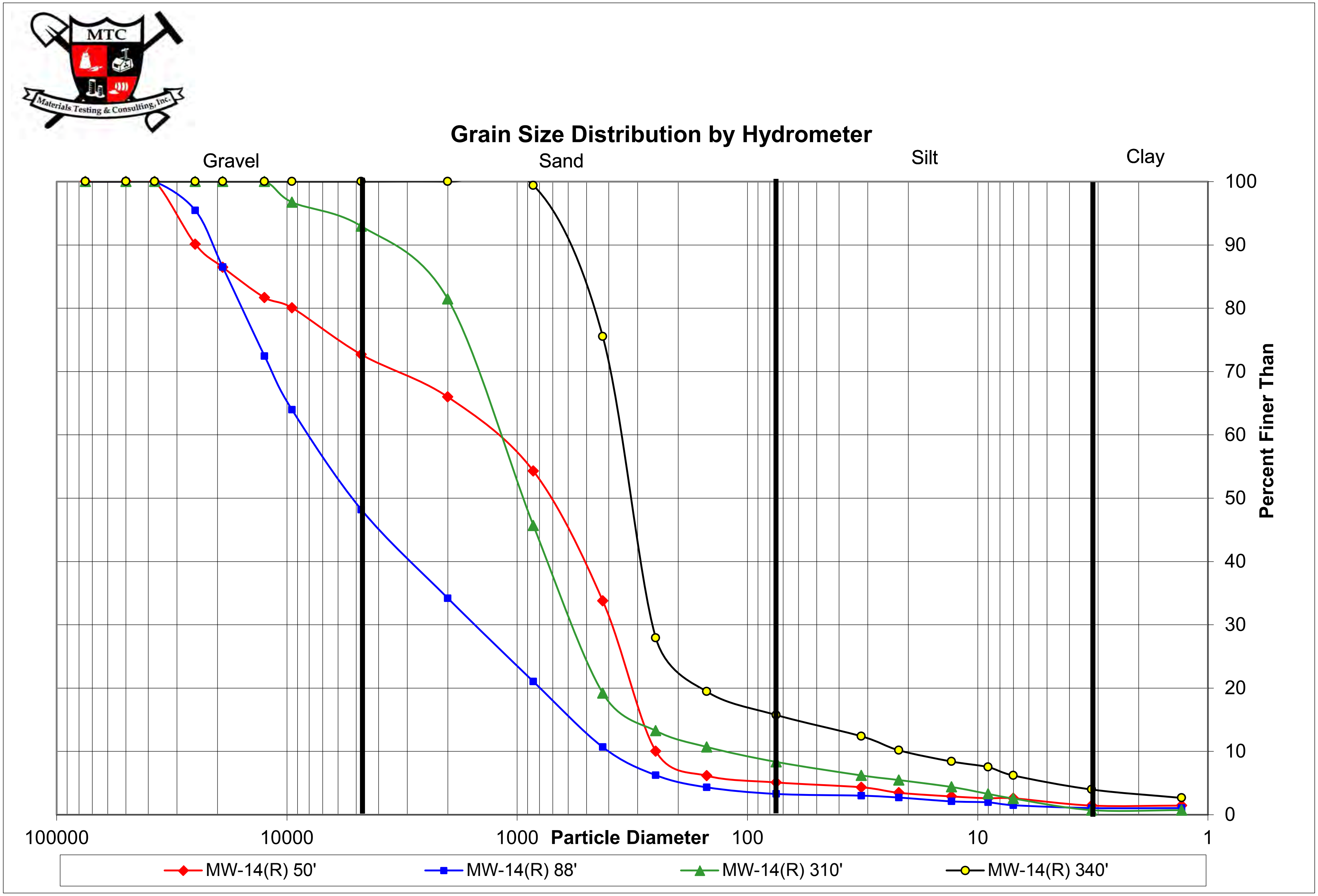
Sample ID	Date Sampled	Date Set up	Date Started	Date Complete	Data Qualifiers
MW-14(R) 130'-132'	Not listed	7/20/2017	7/27/2017	7/31/2017	
	Not listed	7/20/2017	7/27/2017	7/31/2017	
	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-14(R) 50'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-14(R) 88'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-14(R) 310'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-14(R) 340'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-14(R) 380'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-23(Q) 74'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-23(Q) 97'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-23(Q) 109'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-23(Q) 162'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-23(Q) 249'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-23(Q) 275'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-23(Q) 307'	Not listed	7/20/2017	7/27/2017	7/31/2017	
MW-23(Q) 316'	Not listed	7/20/2017	7/27/2017	7/31/2017	

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

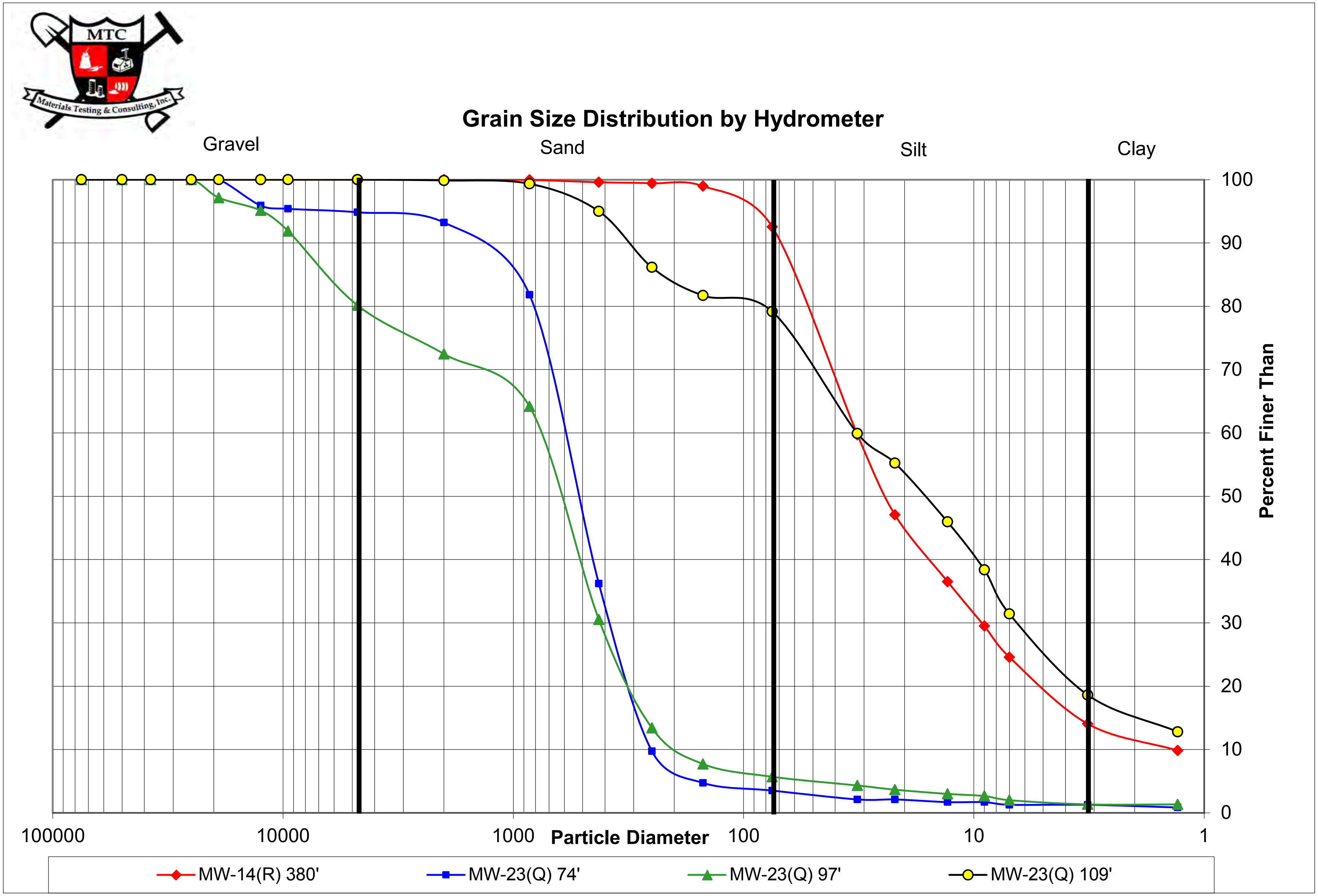
Reviewed by:



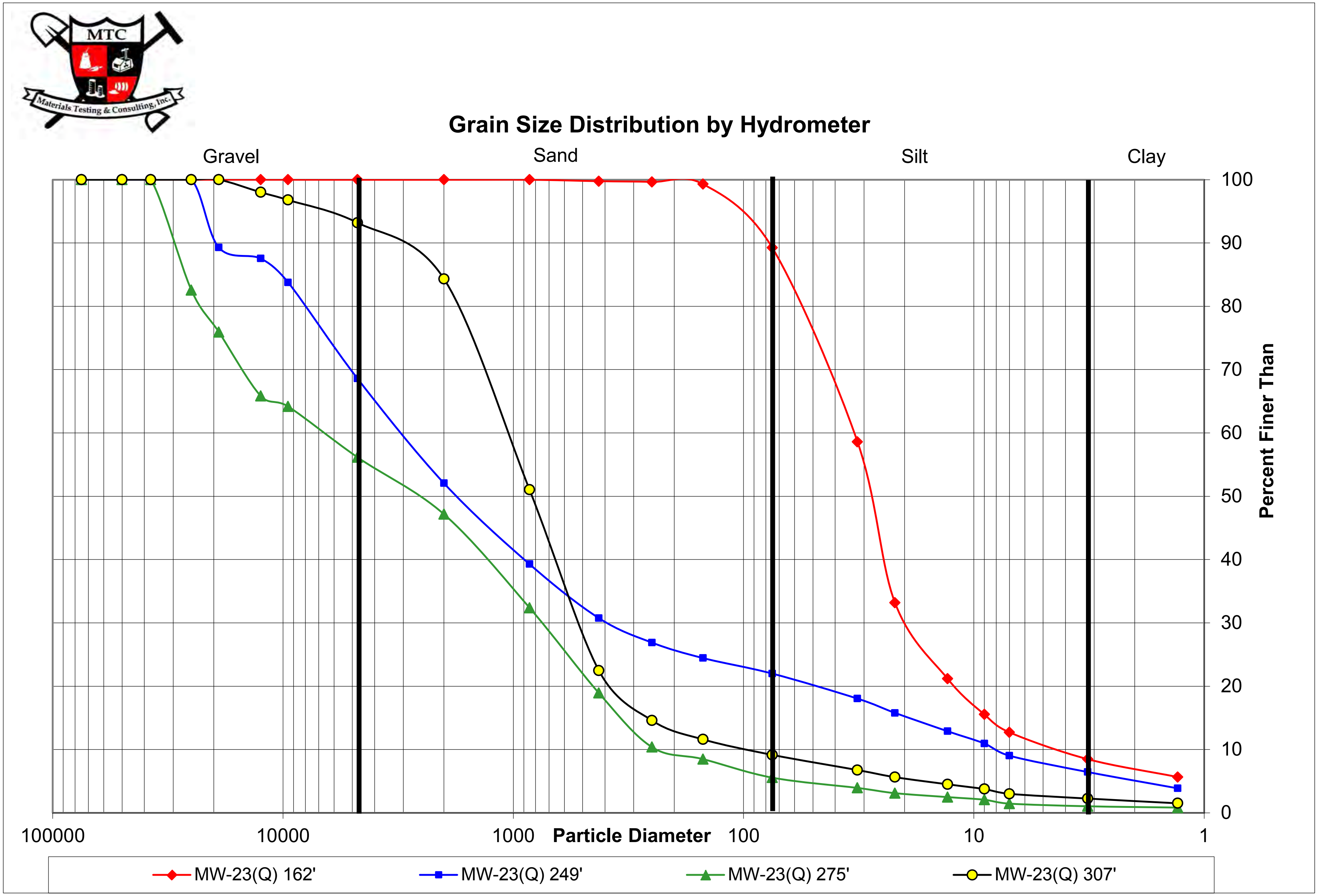
MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-14(R) 130'-132'
MW-14(R) 130'-132'
MW-14(R) 130'-132'



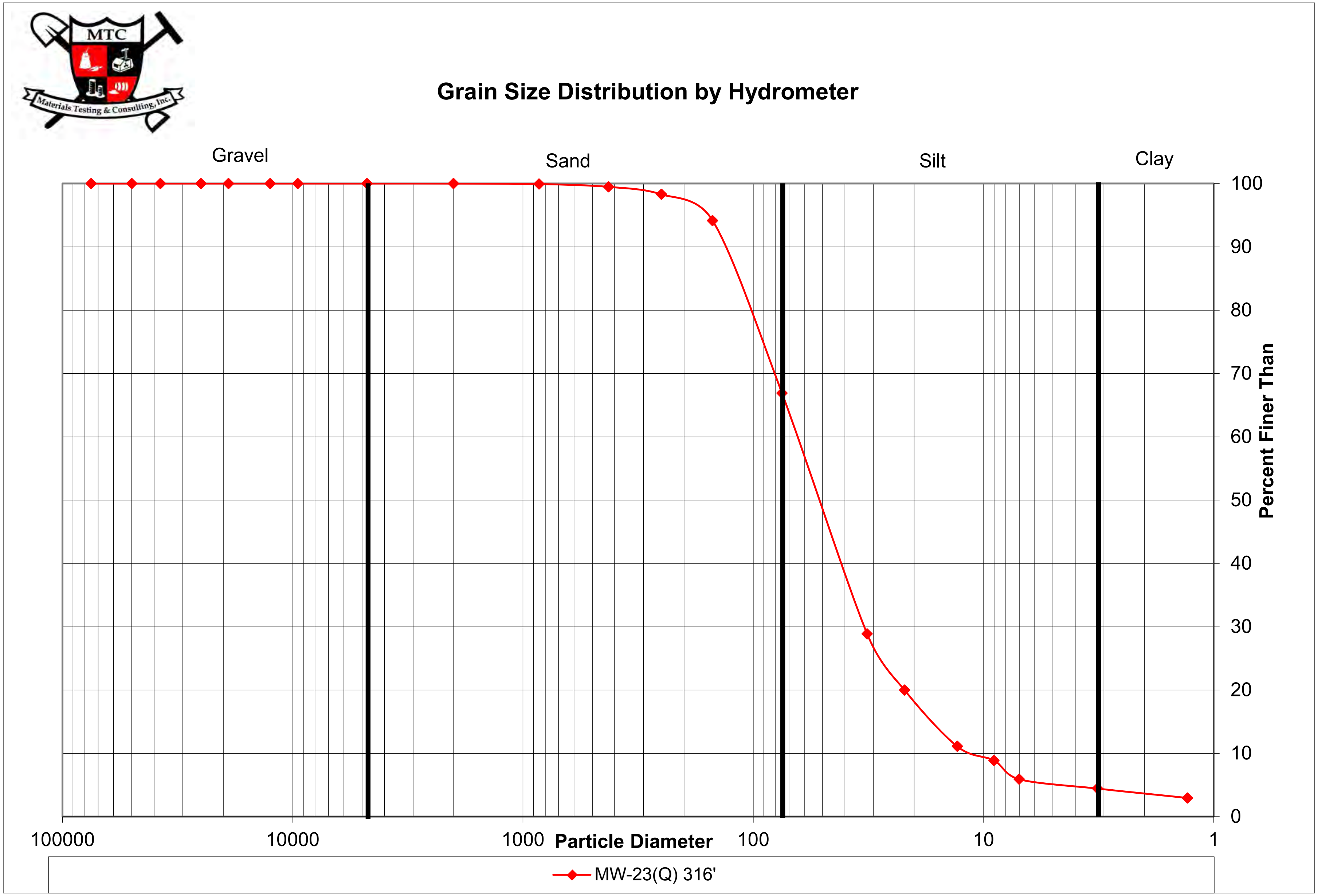
MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-14(R) 50'
MW-14(R) 88'
MW-14(R) 310'
MW-14(R) 340'



MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
Percent Finer Than
100
90
80
70
60
50
40
30
20
10
0
100000
10000
1000
Particle Diameter
100
10
1
MW-14(R) 380'
MW-23(Q) 74'
MW-23(Q) 97'
MW-23(Q) 109'



MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-23(Q) 162'
MW-23(Q) 249'
MW-23(Q) 275'
MW-23(Q) 307'



MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-23(Q) 316'

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project:	LOTT RWIS	**Client:**	HDR
Project #:	17T028		
Date Received:	July 17, 2017	**Sampled by:**	Others
Date Tested:	July 31, 2017	**Tested by:**	B. Goble

Moisture Content - ASTM C-566, ASTM D-2216 & AASHTO T-265

Sample #	Source	Tare	Wet + Tare	Dry + Tare	Wgt. Of Moisture	Wgt. Of Soil	% Moisture
T17-1172-1	MW-23(Q) 74'	103.5	253.1	236.3	16.9	132.8	12.7%
T17-1172-2	MW-23(Q) 74'	109.0	260.8	242.2	18.6	133.2	14.0%
T17-1172-3	MW-23(Q) 74'	102.5	262.4	242.7	19.8	140.2	14.1%
T17-1166	MW-14(R) 50'	99.5	286.1	268.5	17.6	169.0	10.4%
T17-1167	MW-14(R) 88'	109.1	323.6	309.1	14.4	200.1	7.2%
T17-1168	MW-14(R) 130'-132'	103.4	210.4	187.0	23.4	83.7	27.9%
T17-1169	MW-14(R) 310'	103.4	263.2	244.4	18.8	141.0	13.3%
T17-1170	MW-14(R) 340'	113.0	291.5	273.4	18.1	160.4	11.3%
T17-1171	MW-14(R) 380'	102.1	212.4	208.6	3.8	106.5	3.5%
T17-1173	MW-23(Q) 97'	102.7	362.6	343.1	19.5	240.4	8.1%
T17-1174	MW-23(Q) 109'	112.8	217.0	190.8	26.3	77.9	33.7%
T17-1175	MW-23(Q) 162'	103.8	220.1	198.9	21.1	95.2	22.2%
T17-1176	MW-23(Q) 249'	109.3	271.5	258.2	13.3	148.9	8.9%
T17-1177	MW-23(Q) 275'	101.9	315.5	302.8	12.7	200.9	6.3%

Organic Content - ASTM D-2974, AASHTO T-267

Sample #	Source	Tare	Soil + Tare, Pre-Ignition	Soil + Tare, Post Ignition	% Organics
T17-1172-1	MW-23(Q) 74'	103.5	236.3	236.0	0.2%
T17-1172-2	MW-23(Q) 74'	109.0	242.2	241.7	0.4%
T17-1172-3	MW-23(Q) 74'	102.5	242.7	242.2	0.3%
T17-1166	MW-14(R) 50'	99.5	268.5	268.1	0.2%
T17-1167	MW-14(R) 88'	109.1	309.1	308.5	0.3%
T17-1168	MW-14(R) 130'-132'	103.4	187.0	186.5	0.6%
T17-1169	MW-14(R) 310'	103.4	244.4	244.1	0.2%
T17-1170	MW-14(R) 340'	113.0	273.4	272.6	0.5%
T17-1171	MW-14(R) 380'	102.1	208.6	208.2	0.4%
T17-1173	MW-23(Q) 97'	102.7	343.1	342.5	0.2%
T17-1174	MW-23(Q) 109'	112.8	190.8	189.6	1.5%
T17-1175	MW-23(Q) 162'	103.8	198.9	198.4	0.6%
T17-1176	MW-23(Q) 249'	109.3	258.2	257.7	0.3%
T17-1177	MW-23(Q) 275'	101.9	302.8	302.3	0.2%

Reviewed by: E Gabe Goble

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980

Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974

Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project:	LOTT RWIS	**Date Received:**	July 20, 2017
Project #:	17T028	**Sampled By:**	Others
Client :	HDR	**Date Reported:**	August 4, 2017
Source:	Multiple	**Tested By:**	B. Goble, K. DeChurch
MTC Sample#:	Multiple		

CASE NARRATIVE

1. Five samples were submitted for loss on ignition determination according to ASTM D2974, Method A and C.
2. Ten samples were submitted for grain size distribution according to ASTM D422. The samples were prepared according to ASTM D421. One sample from another job was chosen for triplicate analysis. An assumed specific gravity of 2.65 was used in the hydrometer calculations. A standard milkshake mixer type device was used to disperse the fine fraction sample for one minute.
3. The data is provided in summary tables and plots.
4. There were no noted anomalies in this project.

