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# Vashon-Maury Island

## 2005 Well Data Report

Part of the Water Resources Evaluation Project

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September 2006



**King County**

Department of Natural Resources and Parks  
Water and Land Resources Division

**Science Section**

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Part of the Water Resources Evaluation Project

## Submitted by:

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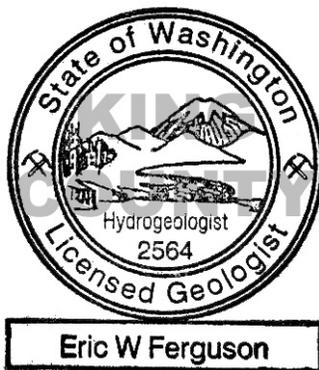
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## Part of the Water Resources Evaluation Project

The technical materials contained in this report were prepared under the supervision of a registered professional hydrogeologist, whose seal appears below.



Eric W. Ferguson, LHG

King County Department of Natural Resources and Parks

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Date

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# Table of Contents

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Executive Summary .....	v
1.0. Introduction.....	6
1.1 Overview.....	6
1.2 Dedicated Monitoring Wells.....	6
1.3 Coordination with King County Department of Transportation.....	7
2.0. Well Construction .....	8
2.1 Well Drilling Activities.....	8
2.1.1 North Vashon: VAS_w-60.....	8
2.1.2 Valley Center: VAS_w-61 .....	9
2.1.3 Maury Island: VAS_w-62.....	9
2.1.4 West Vashon: VAS_w-63.....	10
2.1.5 South Vashon: VAS_w-64.....	11
2.1.6 Valley Center: VAS_w-65.....	11
2.2 Water Level Data .....	12
3.0. Pump Test .....	13
3.1 Overview.....	13
3.2 Pumping Well .....	13
3.3 Observation well.....	13
3.4 Results.....	14
3.4.1 Comparison to other data.....	14
4.0. Summary.....	15
5.0. References.....	16

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## Figures

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Figure 1. Stratigraphic cross-sections and data gaps for the geologic mapping done by GeoMapNW in 2004.....	18
Figure 2. Map of monitoring well locations for Vashon-Maury Island.....	19
Figure 3. Depth to water (DTW) measurements versus time (log scale) at VAS_w-65, the pumping well. ....	20
Figure 4. DTW measurements versus time from 10 to 10,000 minutes into the pumping test. ..	20
Figure 5. Drawdown, in feet, versus time, in minutes, during the pumping test for both wells; VAS_w-65 – the pumping well and VAS_w-61 – the observation well.....	21
Figure 6. Drawdown, in feet, versus time, as $t/t'$ , for the recovery portion of the pump test. Well, VAS_w-65, is the pumping well and VAS_w-61 is the observation well.....	21

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## Tables

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Table 1. Well completion data for the monitoring wells on Vashon-Maury Island (VMI).....	23
Table 2. Water level measurements at the dedicated groundwater monitoring wells on VMI....	24
Table 3. Hydraulic Conductivity estimates of the Qva.....	25

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## Appendices

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Appendix A. Well Logs .....	26
Appendix B. Pump Test Information and Data .....	63

## EXECUTIVE SUMMARY

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Six monitoring wells were drilled and installed in the fall of 2005. These locations were chosen based on data gaps and/or closest available location. The emphasis of this work is to focus on the “main aquifer” known as the Qva geologic unit on Vashon-Maury Island (VMI). The wells were installed in the Qva or the next available aquifer.

The purpose of these wells is to have dedicated monitoring locations for water quality and water quantity (water levels) for long term monitoring of groundwater conditions on VMI. This effort is part of a larger scale data collection that is on-going as part of the Water Resource Evaluation Project. Continuous recording devices, Leveloggers®, have been installed at all sites to expand the data collection effort to monitor water levels across VMI.

A pump test was performed at one location with two wells at the Valley Center Park & Ride. The purpose of this test was to determine the hydraulic conductivity of the Qva. The test consisted of a 3-day pumping test followed by a 3-day recovery period. The hydraulic conductivity values calculated from this test ranged from 4.4 feet/day for the pumping test results and approximately 8.0 feet/day for the recovery test.

The hydraulic conductivity (and the transmissivity) values calculated from the pump test are within the range of values calculated from other work on VMI (0.6 to 33 feet/day).