Reviewed by: EGoble Goble

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT RWIS
Project #: 17T028
Date Received: July 20, 2017
Date Tested: August 3, 2017

Client: HDR
Sampled by: Others
Tested by: B. Goble, K. DeChurch

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
MW-21(P) Qc 256-258	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.4	84.3	42.6	16.8	7.9	5.3	4.4	4.0	3.5	3.5	2.6	1.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.2	43.4	16.9	7.6	5.3	4.4	4.4	4.0	3.1	1.8	1.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	84.9	43.6	17.4	7.9	5.7	4.8	4.4	4.0	3.5	1.3	0.9
MW-21(P) Qva 54-56	100.0	100.0	100.0	93.6	81.9	62.7	54.1	40.4	30.0	20.5	9.2	3.2	2.1	1.6	1.5	1.2	1.1	1.1	1.1	0.5	0.5
MW-21(P) Qva 136-138	100.0	100.0	100.0	100.0	100.0	100.0	99.2	98.4	97.8	89.8	37.6	15.0	11.3	9.7	8.6	7.7	7.3	6.4	5.6	3.0	1.7
MW-21(P) Qf 148-150	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	98.8	94.7	82.1	51.5	26.0	18.4	13.0	9.9	7.7	3.1	3.1
MW-21(P) Qf 186-188	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.8	96.5	93.6	81.6	49.5	23.7	10.0	5.5	3.8	3.4	3.0	2.5	0.8	0.8
MW-21(P) Qc 228-230	100.0	100.0	100.0	88.5	82.0	73.6	70.5	59.0	38.5	20.2	9.5	4.7	3.3	2.5	2.2	1.7	1.4	1.4	1.0	0.3	0.3
MW-25(K) Qva 148-150	100.0	100.0	100.0	76.8	71.0	63.4	60.0	47.5	29.4	16.9	9.4	5.7	4.0	2.9	2.7	2.1	1.7	1.3	1.0	0.5	0.4
MW-25(K) Qva 166-168	100.0	100.0	100.0	100.0	100.0	94.8	89.6	76.6	53.1	38.0	22.3	11.4	6.8	4.5	3.6	2.9	2.4	1.9	1.4	0.5	0.5
MW-25(K) Qf 171-172	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	91.1	49.5	18.7	7.6	4.5	3.6	2.7	2.7	2.2	0.0	0.0
MW-25(K) Qf 179-180	100.0	100.0	100.0	91.5	89.2	70.1	63.3	52.5	42.4	34.2	28.1	24.0	20.9	17.5	13.1	11.1	8.7	7.2	6.8	4.2	2.4

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by:

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT RWIS
Project #: 17T028
Date Received: July 20, 2017
Date Tested: August 3, 2017

Client: HDR
Sampled by: Others
Tested by: B. Goble, K. DeChurch

Percent Retained in Each Size Fraction

Description	% Coarse Gravel				% Gravel			% Coarse Sand	% Medium Sand		% Fine Sand			% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay	
Particle Size (microns)	3-2"	2-1 1/2"	1 1/2"-1"	1-3/4"	3/4-1/2"	1/2-3/8"	3/8"-4750	4750-2000	2000-850	850-425	425-250	250-150	150-75	75-32	32-22	22-13	13-9	9-7	7-3.2	3.2-1.3	<1.3
MW-21(P) Qc 256-258	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	15.1	41.7	25.7	9.0	2.6	0.9	0.4	0.4	0.0	0.9	0.9	1.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	15.2	40.8	26.4	9.3	2.4	0.9	0.0	0.4	0.9	1.3	0.4	1.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	14.6	41.2	26.3	9.5	2.2	0.9	0.4	0.4	0.4	2.2	0.4	0.9
MW-21(P) Qva 54-56	0.0	0.0	6.4	11.7	19.1	8.7	13.6	10.4	9.5	11.3	5.9	1.2	0.5	0.1	0.3	0.1	0.0	0.0	0.5	0.0	0.5
MW-21(P) Qva 136-138	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.6	8.0	52.3	22.6	3.7	1.6	1.2	0.9	0.4	0.9	0.9	2.6	1.3	1.7
MW-21(P) Qf 148-150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.1	4.1	12.7	30.6	25.5	7.7	5.4	3.1	2.3	4.6	0.0	3.1
MW-21(P) Qf 186-188	0.0	0.0	0.0	0.0	0.0	0.0	1.2	2.3	2.9	12.1	32.0	25.8	13.7	4.5	1.7	0.4	0.4	0.4	1.7	0.0	0.8
MW-21(P) Qc 228-230	0.0	0.0	11.5	6.5	8.5	3.1	11.5	20.5	18.3	10.7	4.7	1.4	0.8	0.3	0.5	0.3	0.0	0.3	0.7	0.0	0.3
MW-25(K) Qva 148-150	0.0	0.0	23.2	5.7	7.6	3.4	12.6	18.0	12.6	7.4	3.8	1.7	1.1	0.2	0.6	0.4	0.4	0.3	0.5	0.1	0.4
MW-25(K) Qva 166-168	0.0	0.0	0.0	0.0	5.2	5.2	13.1	23.5	15.1	15.7	10.8	4.6	2.3	1.0	0.7	0.5	0.5	0.5	1.0	0.0	0.5
MW-25(K) Qf 171-172	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	8.7	41.6	30.8	11.1	3.2	0.9	0.9	0.0	0.4	2.2	0.0	0.0
MW-25(K) Qf 179-180	0.0	0.0	8.5	2.4	19.1	6.7	10.8	10.1	8.1	6.1	4.1	3.0	3.4	4.4	2.0	2.4	1.6	0.4	2.6	1.8	2.4

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT RWIS **Client:** HDR
Project #: 17T028
Date Received: July 20, 2017 **Sampled by:** Others
Date Tested: August 3, 2017 **Tested by:** B. Goble, K. DeChurch

Relative Standard Deviation, By Size

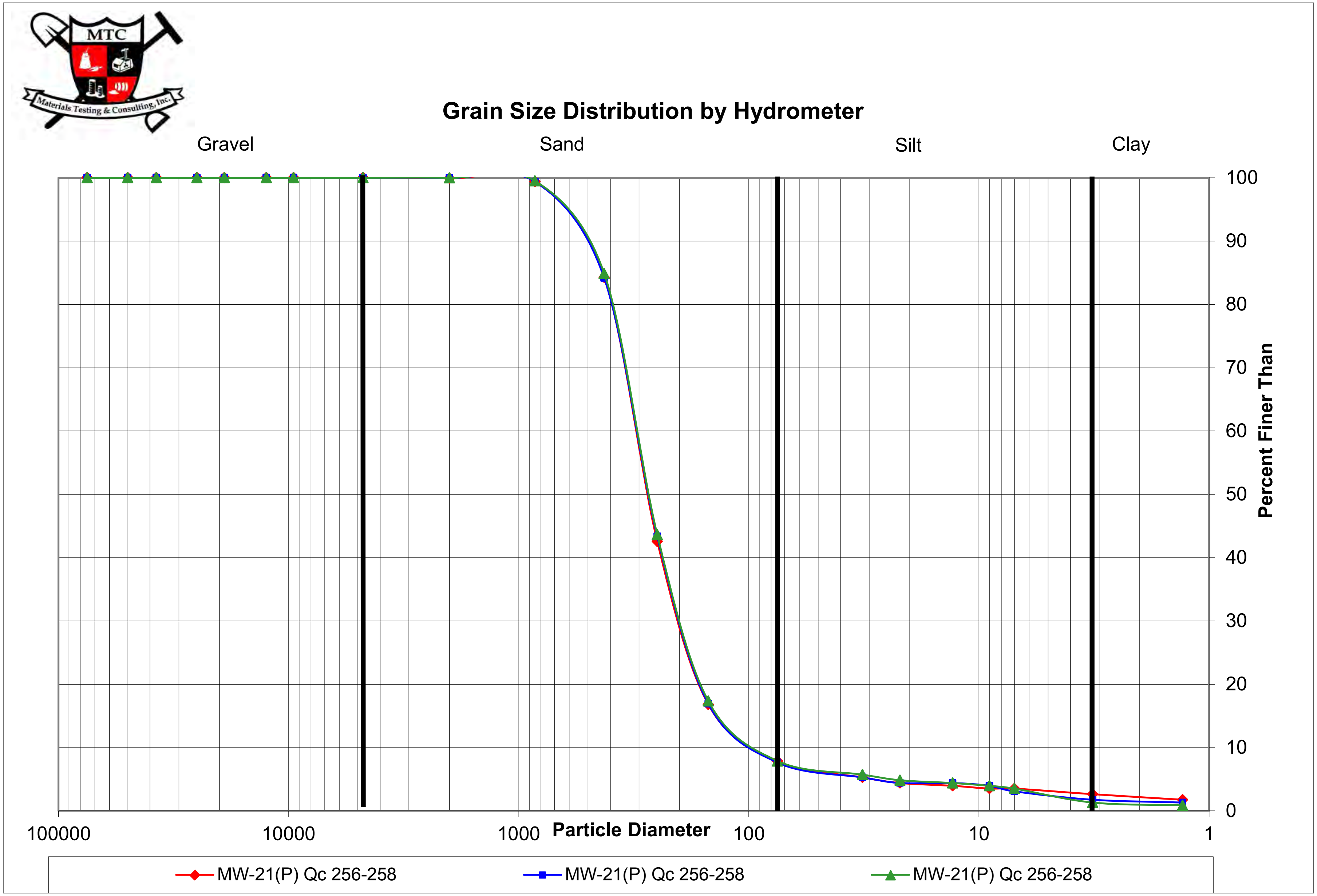
Sample ID	75000	50000	37500	25000	19000	12500	9500	4750	2000	850	425	250	150	75	32	22	13	9	7	3.2	1.3
MW-21(P) Qc 256-258	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.4	84.3	42.6	16.8	7.9	5.3	4.4	4.0	3.5	3.5	2.6	1.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.2	43.4	16.9	7.6	5.3	4.4	4.4	4.0	3.1	1.8	1.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	84.9	43.6	17.4	7.9	5.7	4.8	4.4	4.0	3.5	1.3	0.9
AVE	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.4	43.2	17.0	7.8	5.4	4.6	4.3	3.8	3.4	1.9	1.3
STDEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.5	0.4
%RSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	1.1	1.4	1.4	3.8	4.6	4.9	5.4	6.2	28.8	27.2

This Triplicate applies to the Batch Containing the Following Samples

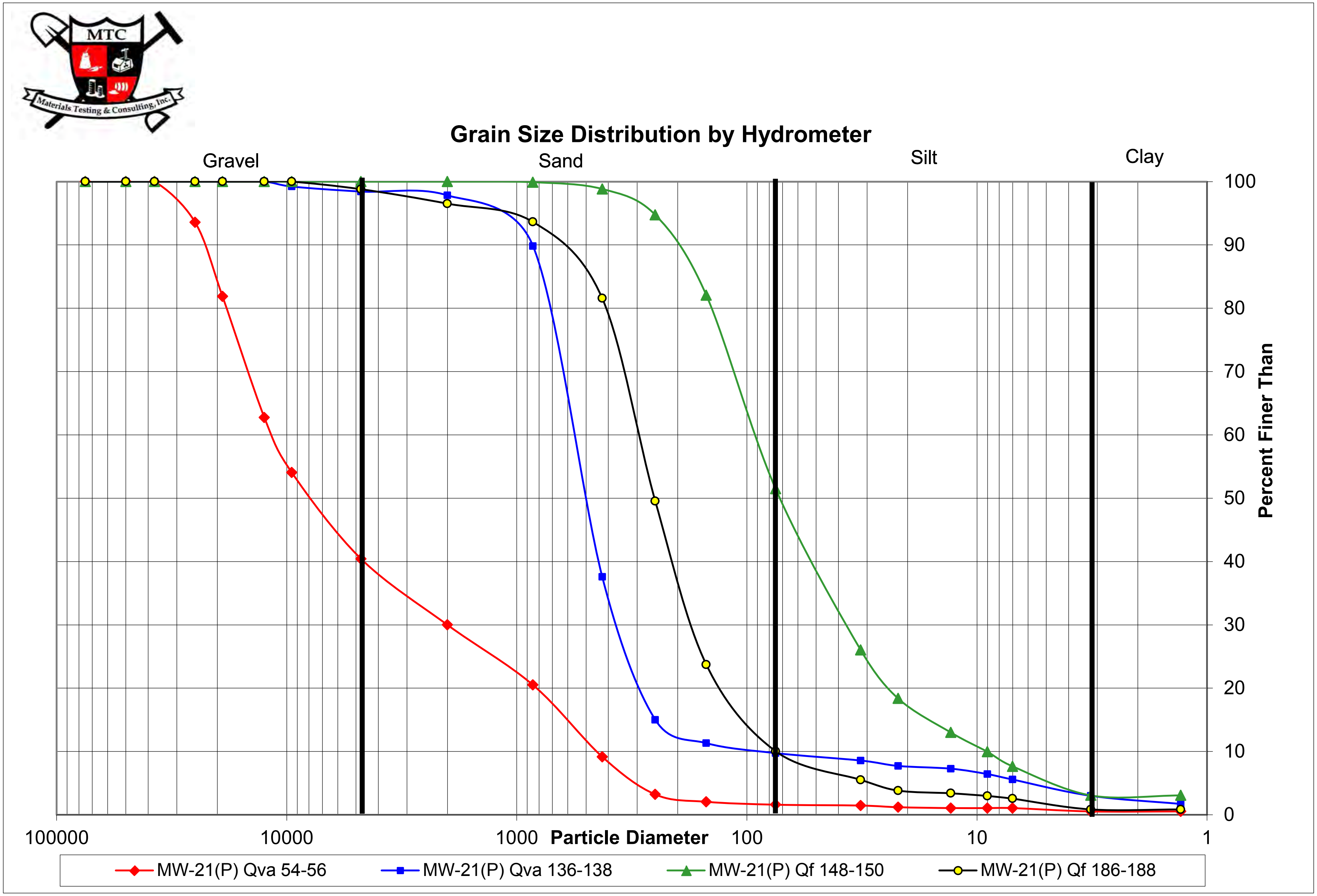
Sample ID	Date Sampled	Date Set up	Date Started	Date Complete	Data Qualifiers
MW-21(P) Qc 256-258	Not Listed	7/26/2017	8/1/2017	8/3/2017	
	Not Listed	7/26/2017	8/1/2017	8/3/2017	
	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-21(P) Qva 54-56	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-21(P) Qva 136-138	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-21(P) Qf 148-150	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-21(P) Qf 186-188	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-21(P) Qc 228-230	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-25(K) Qva 148-150	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-25(K) Qva 166-168	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-25(K) Qf 171-172	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-25(K) Qf 179-180	Not Listed	7/26/2017	8/1/2017	8/3/2017	

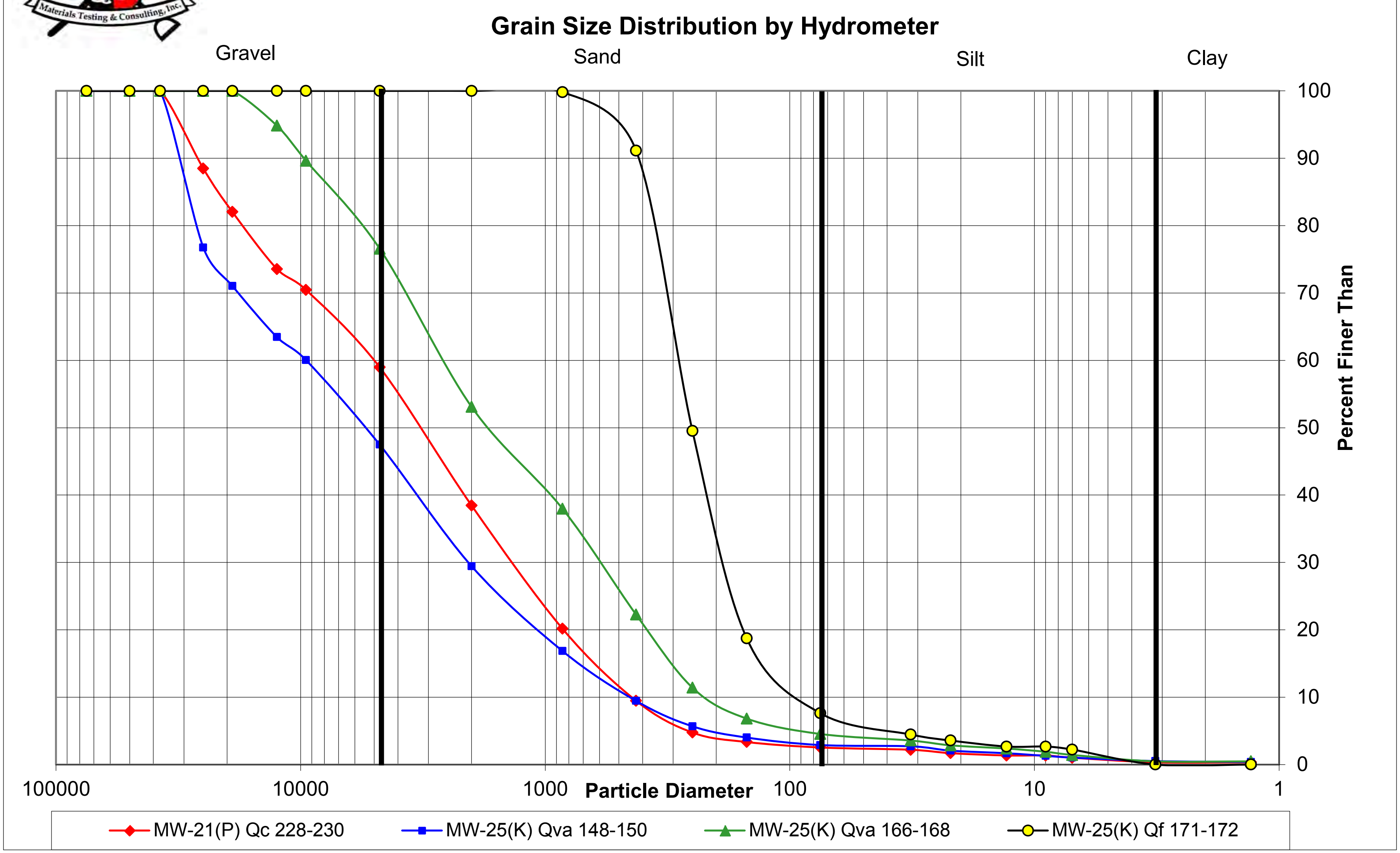
Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: EGoble

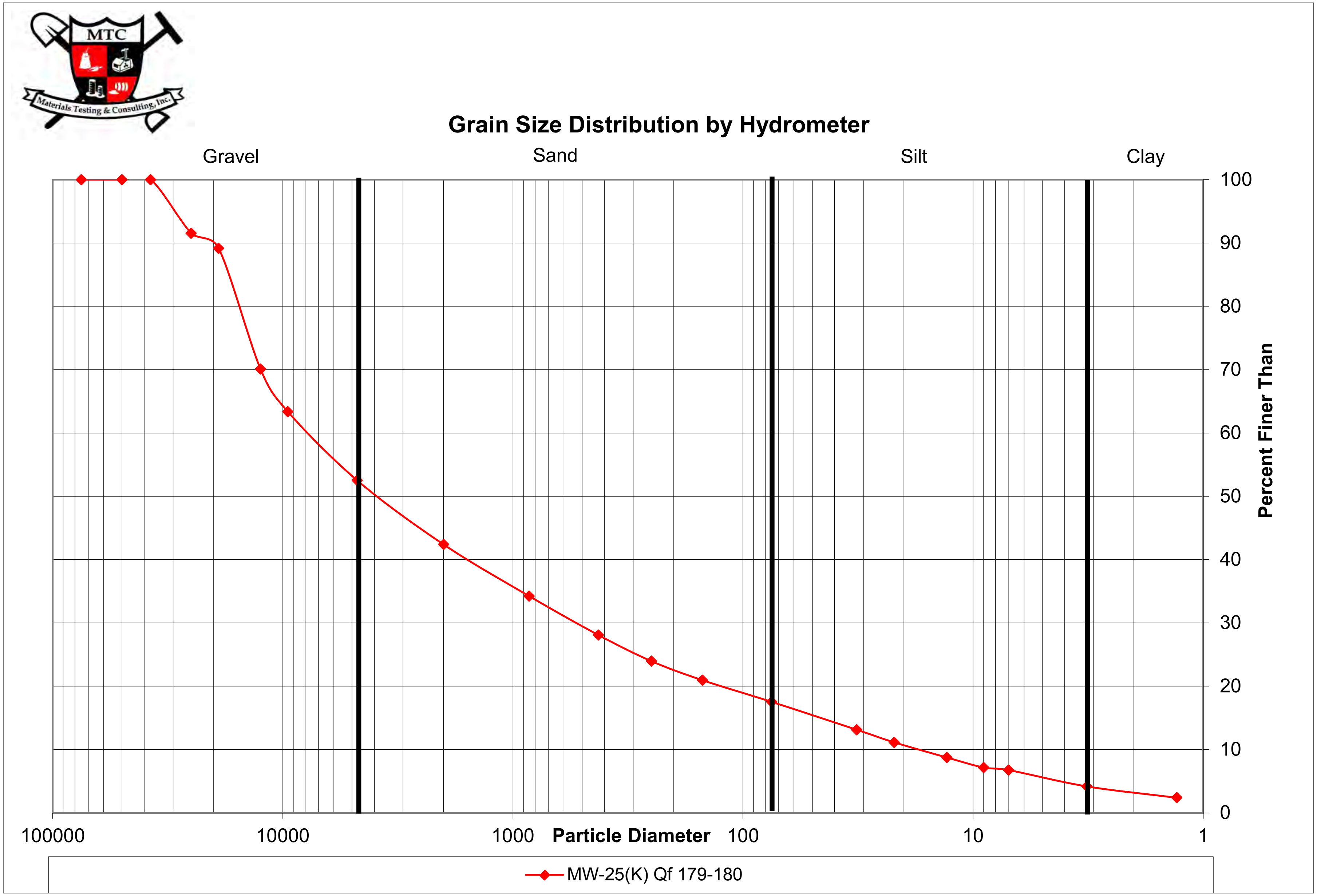


MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-21(P) Qc 256-258
MW-21(P) Qc 256-258
MW-21(P) Qc 256-258


MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
Percent Finer Than
Particle Diameter
100000
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
MW-21(P) Qva 54-56
MW-21(P) Qva 136-138
MW-21(P) Qf 148-150
MW-21(P) Qf 186-188



Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-21(P) Qc 228-230
MW-25(K) Qva 148-150
MW-25(K) Qva 166-168
MW-25(K) Qf 171-172



MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-25(K) Qf 179-180

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT RWIS
Client: HDR
Project #: 17T028
Date Received: July 20, 2017
Sampled by: Others
Date Tested: August 3, 2017
Tested by: B. Goble

Moisture Content - ASTM D2216

Sample #	Source	Tare	Wet + Tare	Dry + Tare	Wgt. Of Moisture	Wgt. Of Soil	% Moisture
T17-1208	MW-21(P) Qva 136-138	101.7	275.3	261.2	14.1	159.6	8.8%
T17-1209	MW-21(P) Qf 148-150	117.4	281.7	251.7	30.0	134.3	22.3%
T17-1211	MW-21(P) Qc 228-230	107.2	347.7	342.7	5.1	235.4	2.2%
T17-1214	MW-25(K) Qva 166-168	103.1	297.2	281.9	15.3	178.9	8.6%
T17-1216	MW-25(K) Qf 179-180	103.9	308.0	299.4	8.6	195.5	4.4%

Organic Content - ASTM D2974

Sample #	Source	Tare	Soil + Tare, Pre-Ignition	Soil + Tare, Post Ignition	% Organics
T17-1208	MW-21(P) Qva 136-138	101.7	261.2	260.4	0.5%
T17-1209	MW-21(P) Qf 148-150	117.4	251.7	250.7	0.7%
T17-1211	MW-21(P) Qc 228-230	107.2	342.7	341.7	0.4%
T17-1214	MW-25(K) Qva 166-168	103.1	281.9	281.2	0.4%
T17-1216	MW-25(K) Qf 179-180	103.9	299.4	298.6	0.4%

Reviewed by: Egabe Goble

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980

Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974

Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project:	LOTT Hawks Prairie	**Date Received:**	July 28, 2017
Project #:	17T028-01	**Sampled By:**	Client
Client :	HDR	**Date Reported:**	August 9, 2017
Source:	Multiple	**Tested By:**	B. Goble
MTC Sample#:	Multiple		

CASE NARRATIVE

1. Four samples were submitted for loss on ignition determination according to ASTM D2974, Method A and C.
2. Eight samples were submitted for grain size distribution according to ASTM D422. The samples were prepared according to ASTM D421. One sample from another job was chosen for triplicate analysis. An assumed specific gravity of 2.65 was used in the hydrometer calculations. A standard milkshake mixer type device was used to disperse the fine fraction sample for one minute.
5. The data is provided in summary tables and plots.
6. There were no noted anomalies in this project.

Reviewed by: E Gabe Goble

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT Hawks Prairie
Project #: 17T028-01
Date Received: July 28, 2017
Date Tested: August 9, 2017

Client: HDR
Sampled by: Client
Tested by: B. Goble

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
T17-1212	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.4	84.3	42.6	16.8	7.9	5.3	4.4	4.0	3.5	3.5	2.6	1.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.2	43.4	16.9	7.6	5.3	4.4	4.4	4.0	3.1	1.8	1.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	84.9	43.6	17.4	7.9	5.7	4.8	4.4	4.0	3.5	1.3	0.9
MW-26(J)-75'	100.0	100.0	100.0	94.8	92.3	82.8	78.6	68.6	60.1	54.5	45.4	31.4	19.9	13.0	10.1	8.8	7.5	6.5	5.4	4.2	2.9
MW-26(J)-98'	100.0	100.0	100.0	94.4	94.4	88.3	84.7	76.7	63.6	48.6	35.9	26.3	21.3	17.5	15.1	13.4	12.2	10.2	9.0	6.1	3.5
MW-26(J)-140'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.8	98.7	90.2	60.1	37.0	33.9	24.7	17.7	10.0	5.4
MW-26(J)-145'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.4	98.9	97.3	82.8	43.2	31.6	24.9	20.8	17.4	11.6	8.3
MW-27(E)-72'	100.0	100.0	100.0	100.0	94.5	81.4	71.5	52.8	36.4	22.5	12.3	4.8	3.4	2.8	2.5	2.2	2.2	1.7	1.4	1.1	1.1
MW-27(E)-108'	100.0	100.0	100.0	84.9	81.2	70.3	63.2	49.3	33.7	20.7	8.9	5.4	4.2	3.5	2.9	2.5	2.3	1.9	1.5	1.0	0.7
MW-27(E)-140'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	97.0	62.6	20.2	7.0	5.1	4.2	3.4	2.1	2.1	0.8	0.4
MW-27(E)-145'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.5	98.7	82.3	40.8	19.6	12.3	8.7	7.0	5.2	4.3	3.5	2.2	1.3

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT Hawks Prairie
Project #: 17T028-01
Date Received: July 28, 2017
Date Tested: August 9, 2017

Client: HDR
Sampled by: Client
Tested by: B. Goble

Percent Retained in Each Size Fraction

Description	% Coarse Gravel				% Gravel			% Coarse Sand	% Medium Sand		% Fine Sand			% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay	
Particle Size (microns)	3-2"	2-1 1/2"	1 1/2"-1"	1-3/4"	3/4-1/2"	1/2-3/8"	3/8"-4750	4750-2000	2000-850	850-425	425-250	250-150	150-75	75-32	32-22	22-13	13-9	9-7	7-3.2	3.2-1.3	<1.3
T17-1212	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	15.1	41.7	25.7	9.0	2.6	0.9	0.4	0.4	0.0	0.9	0.9	1.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	15.2	40.8	26.4	9.3	2.4	0.9	0.0	0.4	0.9	1.3	0.4	1.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	14.6	41.2	26.3	9.5	2.2	0.9	0.4	0.4	0.4	2.2	0.4	0.9
MW-26(J)-75'	0.0	0.0	5.2	2.4	9.6	4.2	10.0	8.5	5.6	9.1	13.9	11.5	6.9	2.9	1.3	1.3	1.0	1.0	1.3	1.3	2.9
MW-26(J)-98'	0.0	0.0	5.6	0.0	6.0	3.7	8.0	13.1	15.0	12.7	9.5	5.0	3.8	2.4	1.7	1.2	2.0	1.2	2.9	2.6	3.5
MW-26(J)-140'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	1.1	8.5	30.1	23.1	3.1	9.2	6.9	7.7	4.6	5.4
MW-26(J)-145'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.5	1.6	14.5	39.6	11.6	6.6	4.2	3.3	5.8	3.3	8.3
MW-27(E)-72'	0.0	0.0	0.0	5.5	13.1	9.9	18.7	16.4	14.0	10.2	7.5	1.4	0.6	0.3	0.3	0.0	0.5	0.3	0.3	0.0	1.1
MW-27(E)-108'	0.0	0.0	15.1	3.6	10.9	7.2	13.8	15.6	13.0	11.8	3.5	1.1	0.8	0.5	0.4	0.1	0.4	0.4	0.4	0.3	0.7
MW-27(E)-140'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.9	34.4	42.5	13.2	1.9	0.8	0.8	1.3	0.0	1.3	0.4	0.4
MW-27(E)-145'	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.8	16.4	41.5	21.2	7.3	3.6	1.7	1.7	0.9	0.9	1.3	0.9	1.3

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT Hawks Prairie
Project #: 17T028-01
Date Received: July 28, 2017
Date Tested: August 9, 2017

Client: HDR
Sampled by: Client
Tested by: B. Goble

Relative Standard Deviation, By Size

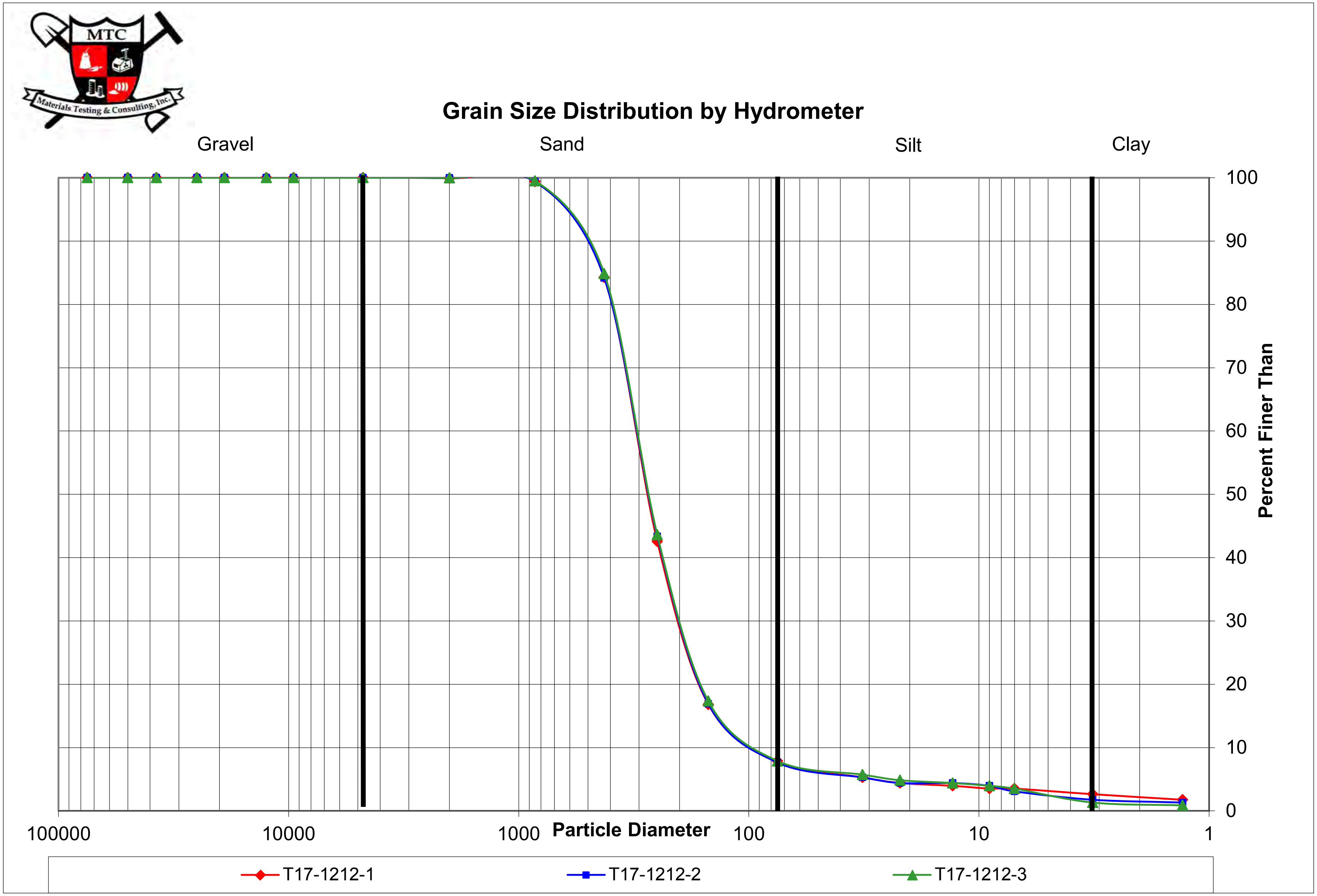
Sample ID	75000	50000	37500	25000	19000	12500	9500	4750	2000	850	425	250	150	75	32	22	13	9	7	3.2	1.3
T17-1212	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.4	84.3	42.6	16.8	7.9	5.3	4.4	4.0	3.5	3.5	2.6	1.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.2	43.4	16.9	7.6	5.3	4.4	4.4	4.0	3.1	1.8	1.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	84.9	43.6	17.4	7.9	5.7	4.8	4.4	4.0	3.5	1.3	0.9
AVE	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.4	43.2	17.0	7.8	5.4	4.6	4.3	3.8	3.4	1.9	1.3
STDEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.5	0.4
%RSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	1.1	1.4	1.4	3.8	4.6	4.9	5.4	6.2	28.8	27.2

This Triplicate applies to the Batch Containing the Following Samples

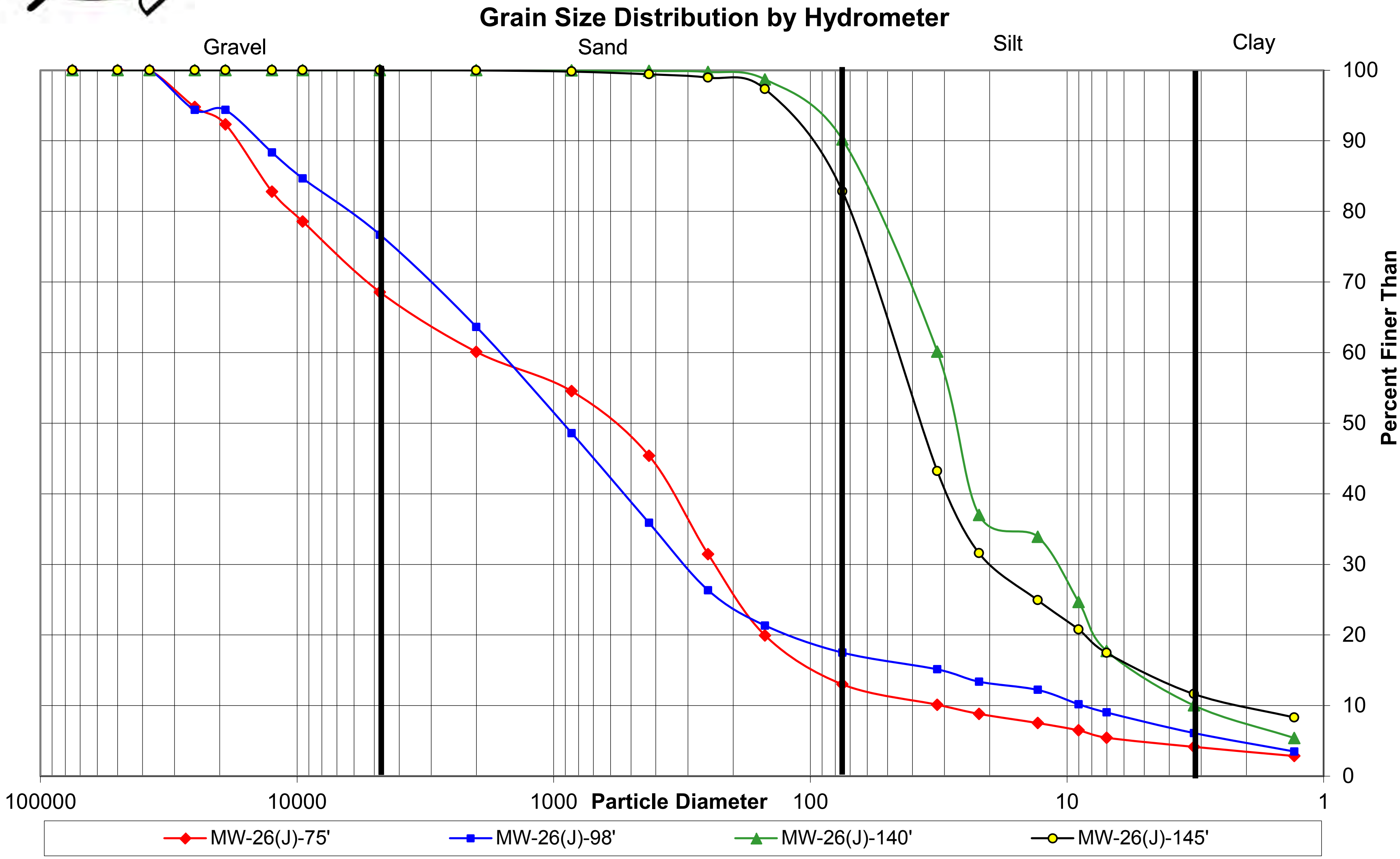
Sample ID	Date Sampled	Date Set up	Date Started	Date Complete	Data Qualifiers
T17-1212	Not Listed	7/26/2017	8/1/2017	8/3/2017	
	Not Listed	7/26/2017	8/1/2017	8/3/2017	
	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-26(J)-75'	Not Listed	8/27/2017	8/7/2017	8/9/2017	
MW-26(J)-98'	Not Listed	8/27/2017	8/7/2017	8/9/2017	
MW-26(J)-140'	Not Listed	8/27/2017	8/7/2017	8/9/2017	
MW-26(J)-145'	Not Listed	8/27/2017	8/7/2017	8/9/2017	
MW-27(E)-72'	Not Listed	8/27/2017	8/7/2017	8/9/2017	
MW-27(E)-108'	Not Listed	8/27/2017	8/7/2017	8/9/2017	
MW-27(E)-140'	Not Listed	8/27/2017	8/7/2017	8/9/2017	
MW-27(E)-145'	Not Listed	8/27/2017	8/7/2017	8/9/2017	

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

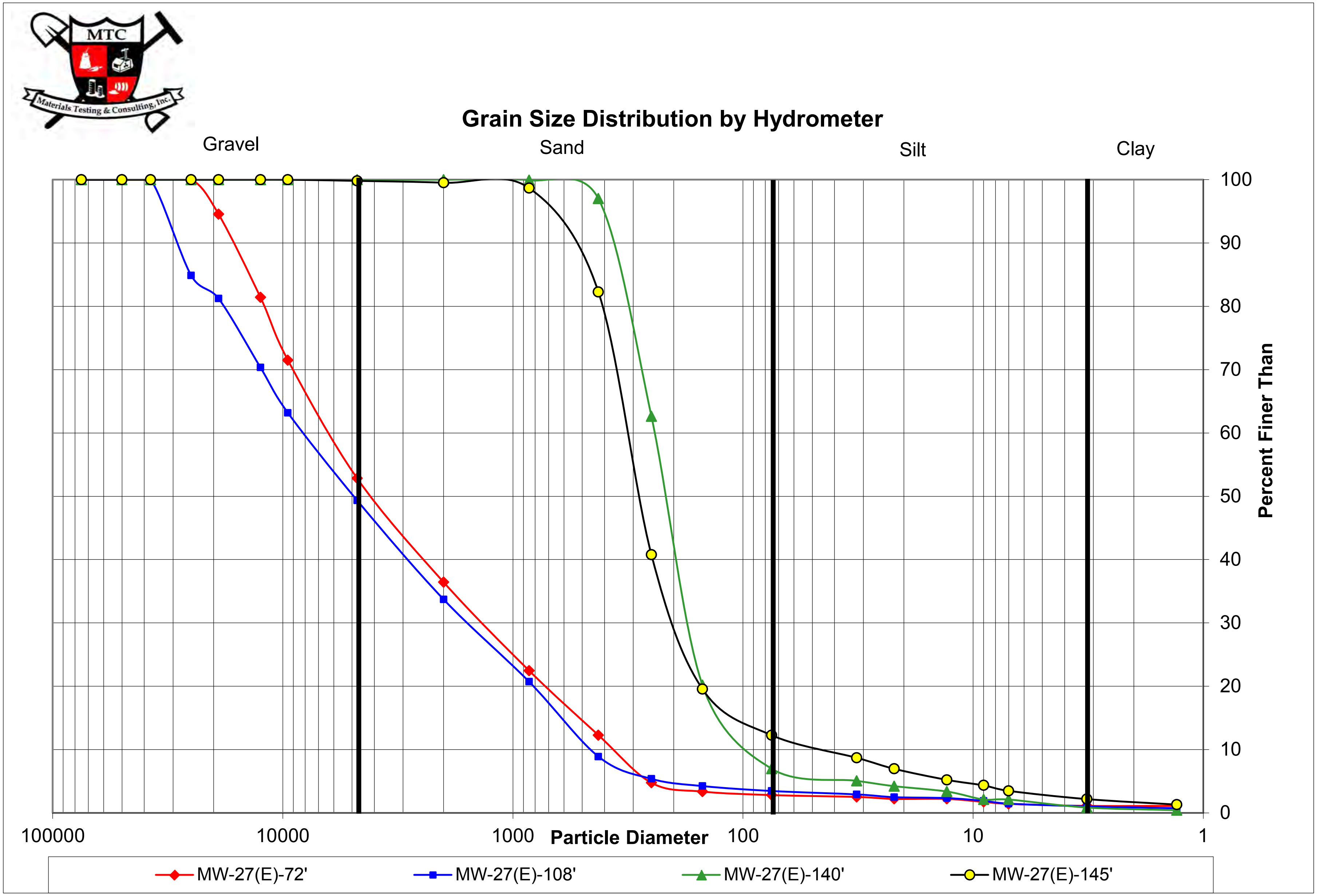
Reviewed by: ______________________



Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
T17-1212-1
T17-1212-2
T17-1212-3



Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-26(J)-75'
MW-26(J)-98'
MW-26(J)-140'
MW-26(J)-145'


MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
Percent Finer Than
Particle Diameter
100000
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
MW-27(E)-72'
MW-27(E)-108'
MW-27(E)-140'
MW-27(E)-145'

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT Hawks Prairie
Project #: 17T028-01
Date Received: July 28, 2017
Date Tested: August 9, 2017

Client: HDR
Sampled by: Client
Tested by: B. Goble

Moisture Content - ASTM D2216

Sample #	Source	Tare	Wet + Tare	Dry + Tare	Wgt. Of Moisture	Wgt. Of Soil	% Moisture
T17-1246-1	MW-27(E)-140'	107.6	262.2	231.4	30.8	123.8	24.9%
T17-1246-2	MW-27(E)-140'	104.5	251.3	221.8	29.5	117.3	25.2%
T17-1246-3	MW-27(E)-140'	105.7	242.0	216.0	26.0	110.3	23.6%
T17-1241	MW-26(J)-98'	108.3	292.0	277.8	14.2	169.6	8.4%
T17-1243	MW-26(J)-145'	107.1	241.9	215.4	26.4	108.3	24.4%
T17-1245	MW-27(E)-108'	107.1	368.4	353.6	14.7	246.5	6.0%

Organic Content - ASTM D2974

Sample #	Source	Tare	Soil + Tare, Pre-Ignition	Soil + Tare, Post Ignition	% Organics
T17-1246-1	MW-27(E)-140'	107.6	231.4	230.9	0.4%
T17-1246-2	MW-27(E)-140'	104.5	221.8	221.4	0.3%
T17-1246-3	MW-27(E)-140'	105.7	216.0	215.5	0.5%
T17-1241	MW-26(J)-98'	108.3	277.8	277.1	0.4%
T17-1243	MW-26(J)-145'	107.1	215.4	213.2	2.1%
T17-1245	MW-27(E)-108'	107.1	353.6	352.9	0.3%

Reviewed by: E Gabe Goble

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project:	LOTT - Hawks Prairie	**Date Received:**	August 7, 2017
Project #:	17T028-01	**Sampled By:**	Client
Client :	HDR	**Date Tested:**	August 14, 2017
Source:	Multiple	**Tested By:**	B. Goble, K. DeChurch
MTC Sample#:	Multiple		

CASE NARRATIVE

1. One sample was submitted for loss on ignition determination according to ASTM D2974, Method A and C.
2. Two samples were submitted for grain size distribution according to ASTM D422. The samples were prepared according to ASTM D421. One sample from another job was chosen for triplicate analysis. An assumed specific gravity of 2.65 was used in the hydrometer calculations. A standard milkshake mixer type device was used to disperse the fine fraction sample for one minute.
3. The data is provided in summary tables and plots.
4. There were no noted anomalies in this project.

Reviewed by: EGable Goble

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980

Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974

Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT - Hawks Prairie
Project #: 17T028-01
Date Received: August 7, 2017
Date Tested: August 14, 2017

Client: HDR
Sampled by: Client
Tested by: B. Goble, K. DeChurch

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
T17-1212	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.4	84.3	42.6	16.8	7.9	5.3	4.4	4.0	3.5	3.5	2.6	1.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.2	43.4	16.9	7.6	5.3	4.4	4.4	4.0	3.1	1.8	1.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	84.9	43.6	17.4	7.9	5.7	4.8	4.4	4.0	3.5	1.3	0.9
MW-28(G)-155'	100.0	100.0	100.0	90.2	65.8	57.4	53.3	45.4	38.8	32.4	26.3	23.4	21.9	20.4	14.7	12.0	9.8	8.4	7.4	5.3	4.1
MW-28(G)-170'	100.0	100.0	100.0	81.1	66.5	56.6	52.6	42.6	33.2	23.4	15.0	11.1	9.0	7.1	5.9	5.2	4.0	3.4	2.8	1.9	1.5

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: EGoble

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT - Hawks Prairie
Project #: 17T028-01
Date Received: August 7, 2017
Date Tested: August 14, 2017

Client: HDR

Sampled by: Client
Tested by: B. Goble, K. DeChurch

Percent Retained in Each Size Fraction

Description	% Coarse Gravel				% Gravel			% Coarse Sand	% Medium Sand		% Fine Sand			% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay	
Particle Size (microns)	3-2"	2-1 1/2"	1 1/2"-1"	1-3/4"	3/4-1/2"	1/2-3/8"	3/8"-4750	4750-2000	2000-850	850-425	425-250	250-150	150-75	75-32	32-22	22-13	13-9	9-7	7-3.2	3.2-1.3	<1.3
T17-1212	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	15.1	41.7	25.7	9.0	2.6	0.9	0.4	0.4	0.0	0.9	0.9	1.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	15.2	40.8	26.4	9.3	2.4	0.9	0.0	0.4	0.9	1.3	0.4	1.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	14.6	41.2	26.3	9.5	2.2	0.9	0.4	0.4	0.4	2.2	0.4	0.9
MW-28(G)-155'	0.0	0.0	9.8	24.4	8.4	4.2	7.8	6.6	6.4	6.2	2.9	1.5	1.5	5.7	2.7	2.2	1.4	1.0	2.1	1.2	4.1
MW-28(G)-170'	0.0	0.0	18.9	14.7	9.9	4.1	10.0	9.3	9.9	8.4	3.9	2.1	1.9	1.1	0.7	1.2	0.6	0.6	0.9	0.4	1.5

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT - Hawks Prairie **Client:** HDR
Project #: 17T028-01
Date Received: August 7, 2017 **Sampled by:** Client
Date Tested: August 14, 2017 **Tested by:** B. Goble, K. DeChurch

Relative Standard Deviation, By Size

Sample ID	75000	50000	37500	25000	19000	12500	9500	4750	2000	850	425	250	150	75	32	22	13	9	7	3.2	1.3
T17-1212	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.4	84.3	42.6	16.8	7.9	5.3	4.4	4.0	3.5	3.5	2.6	1.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.2	43.4	16.9	7.6	5.3	4.4	4.4	4.0	3.1	1.8	1.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	84.9	43.6	17.4	7.9	5.7	4.8	4.4	4.0	3.5	1.3	0.9
AVE	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.4	43.2	17.0	7.8	5.4	4.6	4.3	3.8	3.4	1.9	1.3
STDEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.5	0.4
%RSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	1.1	1.4	1.4	3.8	4.6	4.9	5.4	6.2	28.8	27.2

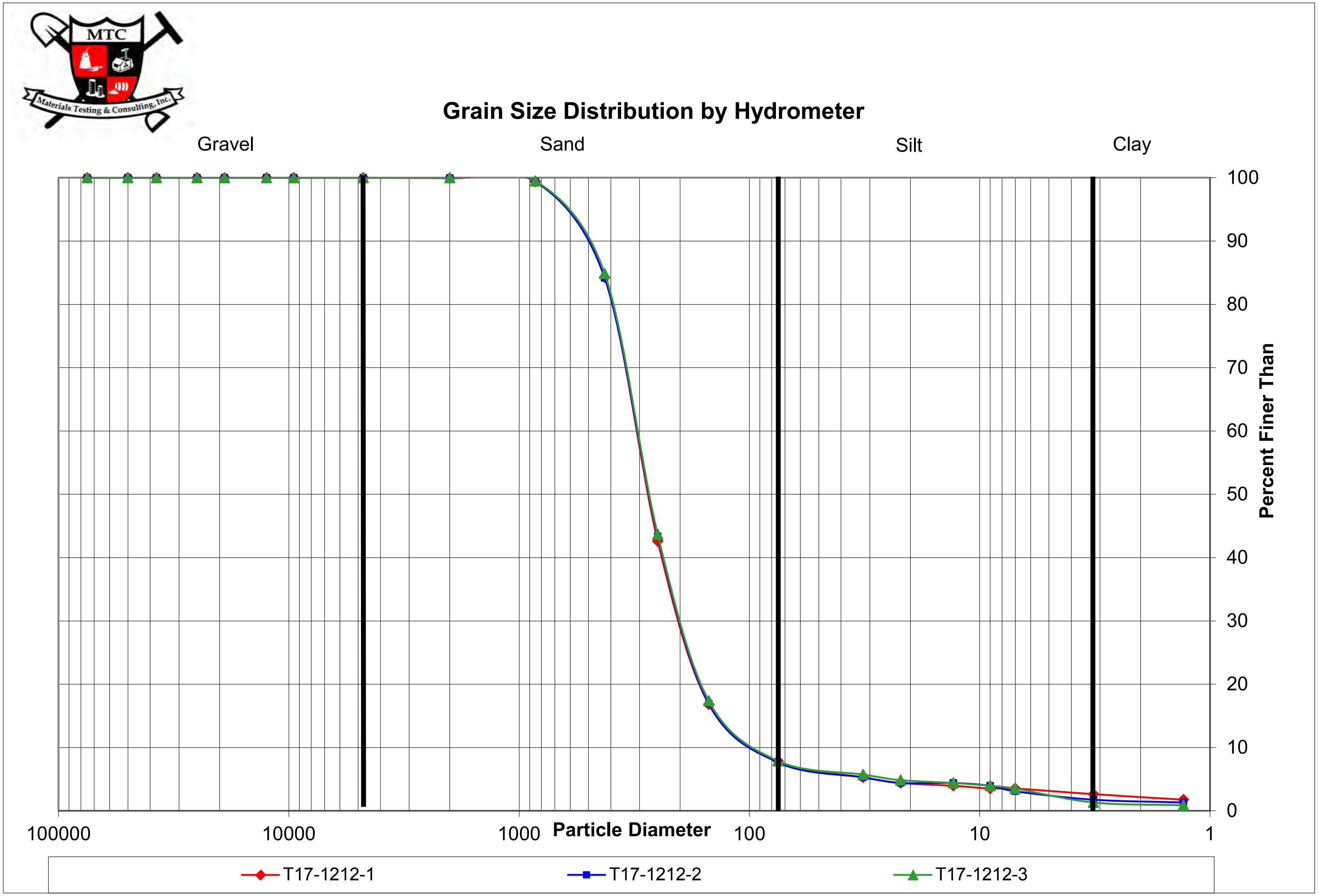
This Triplicate applies to the Batch Containing the Following Samples

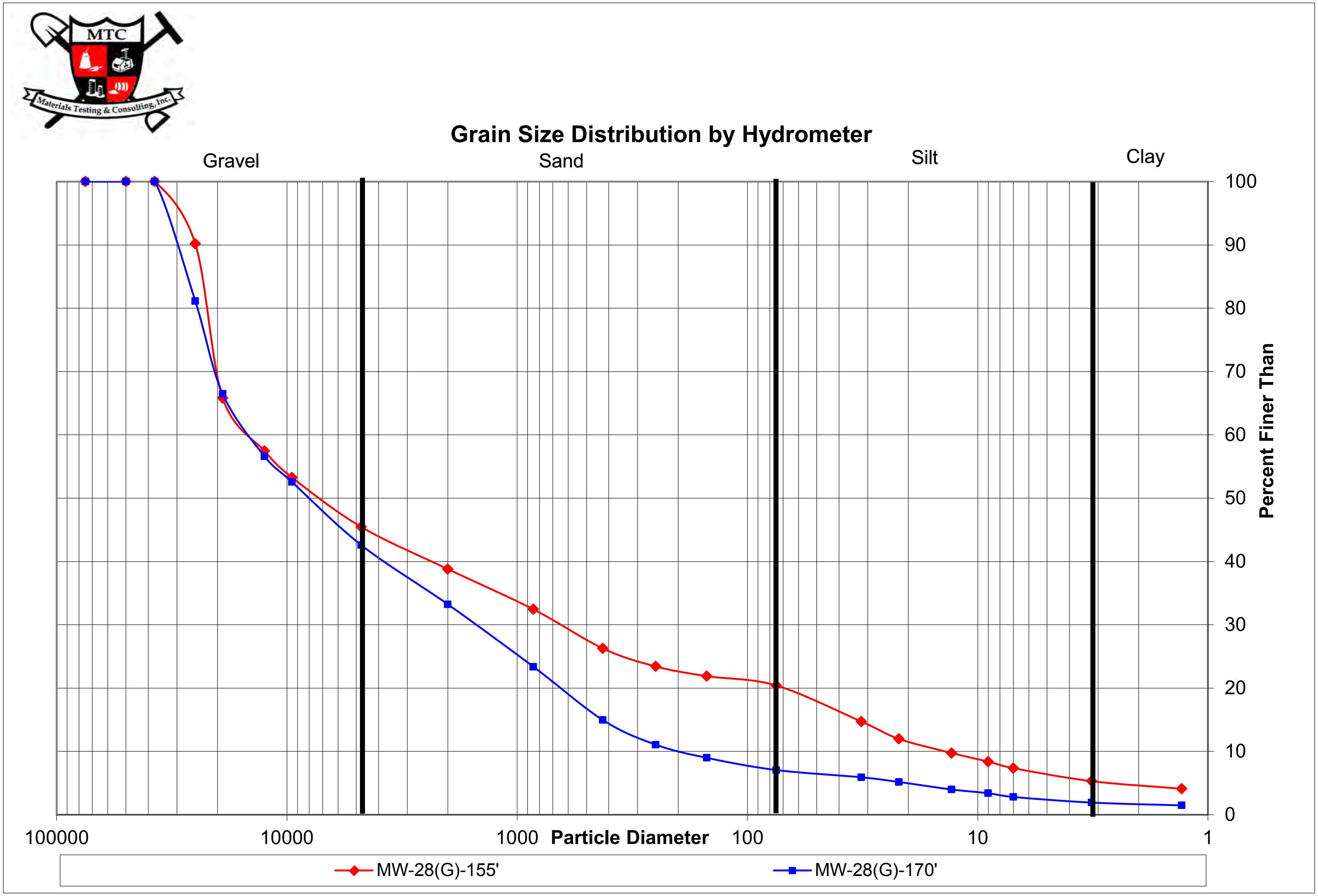
Sample ID	Date Sampled	Date Set up	Date Started	Date Complete	Data Qualifiers
T17-1212	Not Listed	7/26/2017	8/1/2017	8/3/2017	
	Not Listed	7/26/2017	8/1/2017	8/3/2017	
	Not Listed	7/26/2017	8/1/2017	8/3/2017	
MW-28(G)-155'	Not Listed	8/9/2017	8/10/2017	8/14/2017	
MW-28(G)-170'	Not Listed	8/9/2017	8/10/2017	8/14/2017	

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net


MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
T17-1212-1
T17-1212-2
T17-1212-3


Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW-28(G)-155'
MW-28(G)-170'

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project:	LOTT - Hawks Prairie	**Client:**	HDR
Project #:	17T028-01		
Date Received:	August 7, 2017	**Sampled by:**	Client
Date Tested:	August 14, 2017	**Tested by:**	B. Goble

Moisture Content - ASTM D2216

Sample #	Source	Tare	Wet + Tare	Dry + Tare	Wgt. Of Moisture	Wgt. Of Soil	% Moisture
T17-1322	MW-28(G)-170'	106.8	400.6	385.2	15.4	278.4	5.5%

Organic Content - ASTM D2974

Sample #	Source	Tare	Soil + Tare, Pre-Ignition	Soil + Tare, Post Ignition	% Organics
T17-1322	MW-28(G)-170'	106.8	385.2	384.2	0.4%

Reviewed by: E Gabe Goble

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980

Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974

Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project:	LOTT - Hawks Prairie	**Date Received:**	August 11, 2017
Project #:	17T028-01	**Sampled By:**	Client
Client :	HDR	**Date Reported:**	August 23, 2017
Source:	Multiple	**Tested By:**	B. Goble
MTC Sample#:	Multiple		

CASE NARRATIVE

1. Fourteen samples were submitted for grain size distribution according to ASTM D422. The samples were prepared according to ASTM D421.
2. One sample was chosen for triplicate analysis. The triplicate data can be found on the QA summary.
3. An assumed specific gravity of 2.65 was used in the hydrometer calculations.
4. A standard milkshake mixer type device was used to disperse the fine fraction sample for one minute.
5. The data is provided in summary tables and plots.
6. There were no further anomalies in this project.

Reviewed by: E Gabi Goble

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980

Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974

Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT - Hawks Prairie
Project #: 17T028-01
Date Received: August 11, 2017
Date Tested: August 23, 2017

Client: HDR
Sampled by: Client
Tested by: B. Goble

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	3"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
MW15(B1) 20'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.3	97.8	94.1	87.3	80.0	54.1	20.5	15.2	12.9	9.9	9.1	6.1	5.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	98.0	94.1	87.9	81.0	54.9	21.8	15.8	12.8	10.5	8.3	5.3	4.5
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.2	97.3	93.0	85.5	77.5	53.3	24.8	17.3	14.3	12.0	9.8	6.0	5.3
MW15(B1) 30'	100.0	100.0	100.0	96.9	90.1	82.8	76.2	60.5	44.2	25.7	10.6	5.5	4.7	4.3	4.2	3.9	3.7	3.5	3.3	2.7	2.5
MW15(B1) 40'	100.0	100.0	84.1	84.1	84.1	79.2	73.0	59.6	40.9	25.6	12.9	4.6	3.1	2.7	2.3	2.3	2.3	2.3	2.3	1.8	1.6
MW15(B1) 50'	100.0	100.0	100.0	88.4	79.4	76.8	73.3	66.8	60.5	50.0	29.4	12.4	7.6	6.3	5.6	4.8	4.8	4.5	4.0	3.2	2.9
MW15(B1) 60'	100.0	100.0	85.3	63.3	51.5	39.4	33.4	24.2	18.1	14.2	11.9	9.8	8.4	7.1	6.0	5.0	4.4	3.8	3.5	2.3	1.8
MW15(B1) 70'	100.0	100.0	100.0	84.0	77.5	61.0	51.9	37.9	27.6	20.0	14.7	11.2	9.2	7.3	5.6	4.5	4.2	3.8	3.3	2.4	2.1
MW15(B1) 80'	100.0	100.0	100.0	96.0	89.5	75.3	70.2	59.5	47.8	33.3	23.8	18.9	15.9	13.0	12.3	11.5	9.8	9.0	7.7	5.2	4.2
MW16(B2) 20'	100.0	100.0	93.6	80.5	74.5	63.7	58.7	50.6	46.8	41.9	28.7	13.5	9.3	6.8	5.6	5.0	4.4	3.5	2.7	1.7	1.0
MW16(B2) 30'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.8	85.8	46.1	19.4	13.5	11.3	9.8	9.4	8.6	8.1	6.4	5.1	4.7
MW16(B2) 40'	100.0	100.0	100.0	85.7	78.8	63.1	54.2	43.0	34.2	26.5	19.5	10.7	7.9	6.5	6.2	5.7	5.0	4.7	4.3	3.1	2.6
MW16(B2) 50'	100.0	100.0	100.0	93.2	87.0	75.6	68.2	53.0	36.2	18.6	8.5	5.3	4.4	3.7	3.4	3.0	2.8	2.5	2.3	1.7	1.6
MW16(B2) 60'	100.0	100.0	86.0	81.9	72.6	52.7	43.4	30.8	22.3	14.9	11.2	9.0	7.5	6.0	5.5	4.6	3.9	3.3	2.7	2.0	1.8
MW16(B2) 70'	100.0	100.0	90.8	80.7	72.0	57.8	48.9	32.7	21.3	13.2	10.0	8.1	6.7	5.3	4.5	3.9	3.0	2.6	2.4	1.8	1.4
MW16(B2) 80'	100.0	100.0	100.0	89.0	84.1	66.3	59.5	46.9	38.7	29.8	22.6	14.1	8.9	6.9	6.3	5.6	4.6	4.1	3.6	2.5	2.2

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by:

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT - Hawks Prairie
Project #: 17T028-01
Date Received: August 11, 2017
Date Tested: August 23, 2017

Client: HDR

Sampled by: Client
Tested by: B. Goble

Percent Retained in Each Size Fraction

Description	% Coarse Gravel				% Gravel			% Coarse Sand	% Medium Sand		% Fine Sand			% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay	
Particle Size (microns)	3-2"	2-1 1/2"	1 1/2"-1"	1-3/4"	3/4-1/2"	1/2-3/8"	3/8"-4750	4750-2000	2000-850	850-425	425-250	250-150	150-75	75-32	32-22	22-13	13-9	9-7	7-3.2	3.2-1.3	<1.3
MW15(B1) 20'	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6	1.5	3.7	6.7	7.3	25.9	33.6	5.3	2.3	3.0	0.8	3.0	0.8	5.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.5	3.9	6.2	6.9	26.1	33.1	6.0	3.0	2.3	2.3	3.0	0.8	4.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.9	4.3	7.5	8.1	24.1	28.6	7.5	3.0	2.3	2.3	3.8	0.8	5.3
MW15(B1) 30'	0.0	0.0	3.1	6.8	7.3	6.6	15.7	16.3	18.5	15.1	5.1	0.7	0.4	0.1	0.4	0.2	0.2	0.2	0.6	0.2	2.5
MW15(B1) 40'	0.0	15.9	0.0	0.0	4.9	6.2	13.3	18.7	15.3	12.7	8.2	1.6	0.4	0.4	0.0	0.0	0.0	0.0	0.5	0.2	1.6
MW15(B1) 50'	0.0	0.0	11.6	9.1	2.6	3.5	6.5	6.2	10.6	20.6	17.0	4.8	1.4	0.7	0.8	0.0	0.3	0.5	0.8	0.3	2.9
MW15(B1) 60'	0.0	14.7	21.9	11.8	12.2	6.0	9.2	6.1	3.9	2.2	2.1	1.4	1.3	1.1	0.9	0.6	0.6	0.3	1.2	0.5	1.8
MW15(B1) 70'	0.0	0.0	16.0	6.5	16.5	9.1	14.0	10.2	7.7	5.3	3.5	2.0	1.9	1.8	1.1	0.3	0.5	0.5	0.9	0.3	2.1
MW15(B1) 80'	0.0	0.0	4.0	6.5	14.2	5.1	10.8	11.6	14.6	9.5	4.9	3.0	2.9	0.7	0.8	1.7	0.8	1.3	2.5	1.0	4.2
MW16(B2) 20'	0.0	6.4	13.0	6.0	10.9	5.0	8.1	3.8	4.9	13.2	15.2	4.2	2.4	1.2	0.6	0.6	0.8	0.8	1.0	0.6	1.0
MW16(B2) 30'	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	12.0	39.7	26.7	5.9	2.2	1.5	0.4	0.9	0.4	1.7	1.3	0.4	4.7
MW16(B2) 40'	0.0	0.0	14.3	6.8	15.7	8.9	11.2	8.8	7.7	7.0	8.9	2.7	1.4	0.3	0.5	0.7	0.3	0.3	1.2	0.5	2.6
MW16(B2) 50'	0.0	0.0	6.8	6.2	11.4	7.5	15.1	16.9	17.6	10.0	3.2	1.0	0.7	0.3	0.5	0.2	0.3	0.2	0.6	0.2	1.6
MW16(B2) 60'	0.0	14.0	4.1	9.3	19.9	9.3	12.7	8.5	7.4	3.7	2.1	1.5	1.5	0.4	0.9	0.7	0.6	0.6	0.7	0.2	1.8
MW16(B2) 70'	0.0	9.2	10.1	8.6	14.3	8.8	16.2	11.4	8.1	3.2	2.0	1.4	1.3	0.8	0.6	0.8	0.4	0.2	0.6	0.4	1.4
MW16(B2) 80'	0.0	0.0	11.0	4.9	17.8	6.8	12.6	8.2	8.9	7.3	8.5	5.2	2.0	0.6	0.7	1.0	0.5	0.5	1.0	0.3	2.2

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

Reviewed by: ______________________

Corporate ~ 777 Chrysler Drive • Burlington, WA 98233 • Phone (360) 755-1990 • Fax (360) 755-1980
Regional Offices: Olympia ~ 360.534.9777 Bellingham ~ 360.647.6111 Silverdale ~ 360.698.6787 Tukwila ~ 206.241.1974
Visit our website: www.mtc-inc.net

Materials Testing & Consulting, Inc.

Geotechnical Engineering • Special Inspection • Materials Testing • Environmental Consulting

Project: LOTT - Hawks Prairie
Project #: 17T028-01
Date Received: August 11, 2017
Date Tested: August 23, 2017

Client: HDR
Sampled by: Client
Tested by: B. Goble

Relative Standard Deviation, By Size

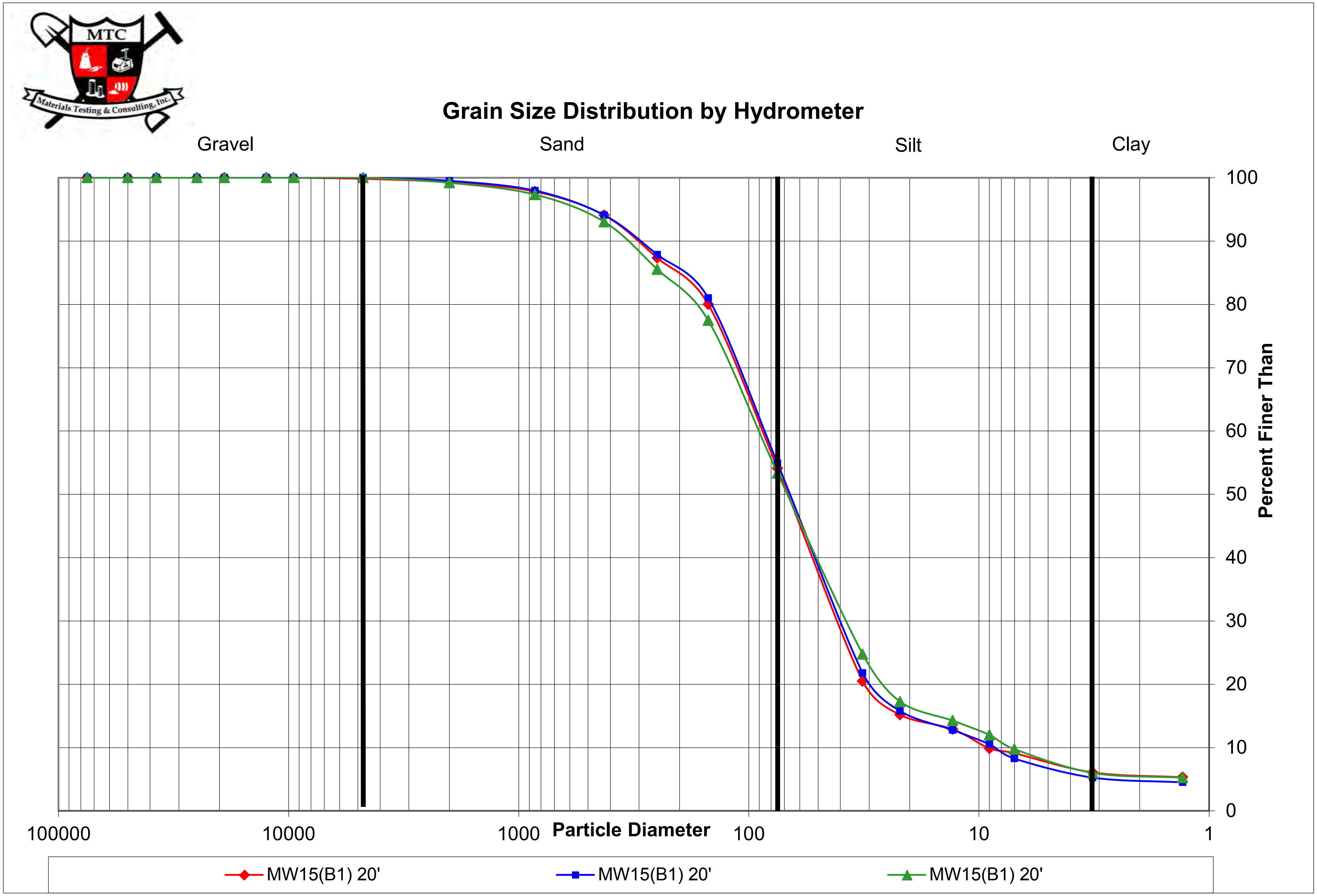
Sample ID	75000	50000	37500	25000	19000	12500	9500	4750	2000	850	425	250	150	75	32	22	13	9	7	3.2	1.3
MW15(B1) 20'	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.3	97.8	94.1	87.3	80.0	54.1	20.5	15.2	12.9	9.9	9.1	6.1	5.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	98.0	94.1	87.9	81.0	54.9	21.8	15.8	12.8	10.5	8.3	5.3	4.5
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.2	97.3	93.0	85.5	77.5	53.3	24.8	17.3	14.3	12.0	9.8	6.0	5.3
AVE	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.3	97.7	93.7	86.9	79.5	54.1	22.4	16.1	13.3	10.8	9.0	5.8	5.0
STDEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.5	1.0	1.5	0.6	1.8	0.9	0.7	0.9	0.6	0.4	0.4
%RSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.5	1.1	1.9	1.2	8.0	5.4	5.0	8.3	6.7	6.4	7.3

This Triplicate applies to the Batch Containing the Following Samples

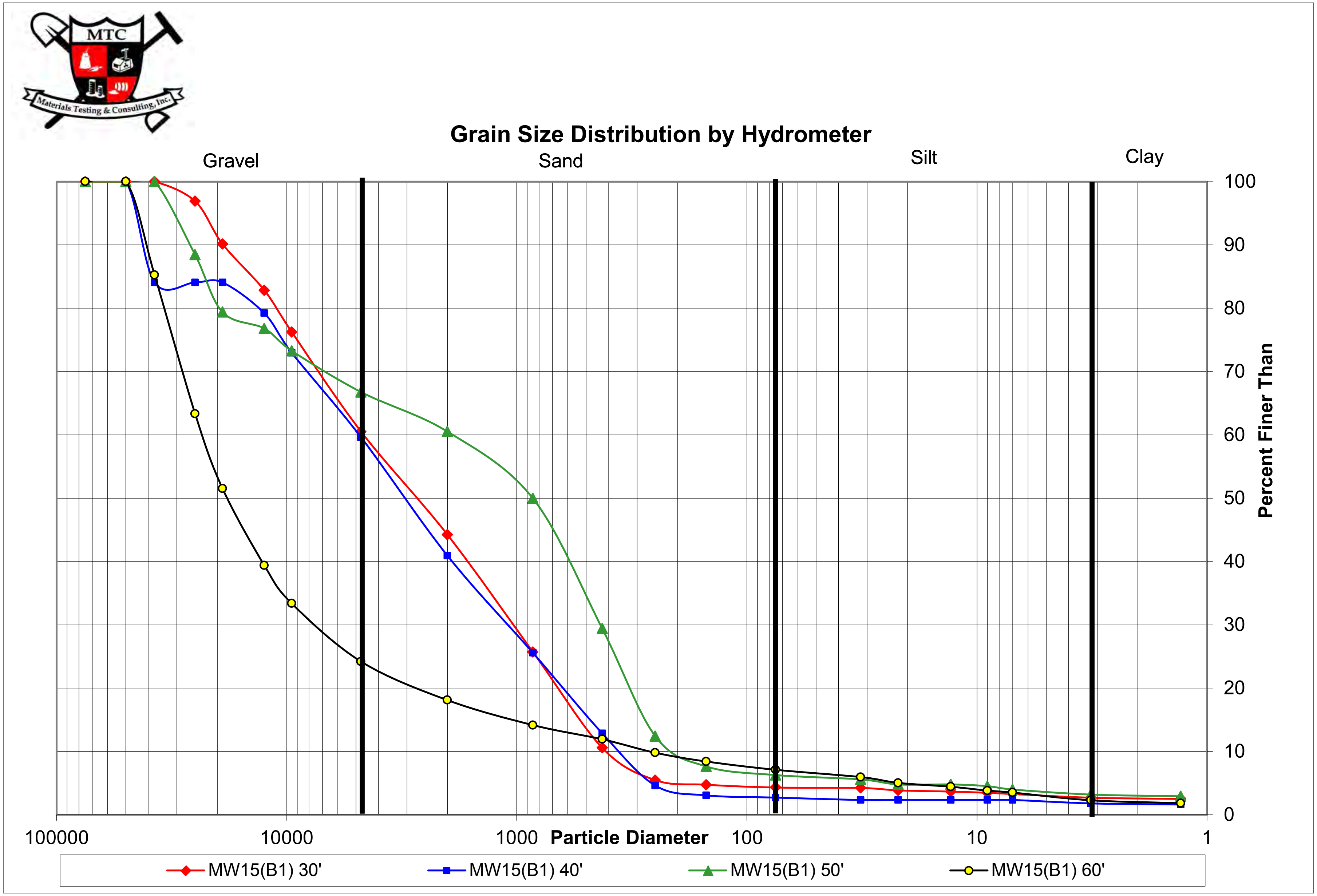
Sample ID	Date Sampled	Date Set up	Date Started	Date Complete	Data Qualifiers
MW15(B1) 20'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
	Not Listed	8/14/2017	8/18/2017	8/23/2017	
	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW15(B1) 30'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW15(B1) 40'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW15(B1) 50'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW15(B1) 60'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW15(B1) 70'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW15(B1) 80'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW16(B2) 20'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW16(B2) 30'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW16(B2) 40'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW16(B2) 50'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW16(B2) 60'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW16(B2) 70'	Not Listed	8/14/2017	8/18/2017	8/23/2017	
MW16(B2) 80'	Not Listed	8/14/2017	8/18/2017	8/23/2017	

Testing performed according to ASTM D421/D422
Organics were not removed prior to analysis. The grain size distribution reported is the "apparent grain size distribution".

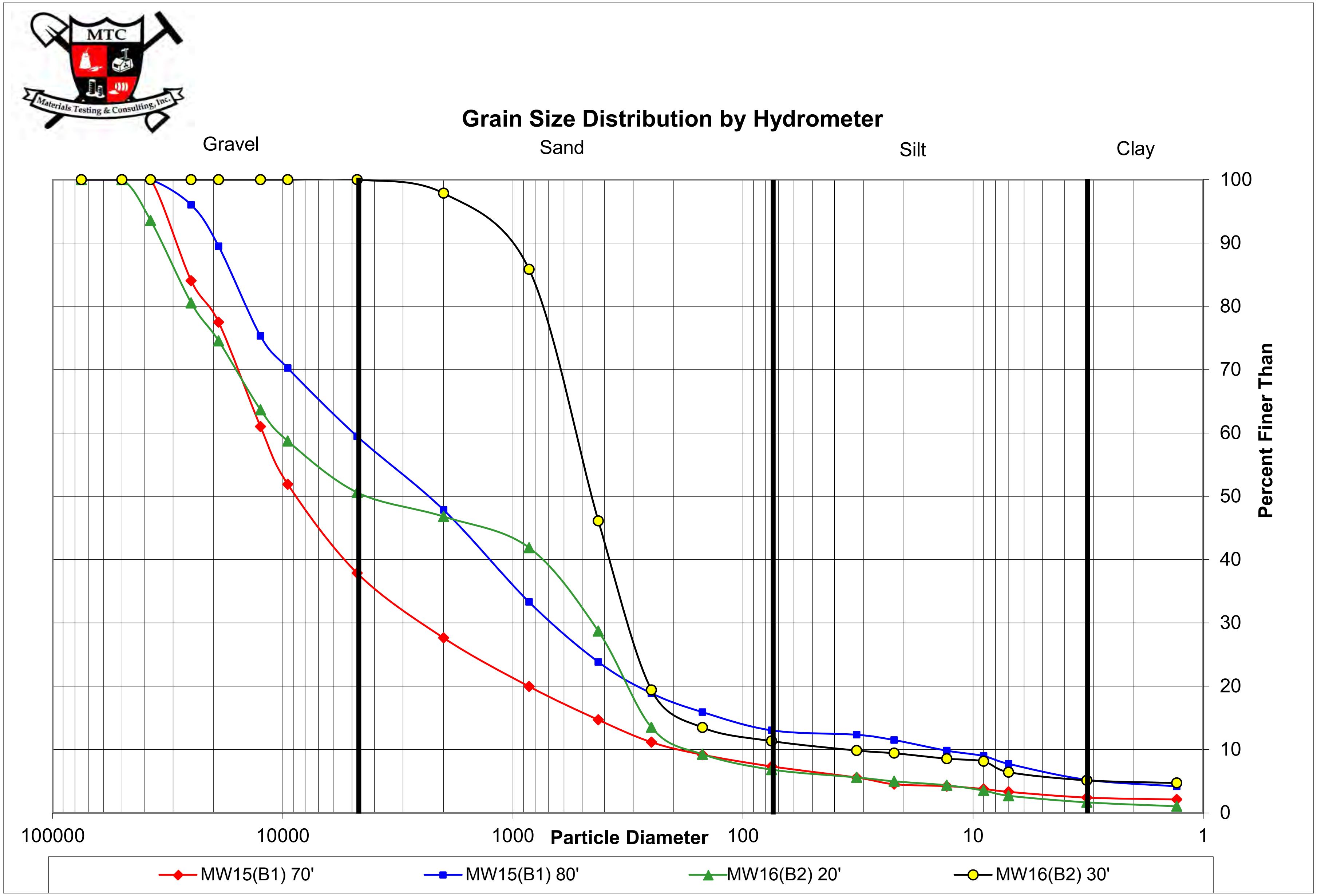
Reviewed by: EGoble



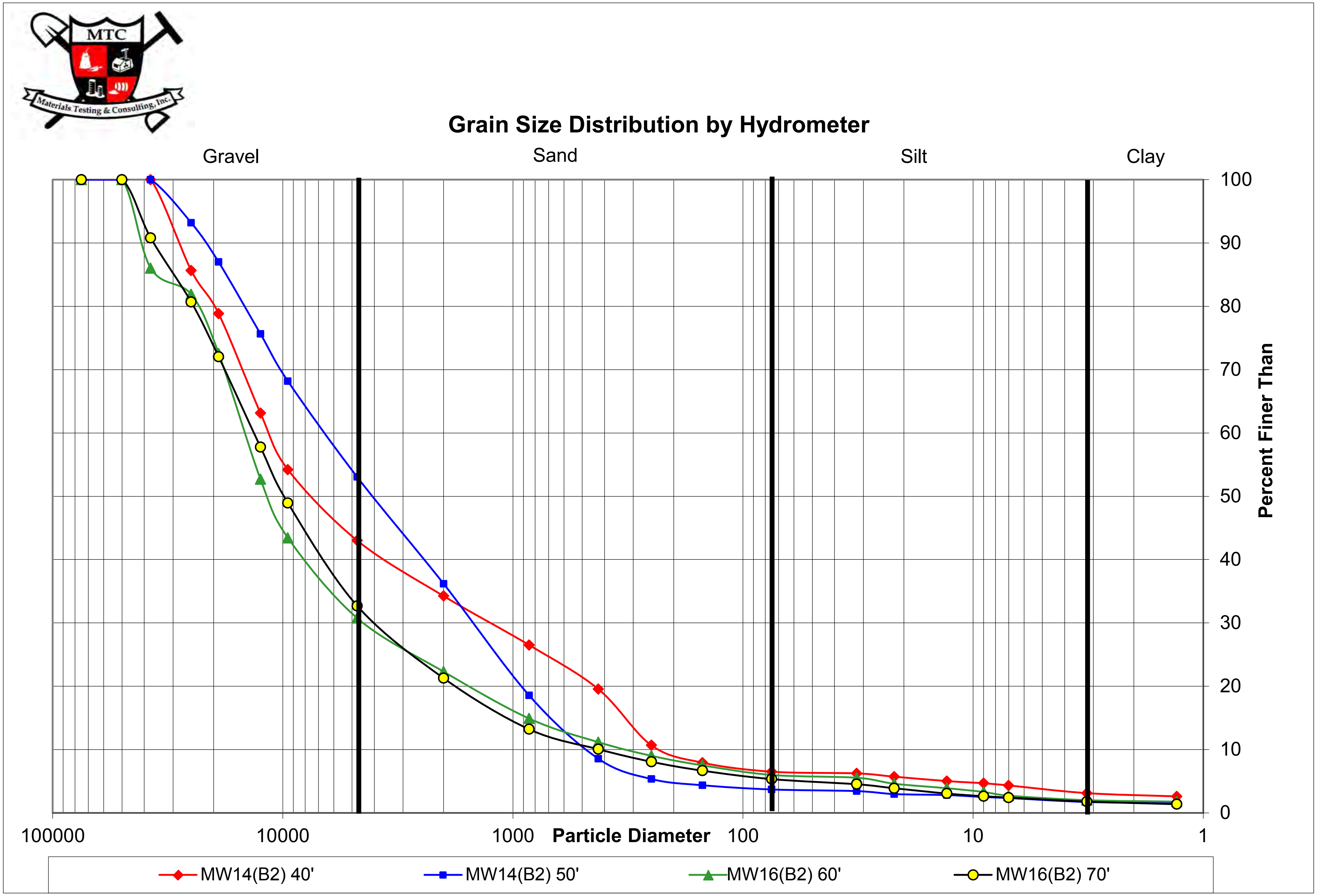
MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW15(B1) 20'
MW15(B1) 20'
MW15(B1) 20'



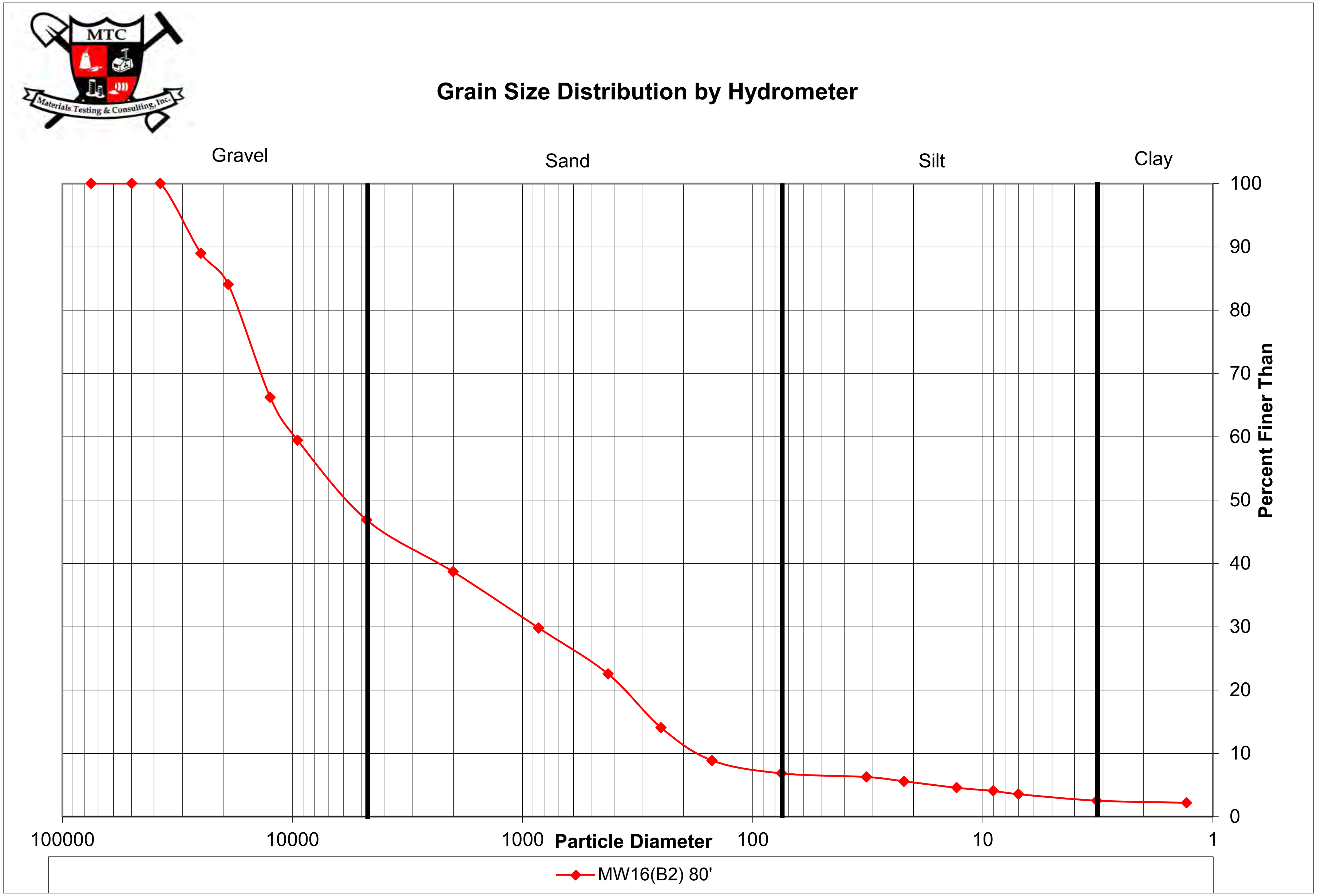
MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW15(B1) 30'
MW15(B1) 40'
MW15(B1) 50'
MW15(B1) 60'



Materials Testing & Consulting, Inc.
MTC
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW15(B1) 70'
MW15(B1) 80'
MW16(B2) 20'
MW16(B2) 30'



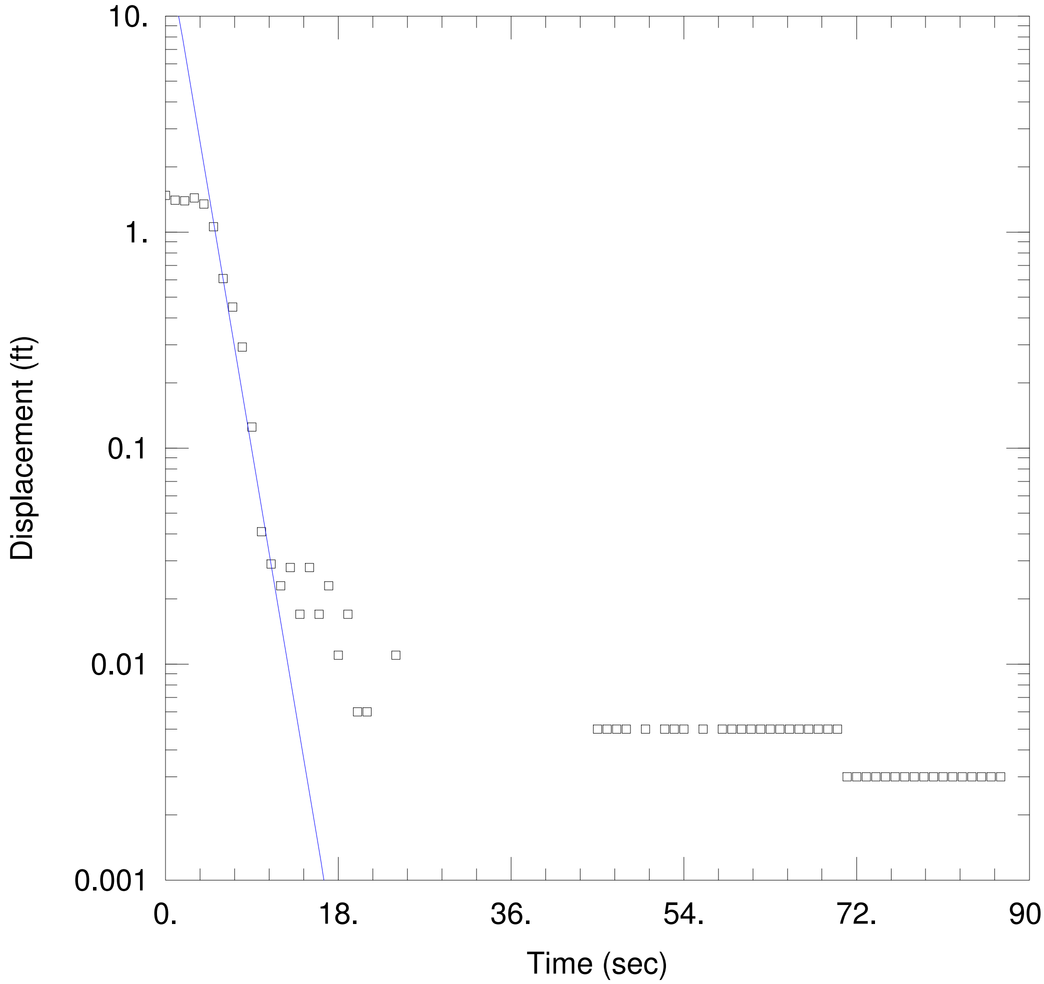
MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
Percent Finer Than
100
90
80
70
60
50
40
30
20
10
0
100000
10000
1000
Particle Diameter
100
10
1
MW14(B2) 40'
MW14(B2) 50'
MW16(B2) 60'
MW16(B2) 70'



MTC
Materials Testing & Consulting, Inc.
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
Particle Diameter
100
10
1
MW16(B2) 80'

Appendix F – Slug Aquifer Testing Analyses

This page intentionally left blank.



MW-12 (O) TEST 1

Data Set: P:\...\MW12_O_LowerVolum_test1.aqt
Date: 10/04/17 Time: 15:32:33

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-12 (O)
Test Date: 9/21/2017

AQUIFER DATA

Saturated Thickness: 110. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW 12)

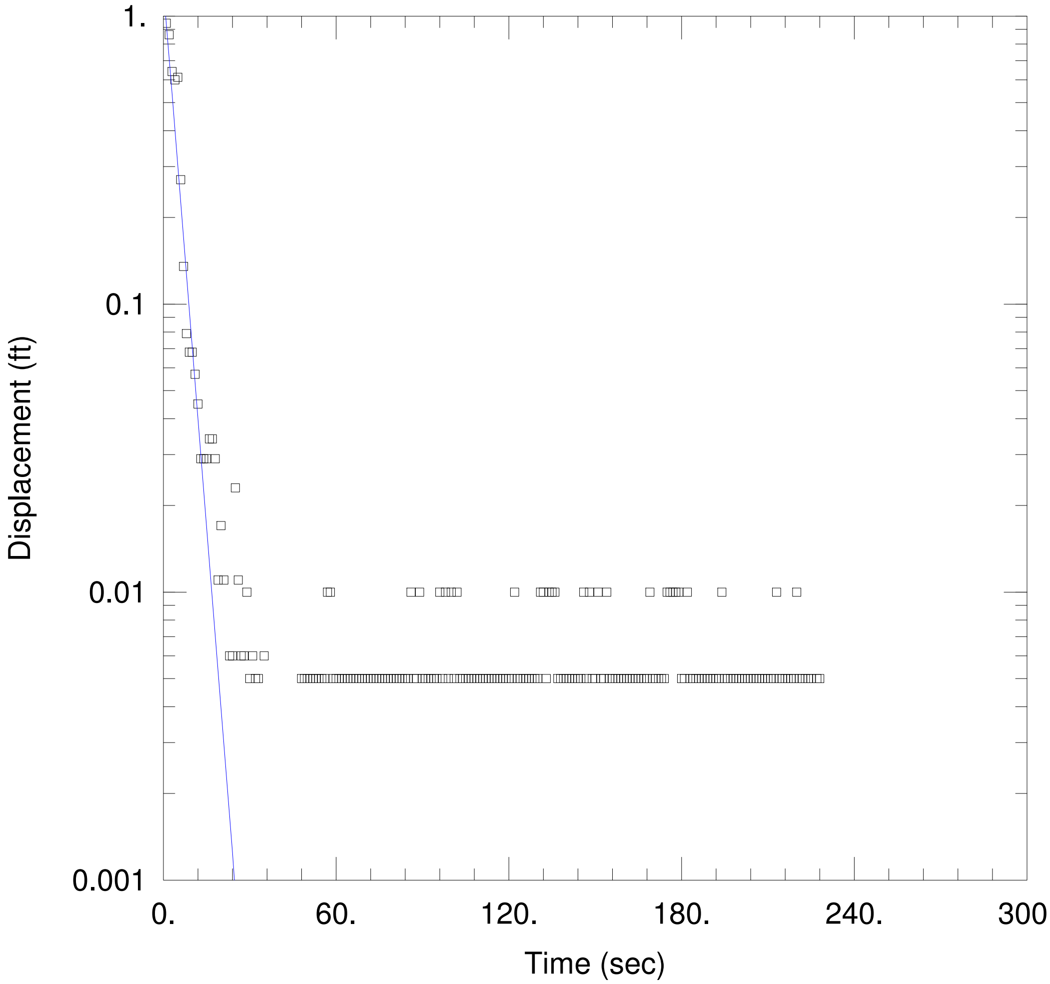
Initial Displacement: 1.479 ft
Total Well Penetration Depth: 24.7 ft
Casing Radius: 0.1042 ft

Static Water Column Height: 165.9 ft
Screen Length: 20. ft
Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 54.96 ft/day y0 = 23.43 ft



MW-12 (O) TEST 2

Data Set: P:\...\MW12_O_LowerVolum_test2.aqt
Date: 10/04/17 Time: 15:33:55

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-12 (O)
Test Date: 9/21/2017

AQUIFER DATA

Saturated Thickness: 110. ft
Anisotropy Ratio (Kz/Kr): 0.1

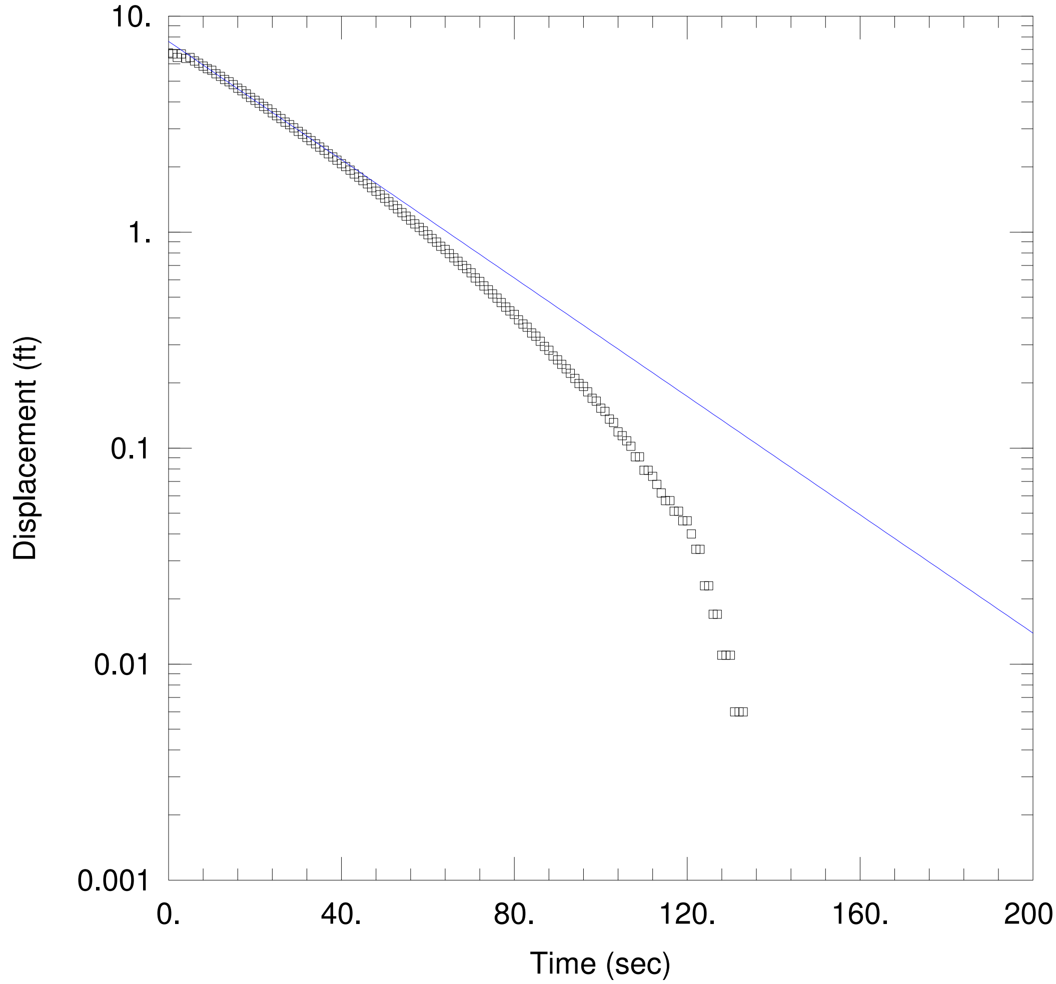
WELL DATA (MW 12)

Initial Displacement: 1.09 ft
Total Well Penetration Depth: 24.7 ft
Casing Radius: 0.1042 ft
Static Water Column Height: 165.9 ft
Screen Length: 20. ft
Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 26.09 ft/day
y0 = 1.284 ft



MW-14 (R) TEST 1

Data Set: P:\...\MW14_R_20170920_test1.aqt
Date: 10/04/17
Time: 15:34:43

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-14 (R)
Test Date: 9/20/2017

AQUIFER DATA

Saturated Thickness: 60. ft
Anisotropy Ratio (Kz/Kr): 0.1

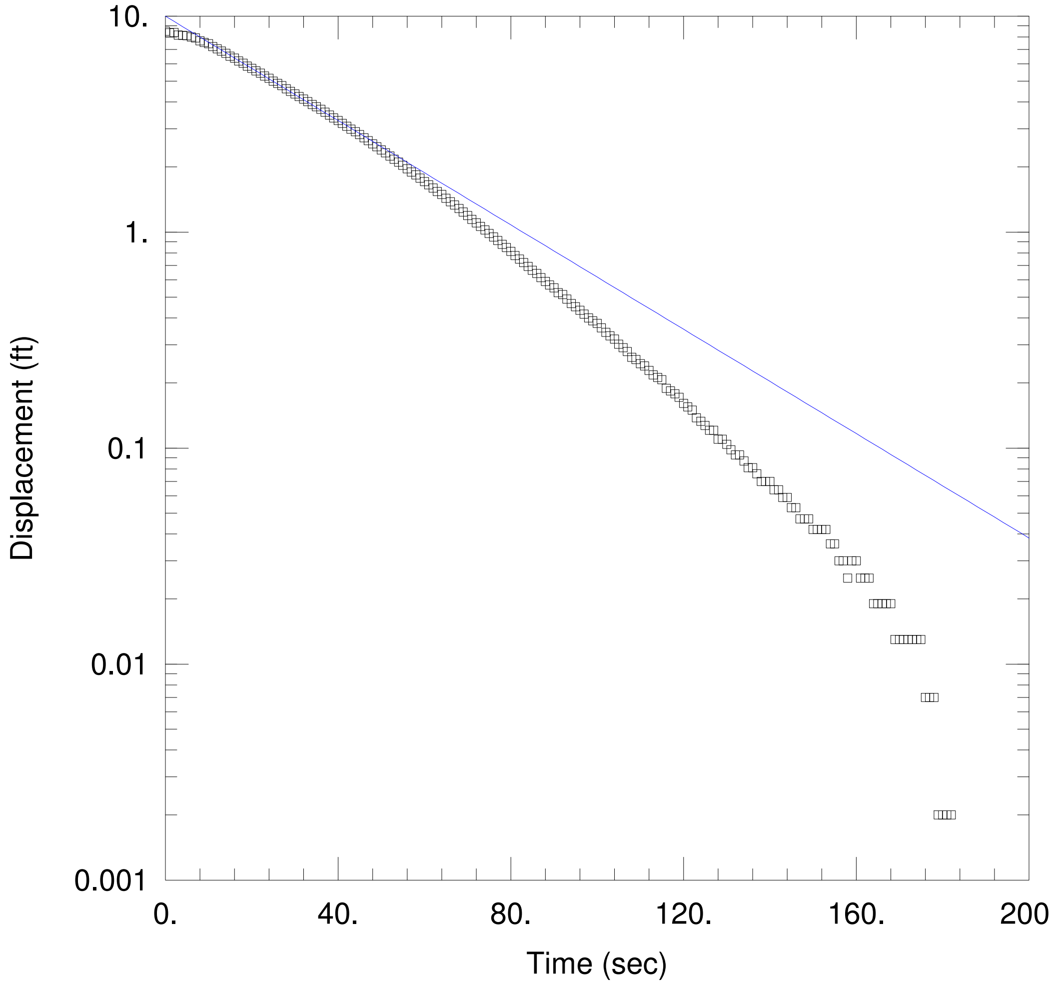
WELL DATA (MW-14)

Initial Displacement: 6.743 ft
Static Water Column Height: 173.8 ft
Total Well Penetration Depth: 21. ft
Screen Length: 20. ft
Casing Radius: 0.1042 ft
Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.783 ft/day
y0 = 7.634 ft



MW-14 (R) TEST 2

Data Set: P:\...\MW14_R_20170920_test2.aqt
Date: 10/04/17 Time: 15:35:25

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-14 (R)
Test Date: 9/20/2017

AQUIFER DATA

Saturated Thickness: 60. ft Anisotropy Ratio (Kz/Kr): 0.1

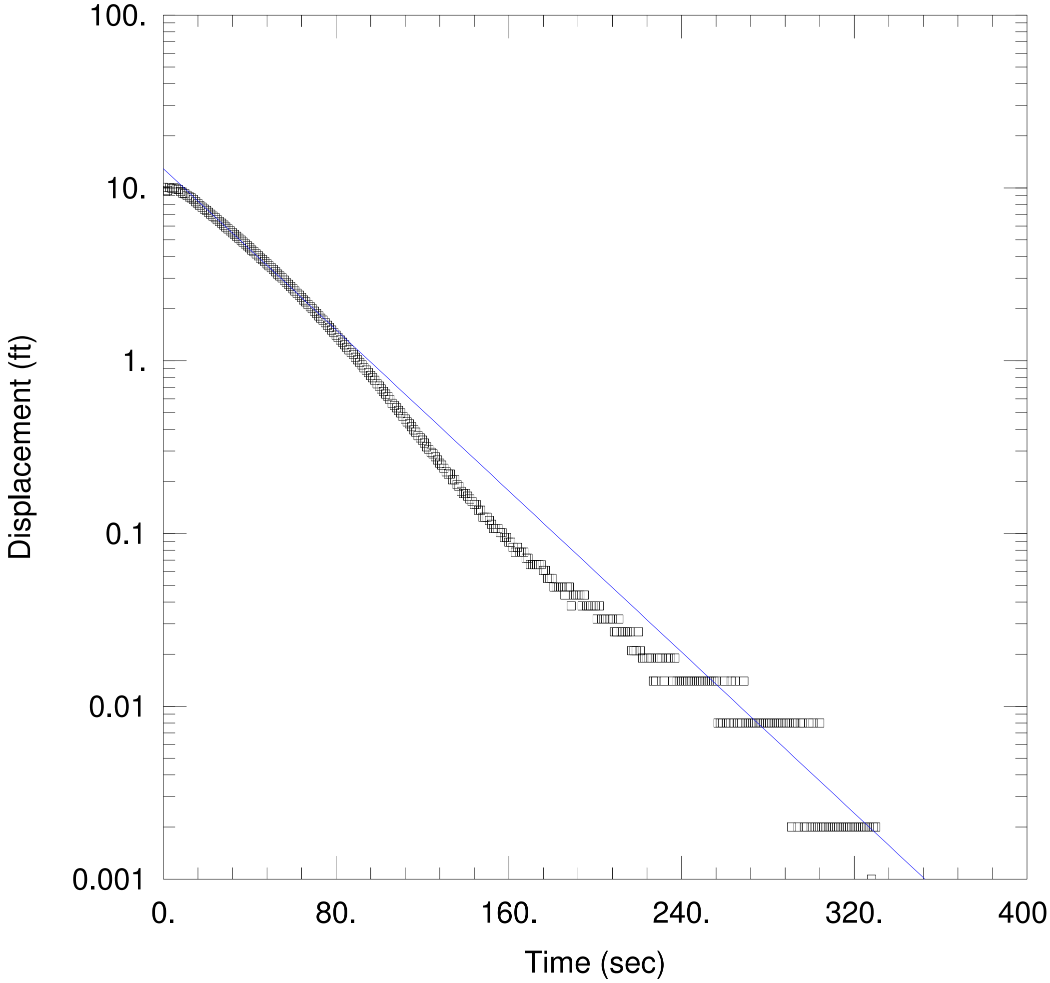
WELL DATA (MW-14)

Initial Displacement: 8.493 ft Static Water Column Height: 173.8 ft
Total Well Penetration Depth: 21. ft Screen Length: 20. ft
Casing Radius: 0.1042 ft Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.454 ft/day y0 = 9.981 ft



MW-14 (R) TEST 3

Data Set: P:\...\MW14_R_20170920_test3.aqt
Date: 10/04/17 Time: 15:36:20

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-14 (R)
Test Date: 9/20/2017

AQUIFER DATA

Saturated Thickness: 60. ft Anisotropy Ratio (Kz/Kr): 0.1

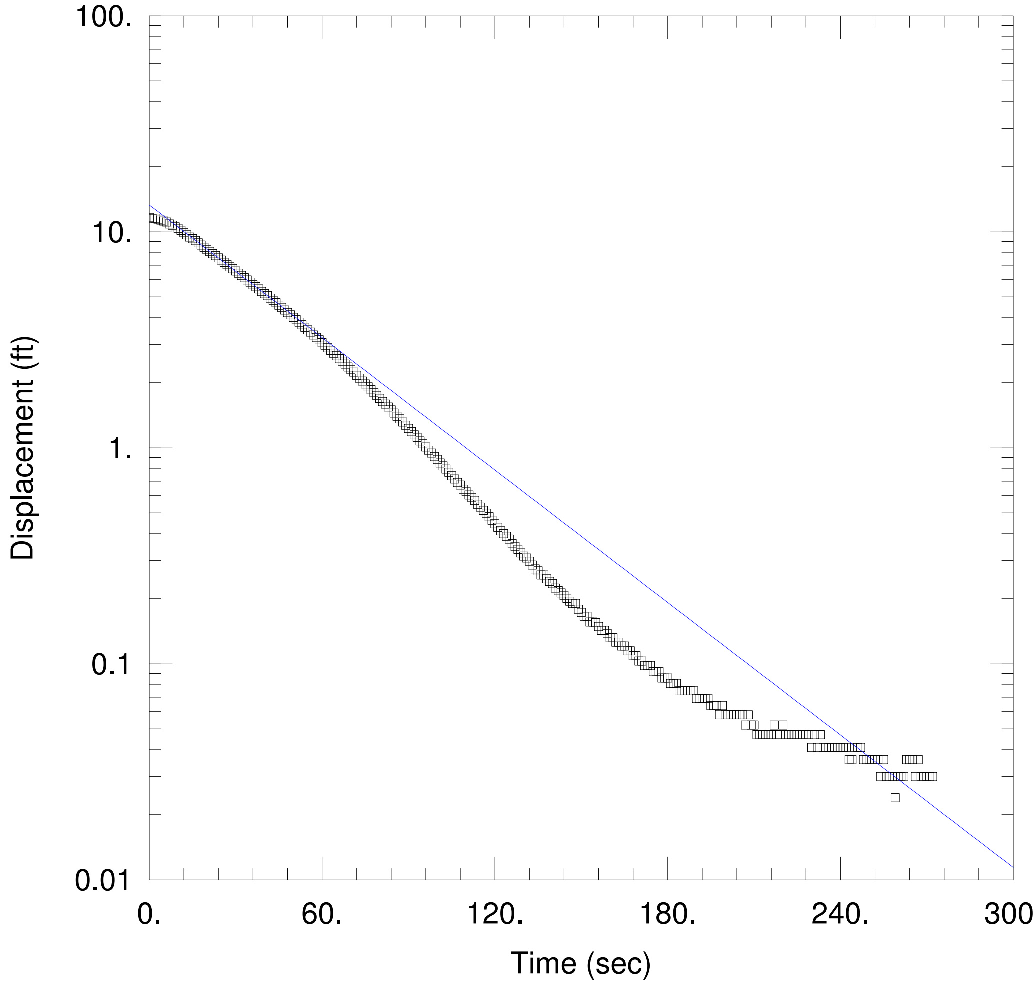
WELL DATA (MW-14)

Initial Displacement: 10.06 ft
Total Well Penetration Depth: 21. ft
Casing Radius: 0.1042 ft
Static Water Column Height: 173.8 ft
Screen Length: 20. ft
Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.368 ft/day y0 = 12.9 ft



MW-14 (R) TEST 4

Data Set: P:\...\MW14_R_20170920_test4.aqt
Date: 10/04/17 Time: 15:37:01

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-14 (R)
Test Date: 9/20/2017

AQUIFER DATA

Saturated Thickness: 60. ft Anisotropy Ratio (Kz/Kr): 0.1

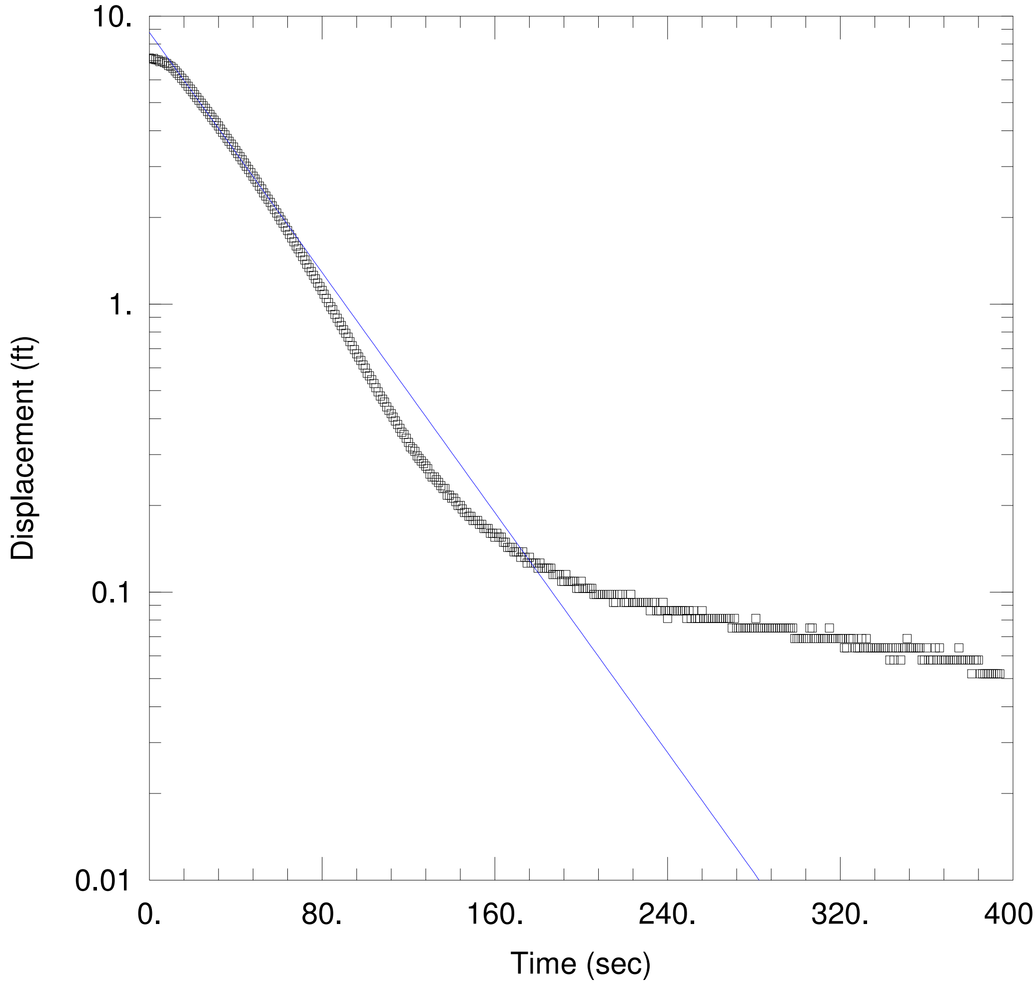
WELL DATA (MW-14)

Initial Displacement: 11.65 ft
Total Well Penetration Depth: 21. ft
Casing Radius: 0.1042 ft
Static Water Column Height: 173.8 ft
Screen Length: 20. ft
Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.077 ft/day y0 = 13.31 ft



MW-14 (R) TEST 5

Data Set: P:\...\MW14_R_20170920_test5.aqt
Date: 10/04/17 Time: 15:37:48

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-14 (R)
Test Date: 9/20/2017

AQUIFER DATA

Saturated Thickness: 60. ft Anisotropy Ratio (Kz/Kr): 0.1

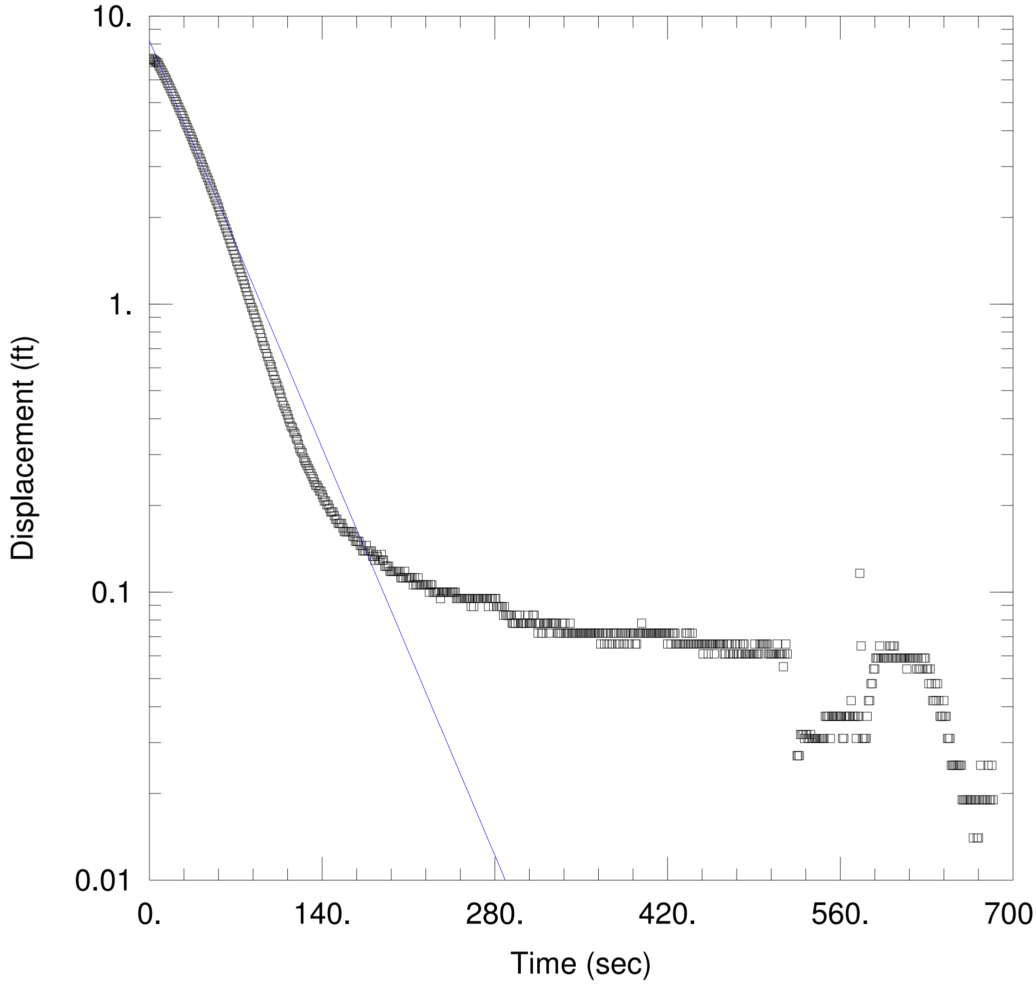
WELL DATA (MW-14)

Initial Displacement: 7.137 ft Static Water Column Height: 173.8 ft
Total Well Penetration Depth: 21. ft Screen Length: 20. ft
Casing Radius: 0.1042 ft Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.117 ft/day y0 = 8.767 ft



MW-14 (R) TEST 6

Data Set: P:\...\MW14_R_20170920_test6.aqt
Date: 10/04/17 Time: 15:38:33

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-14 (R)
Test Date: 9/20/2017

AQUIFER DATA

Saturated Thickness: 60. ft
Anisotropy Ratio (Kz/Kr): 0.1

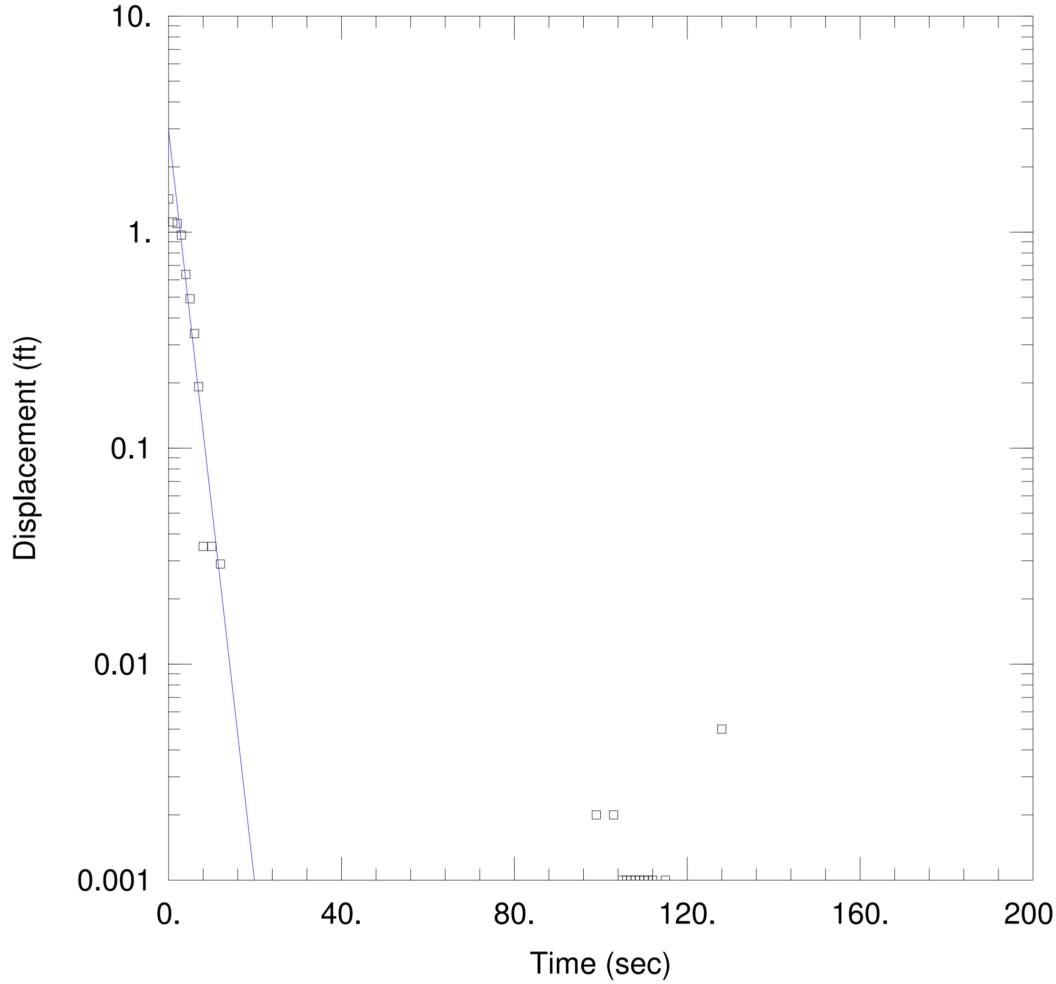
WELL DATA (MW-14)

Initial Displacement: 7.064 ft
Total Well Penetration Depth: 21. ft
Casing Radius: 0.1042 ft
Static Water Column Height: 173.8 ft
Screen Length: 20. ft
Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 2.053 ft/day
y0 = 8.222 ft



MW-21 (P) TEST 1

Data Set: P:\...\MW21_P_lowerVOlume_test1.aqt
Date: 10/04/17
Time: 15:39:30

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-21 (P)
Test Date: 9/22/2017

AQUIFER DATA

Saturated Thickness: 150. ft
Anisotropy Ratio (Kz/Kr): 0.1

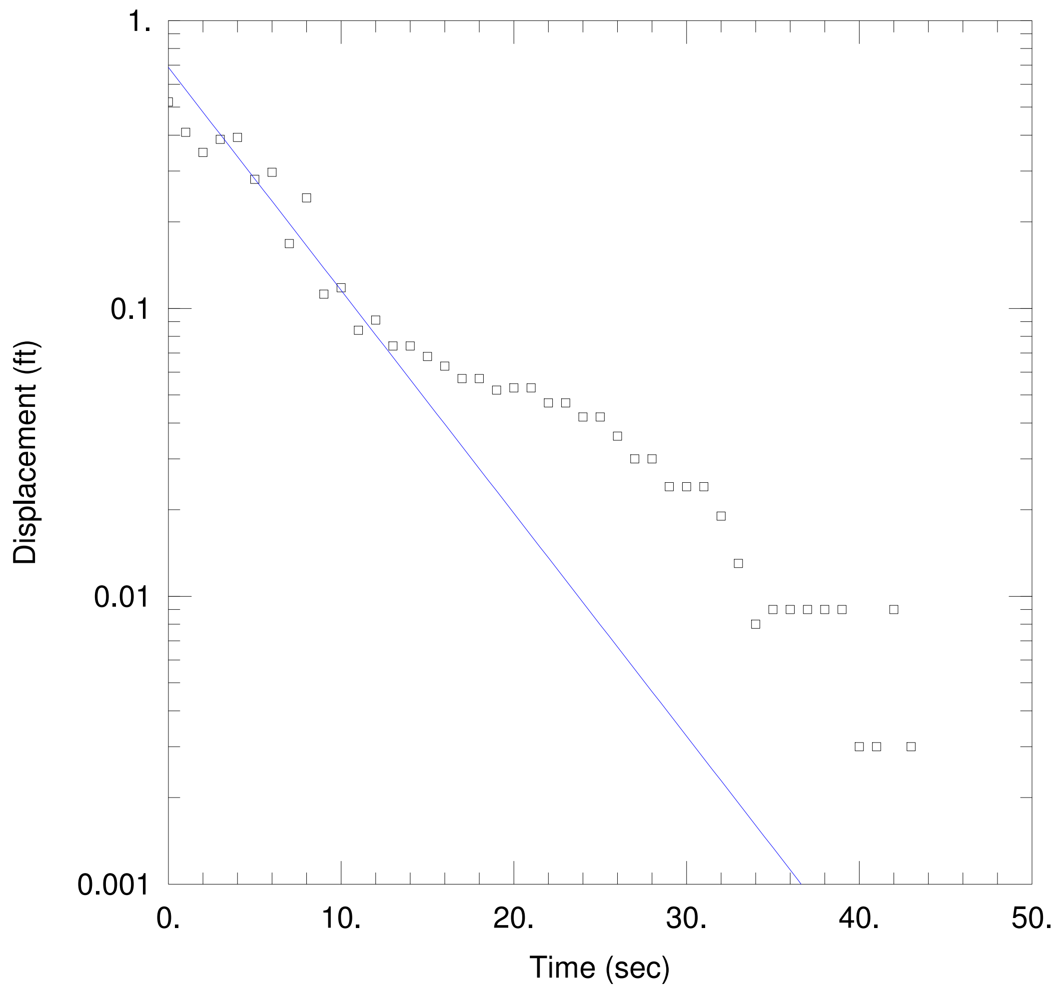
WELL DATA (MW-21)

Initial Displacement: 1.425 ft
Total Well Penetration Depth: 45. ft
Casing Radius: 0.1042 ft
Static Water Column Height: 99.47 ft
Screen Length: 20. ft
Well Radius: 0.3333 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 38. ft/day
y0 = 2.969 ft



MW-21 (P) TEST 2

Data Set: P:\...\MW21_P_lowerVOlume_test2.aqt
Date: 10/04/17 Time: 15:40:18

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-21 (P)
Test Date: 9/22/2017

AQUIFER DATA

Saturated Thickness: 150. ft Anisotropy Ratio (Kz/Kr): 0.1

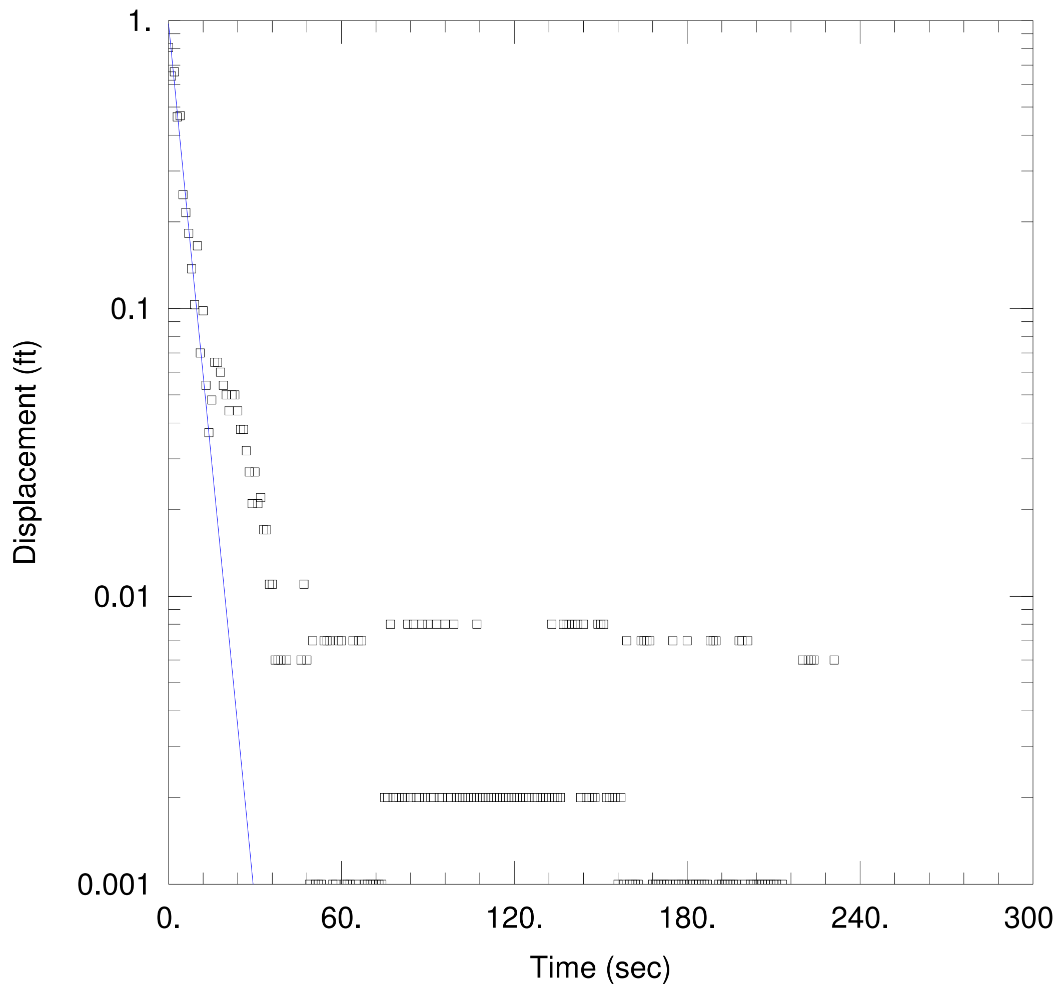
WELL DATA (MW-21)

Initial Displacement: 0.522 ft
Total Well Penetration Depth: 45. ft
Casing Radius: 0.1042 ft
Static Water Column Height: 99.47 ft
Screen Length: 20. ft
Well Radius: 0.3333 ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 16.83 ft/day y0 = 0.6869 ft



MW-21 (P) TEST 3

Data Set: P:\...\MW21_P_lowerVOlume_test3.aqt
Date: 10/04/17
Time: 15:41:19

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-21 (P)
Test Date: 9/22/2017

AQUIFER DATA

Saturated Thickness: 150. ft
Anisotropy Ratio (Kz/Kr): 0.1

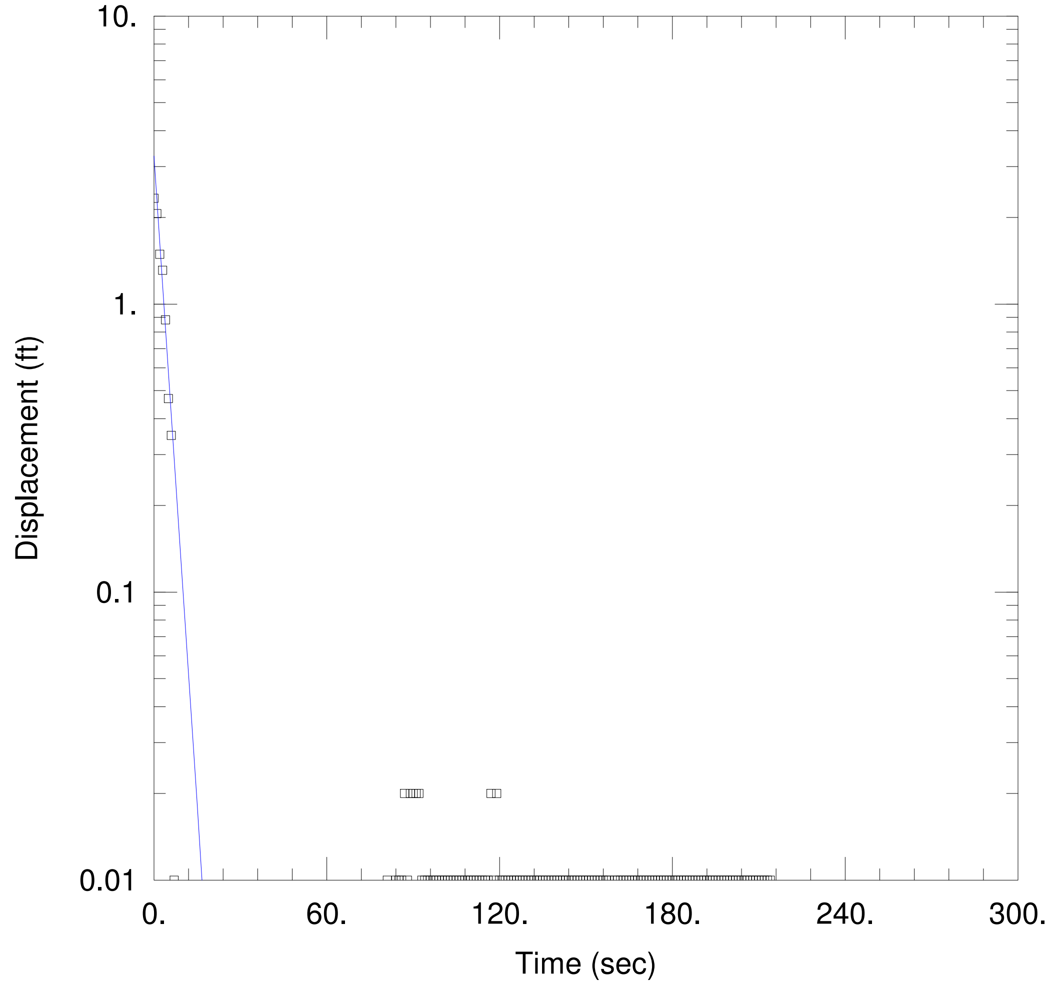
WELL DATA (MW-21)

Initial Displacement: 0.805 ft
Static Water Column Height: 99.47 ft
Total Well Penetration Depth: 45. ft
Screen Length: 20. ft
Casing Radius: 0.1042 ft
Well Radius: 0.3333 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 22.1 ft/day
y0 = 0.973 ft



MW-23 (Q) TEST 1

Data Set: P:\...\MW23_Q_lowerVolume_Test1.aqt
Date: 10/04/17
Time: 15:42:23

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-23 (Q)
Test Date: 9/21/2017

AQUIFER DATA

Saturated Thickness: 100. ft
Anisotropy Ratio (Kz/Kr): 0.1

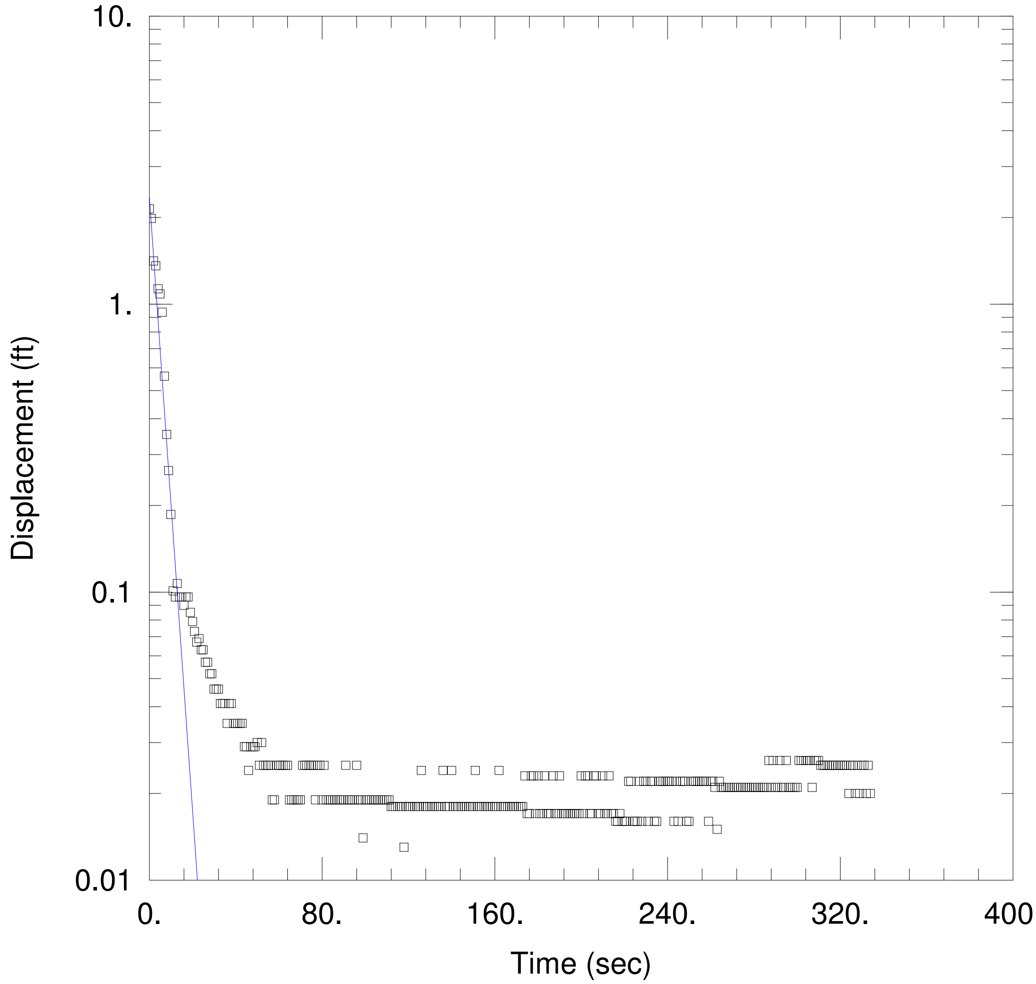
WELL DATA (MW - 23)

Initial Displacement: 2.33 ft
Total Well Penetration Depth: 45. ft
Casing Radius: 0.1042 ft
Static Water Column Height: 138.3 ft
Screen Length: 30. ft
Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 23.48 ft/day
y0 = 3.268 ft



MW-23 (Q) TEST 2

Data Set: P:\...\MW23_Q_lowerVolume_Test2.aqt
Date: 10/04/17
Time: 15:43:14

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-23 (Q)
Test Date: 9/21/2017

AQUIFER DATA

Saturated Thickness: 100. ft
Anisotropy Ratio (Kz/Kr): 0.1

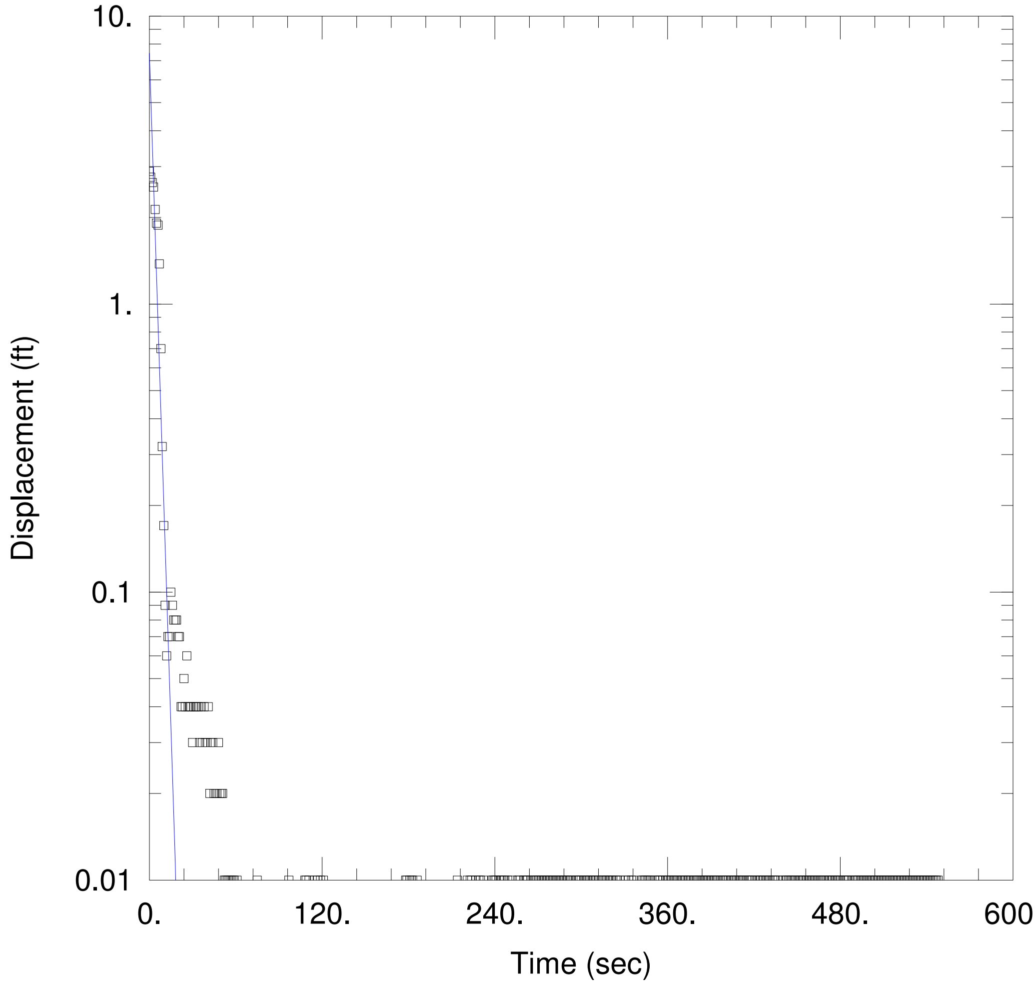
WELL DATA (MW - 23)

Initial Displacement: 2.14 ft
Total Well Penetration Depth: 45. ft
Casing Radius: 0.1042 ft
Static Water Column Height: 138.3 ft
Screen Length: 30. ft
Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 16.67 ft/day
y0 = 2.342 ft



MW-23 (Q) TEST 3

Data Set: P:\...\MW23_Q_lowerVolume_Test3.aqt
Date: 10/04/17 Time: 15:44:07

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-23 (Q)
Test Date: 9/21/2017

AQUIFER DATA

Saturated Thickness: 100. ft
Anisotropy Ratio (Kz/Kr): 0.1

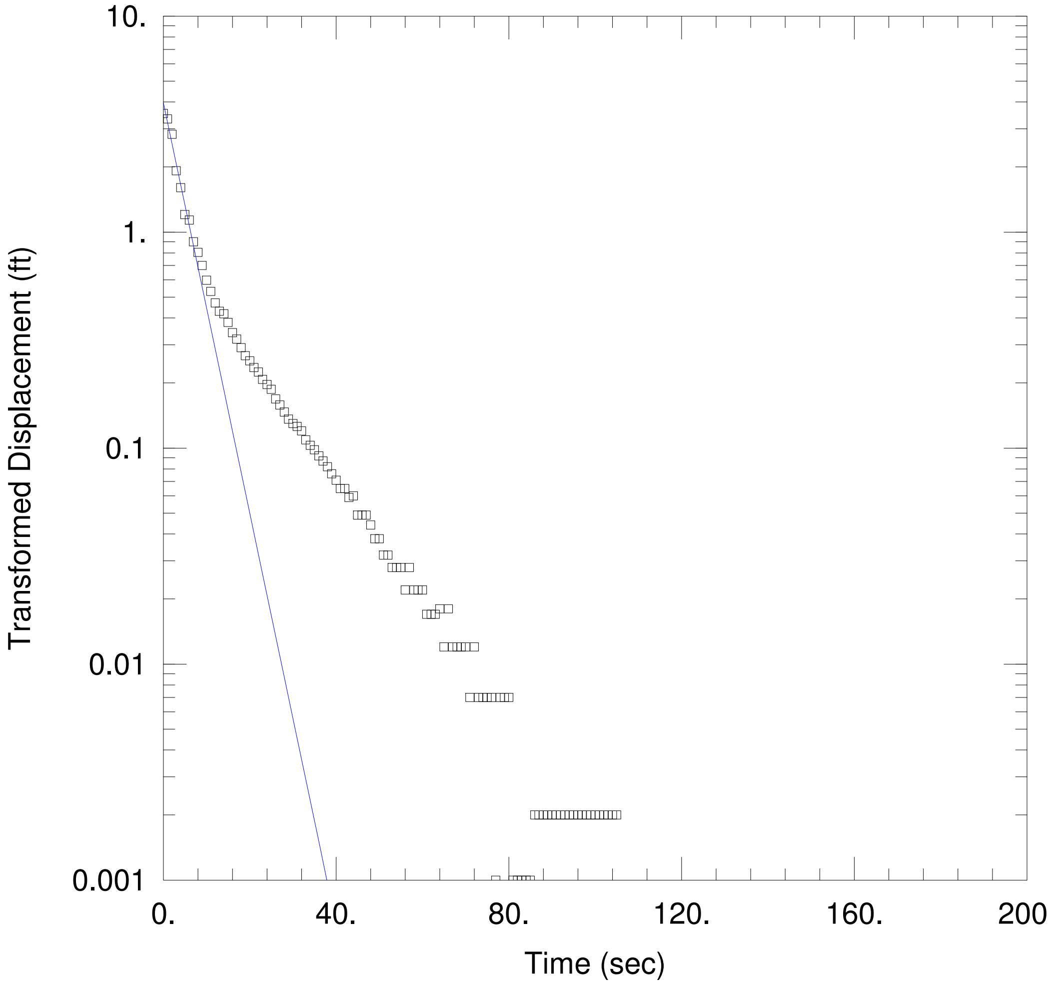
WELL DATA (MW - 23)

Initial Displacement: 2.89 ft
Static Water Column Height: 138.3 ft
Total Well Penetration Depth: 45. ft
Screen Length: 30. ft
Casing Radius: 0.1042 ft
Well Radius: 0.2917 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 24.5 ft/day
y0 = 7.429 ft



MW-24 (C) TEST 1

Data Set: P:\...\MW24_C_LowerVolume_Test1.aqt
Date: 10/04/17 Time: 15:44:55

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-24 (C)
Test Date: 9/22/2017

AQUIFER DATA

Saturated Thickness: 42.34 ft Anisotropy Ratio (Kz/Kr): 0.1

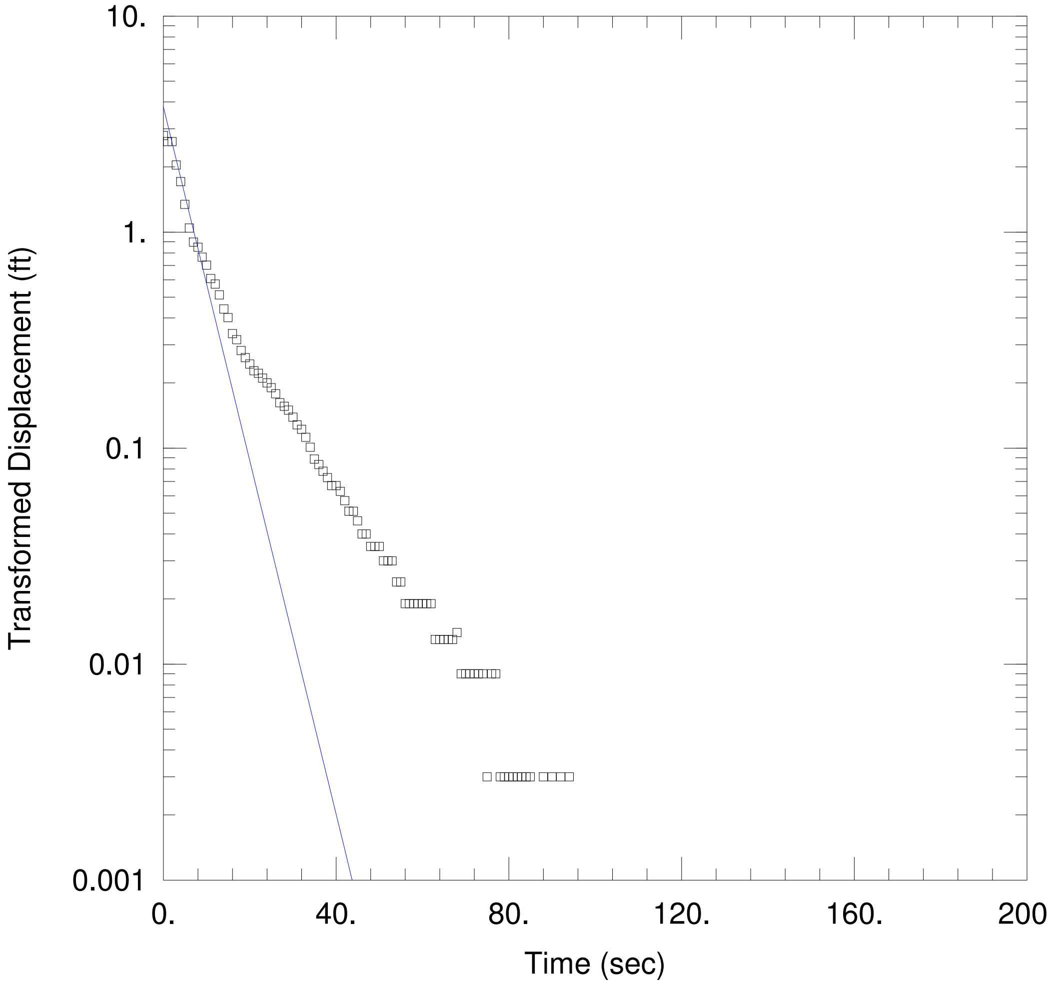
WELL DATA (MW-24)

Initial Displacement: 3.535 ft
Total Well Penetration Depth: 25.34 ft
Casing Radius: 0.08333 ft
Static Water Column Height: 25.34 ft
Screen Length: 25. ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 10.92 ft/day y0 = 3.967 ft



MW-24 (C) TEST 2

Data Set: P:\...\MW24_C_LowerVolume_Test2.aqt
Date: 10/04/17 Time: 15:45:35

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-24 (C)
Test Date: 9/22/2017

AQUIFER DATA

Saturated Thickness: 42.34 ft
Anisotropy Ratio (Kz/Kr): 0.1

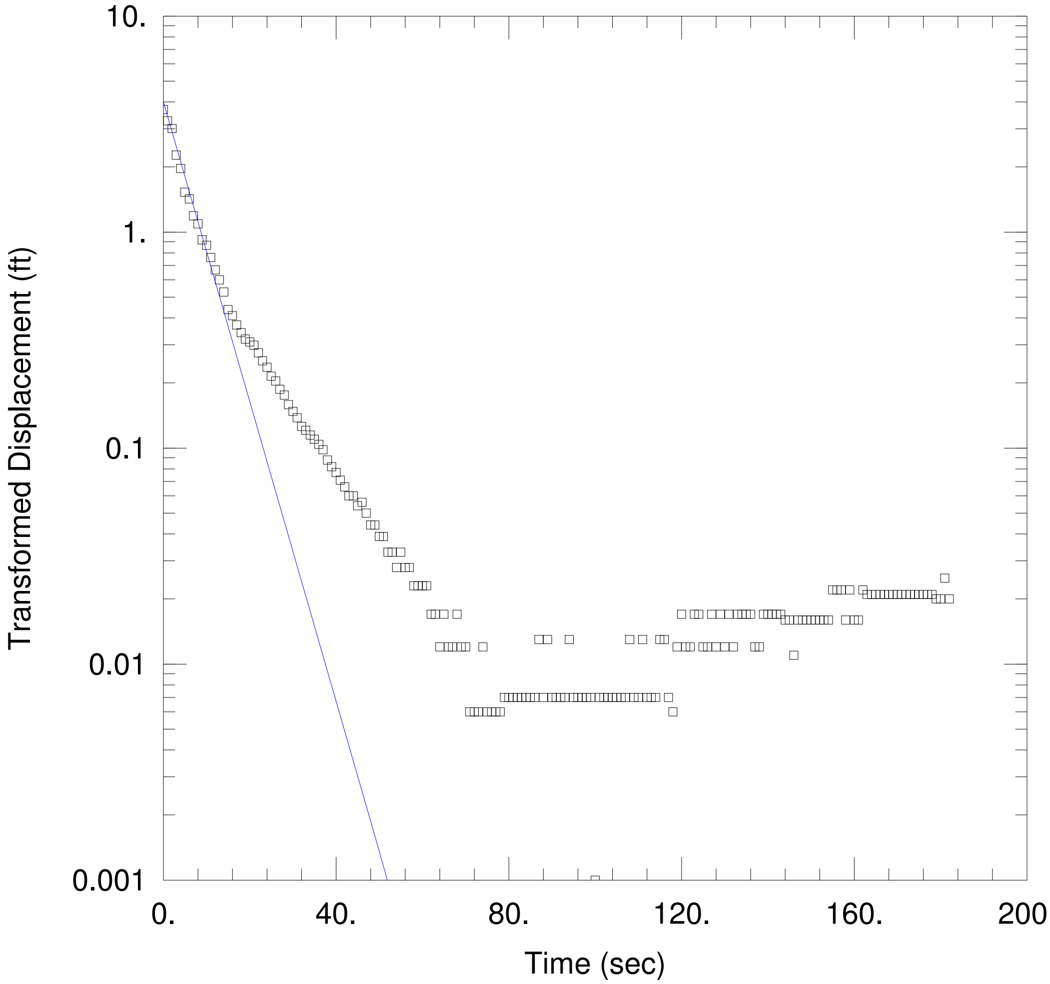
WELL DATA (MW-24)

Initial Displacement: 2.799 ft
Static Water Column Height: 25.34 ft
Total Well Penetration Depth: 25.34 ft
Screen Length: 25. ft
Casing Radius: 0.08333 ft
Well Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 9.406 ft/day
y0 = 3.785 ft



MW-24 (C) TEST 3

Data Set: P:\...\MW24_C_LowerVolume_Test3.aqt
Date: 10/04/17 Time: 15:46:46

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prairie
Test Well: MW-24 (C)
Test Date: 9/22/2017

AQUIFER DATA

Saturated Thickness: 42.34 ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW-24)

Initial Displacement: 3.687 ft
Total Well Penetration Depth: 25.34 ft
Casing Radius: 0.08333 ft
Static Water Column Height: 25.34 ft
Screen Length: 25. ft
Well Radius: 0.25 ft

SOLUTION

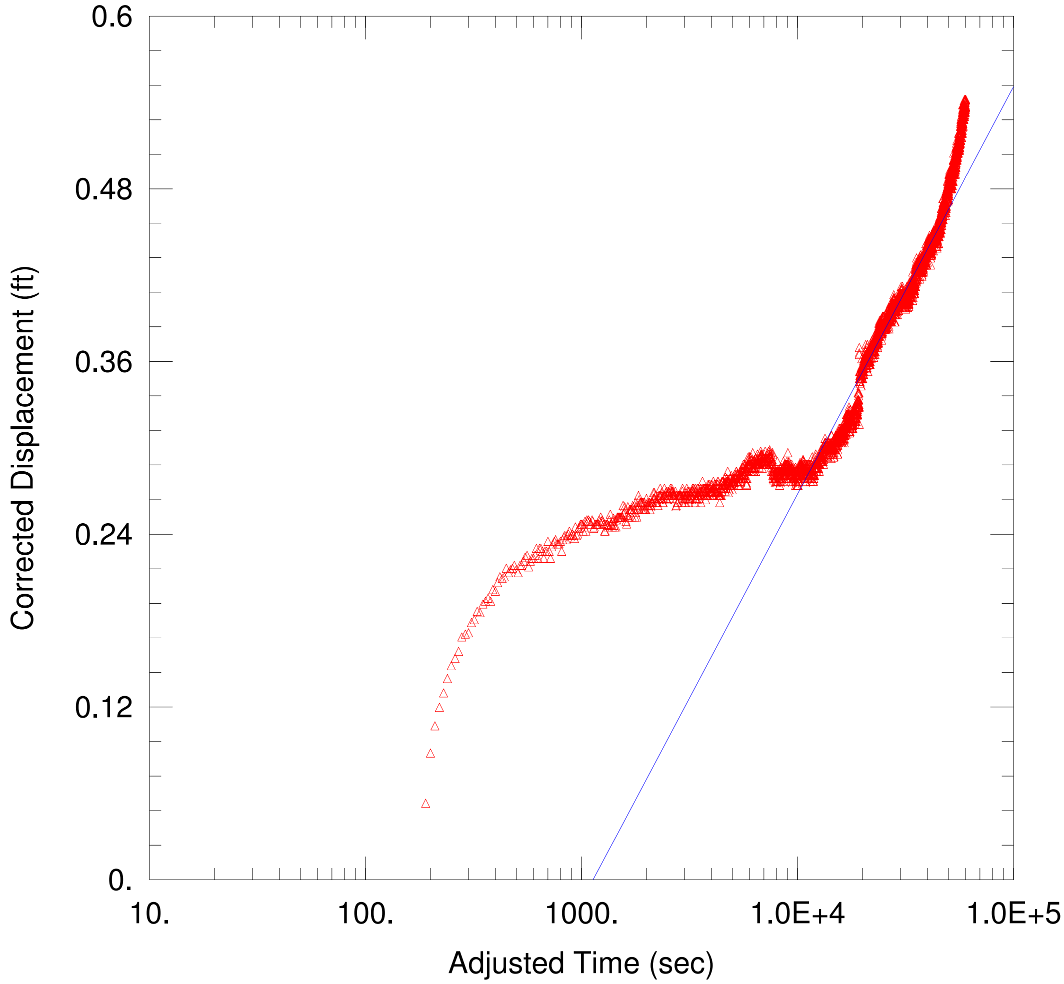
Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 7.976 ft/day y0 = 4.005 ft

This page intentionally left blank.

Appendix G – Pumping Test Aquifer Testing Analyses

This page intentionally left blank.



MW-16 PUMPING TEST, MW-2 OBSERVATION WELL

Data Set: P:\...\MW-16 Pumping Test_MW-2 OW_CooperJacob.aqt
Date: 10/03/17 Time: 13:43:35

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-16
Test Date: 9/13/2017

AQUIFER DATA

Saturated Thickness: 31. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
MW-16 (B2)	0	0

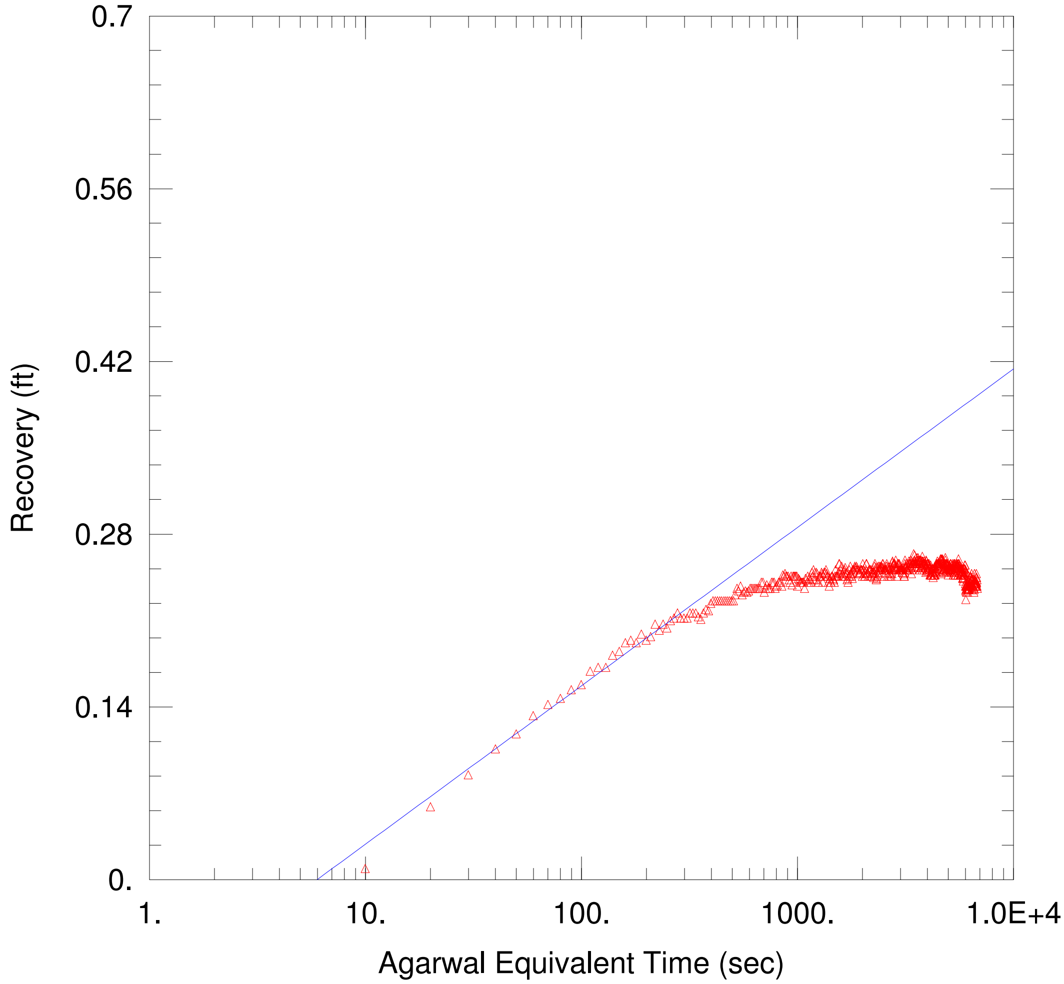
Observation Wells

Well Name	X (ft)	Y (ft)
△ MW-2	0	71

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 2118.1 ft^2/day S = 0.01239



MW-16 PUMPING TEST, MW-2 OBSERVATION WELL

Data Set: P:\...\MW-16 Pumping Test_MW-2 OW_CooperJacobRecovery.aqt
Date: 10/09/17 Time: 11:11:52

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-16
Test Date: 9/13/2017

AQUIFER DATA

Saturated Thickness: 31. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
MW-16 (B2)	0	0

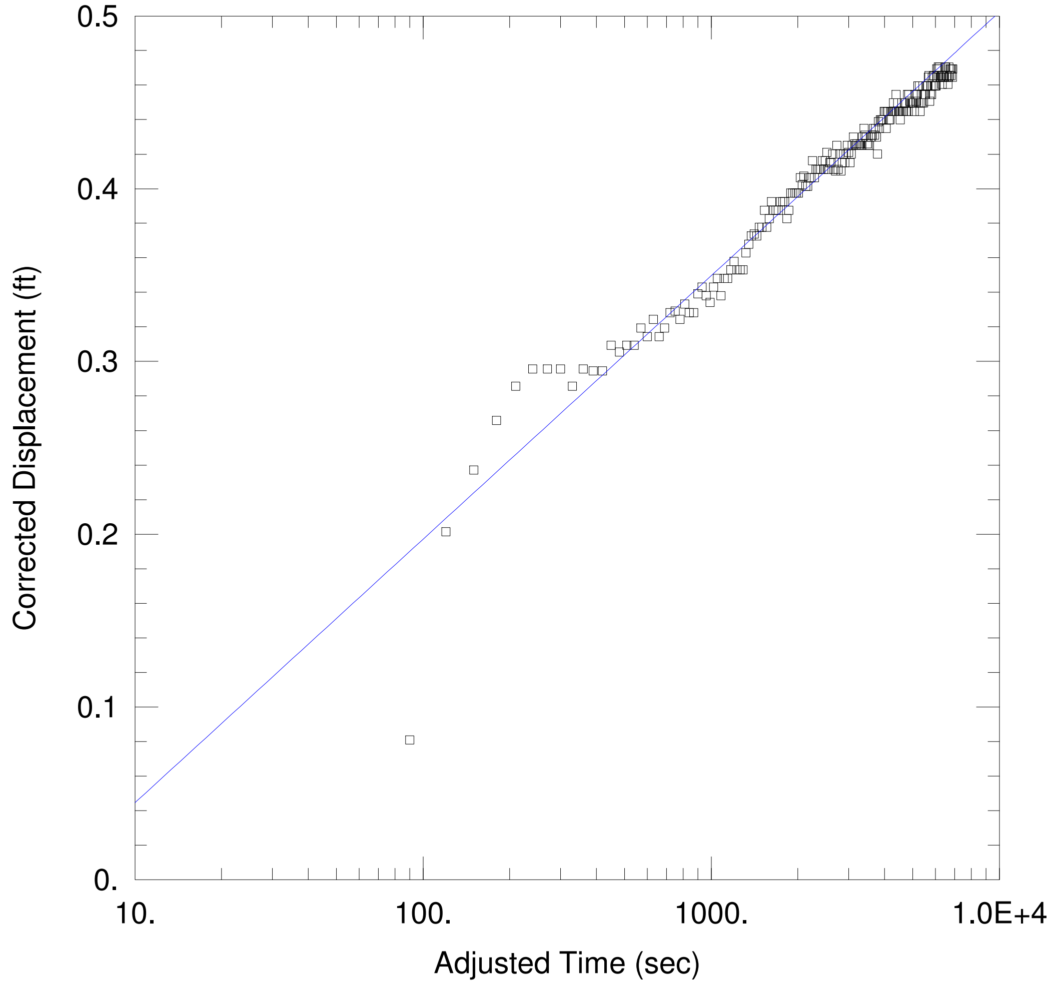
Observation Wells

Well Name	X (ft)	Y (ft)
MW-2	0	71

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 4670.2 ft^2/day S = 0.000144



MW-2 PUMPING TEST, MW-16 OBSERVATION WELL

Data Set: P:\...\MW-2 Pumping Test_MW-16 OW_CooperJacob.aqt
Date: 10/03/17 Time: 13:44:03

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-2
Test Date: 9/19/2017

AQUIFER DATA

Saturated Thickness: 31. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
MW-2	0	0

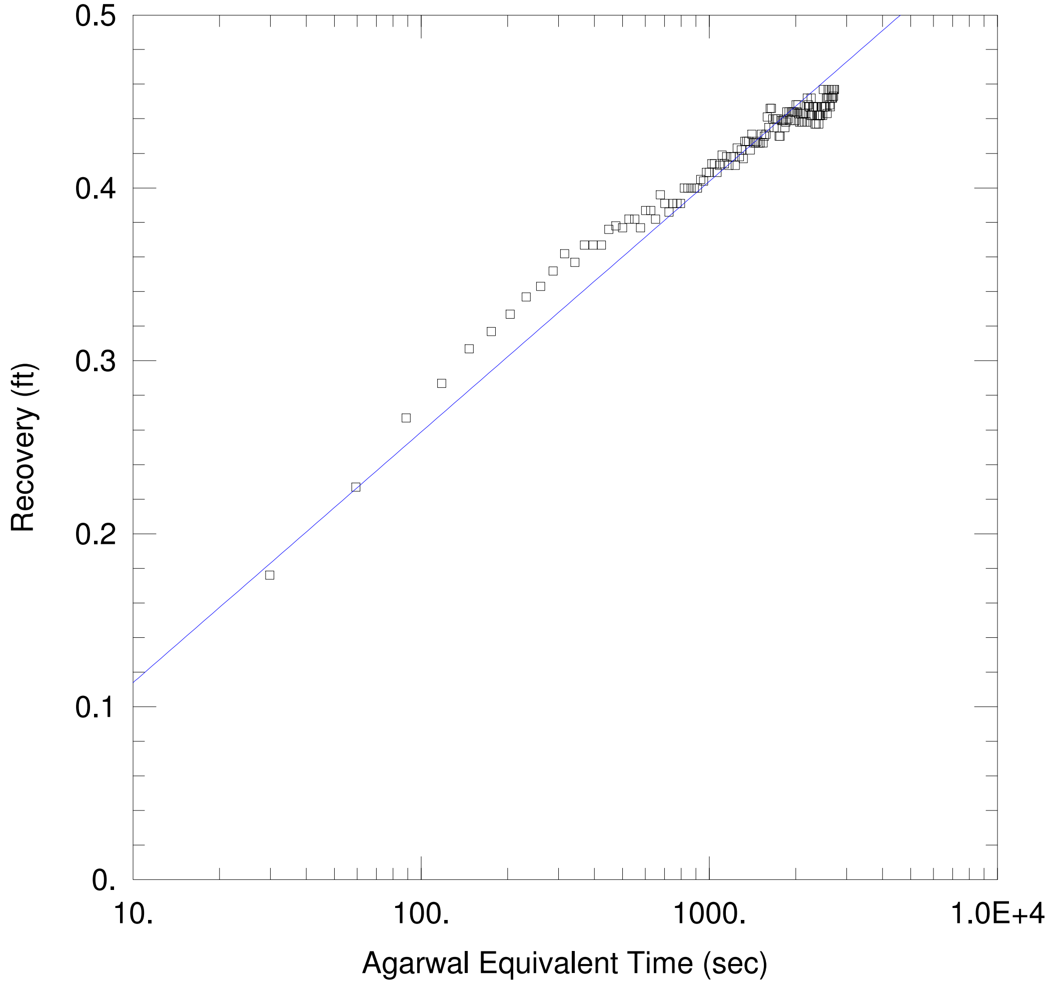
Observation Wells

Well Name	X (ft)	Y (ft)
□ MW-16 (B2)	0	71

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 6935.4 ft^2/day S = 0.0001826



MW-2 PUMPING TEST, MW-16 OBSERVATION WELL

Data Set: P:\...\MW-2 Pumping Test_MW-16 OW_CooperJacobRecovery.aqt
Date: 10/09/17 Time: 11:10:07

PROJECT INFORMATION

Company: HDR
Client: LOTT
Location: Hawks Prarie
Test Well: MW-2
Test Date: 9/19/2017

AQUIFER DATA

Saturated Thickness: 31. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
MW-2	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ MW-16 (B2)	0	71

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 7298.3 ft^2/day S = 6.173E-5