# 1.0. INTRODUCTION

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The Water Resource Evaluation (WRE) Project is intended to cover monitoring, modeling, and data management activities within Vashon-Maury Island (VMI) for seven years (2004-2010). As part of this work, six dedicated monitoring wells were installed in 2005; this activity is summarized in this report. The structure of the report is as follows: Section 1.0 – Introduction and Overview; Section 2.0 – Well Construction; Section 3.0 – Pump Test; Section 4.0 – Summary.

## 1.1 Overview

Vashon-Maury Island is an island that lies in the Puget Lowland encompassing about 36 square miles. All drinking water sources on the island (springs, surface water, and groundwater) are supplied by precipitation directly on the island. Groundwater is the portion of precipitation that soaks into the ground and gets stored in underground geological water systems called aquifers. Every groundwater system is unique and dependent upon external factors such as the rate of precipitation, the interaction of groundwater with streams and other surface water bodies, and the rate of evapotranspiration. These external factors all contribute to the overall water budget. Understanding the water budget for Vashon-Maury Island and how it changes in response to human activities and climate changes is important in determining the amount of drinking water that can be used on a sustained basis.

A long-term plan that describes and evaluates the different components of the Vashon-Maury Island water budget is being implemented to address needs and concerns identified by residents of Vashon-Maury Island and King County staff. Much interest has been expressed over the years in the sustainability of the water supply on the island, although to date there has not been a comprehensive study to address many major water supply issues.

The work plan of the WRE Project is designed to provide a scientific evaluation of the water supply issues (both water quantity and quality related) on VMI. The work plan can be found at: <http://dnr.metrokc.gov/wlr/WQ/vashon-island/pdf/Vashon-Maury-Island-plan.pdf>. As part of this work plan, an island wide network of dedicated monitoring wells will help evaluate the water resources on VMI.

## 1.2 Dedicated Monitoring Wells

The WRE project work plan called for the installation of monitoring wells on VMI in 2005. These wells will be dedicated for monitoring water quantity (water levels) and water quality. The area selection for locating the wells was determined by identifying where data gaps and/or where there was a need for further data. The hierarchy of data needs that drive the site selection criteria is as follows:

1. Water levels (flow regime)
2. Aquifer areas of water quality concern

3. Stratigraphy
4. Aquifer properties

Recent geologic mapping work by GeoMapNW helped delineate those areas where data gaps exist. Figure 1 displays the stratigraphic cross-sections and highlights areas (with a black circle) where data gaps exist on VMI based on GeoMapNW's work.

### 1.3 Coordination with King County Department of Transportation

To save time and money for the WRE project, King County Department of Natural Resources and Parks (DNRP) staff contacted King County Department of Transportation (DOT) to inquire their assistance in the installation of monitoring wells on VMI. King County DOT has several "on-call" contracts with local drilling firms. As DOT has already done the public bidding process for their drilling contracts, time and money is saved by utilizing DOT for this task.

Several meetings occurred between DNRP and DOT staff to help outline the scope of work for installing dedicated monitoring wells. After these meetings, DOT requested estimates from their contractors for this body of work. The lowest estimate from the drilling firms was chosen (Holocene Drilling). A field visit/meeting was held with KC DNRP, DOT and Holocene Drilling staff to evaluate each proposed site for accessibility, safety, and usability.

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## 2.0. WELL CONSTRUCTION

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As mentioned in section 1.3, KC DOT assisted in the installation of dedicated monitoring wells on VMI. This section outlines the work completed at each site, describes the stratigraphy, provides the well completion data, and any additional data collected in 2005 at the new well sites.

### 2.1 Well Drilling Activities

After the site assessments were completed, DOT obtained clearance of the sites through a Utility Locate service. DOT also filed the necessary “Notice of Intent to Construct a Monitoring/Resource Protection Well” with the WA Department of Ecology (DoE). DoE gave notice to proceed to DOT and their contractor, Holocene Drilling, on September 20<sup>th</sup>, 2005. Wells, VAS\_w-60, VAS\_w-61, VAS\_w-62, VAS\_w-63 and VAS\_w-64, were drilled by Holocene Drilling using a truck mounted B-65 drill employing a mud rotary system to advance and support the boring. Soil samples were collected at selected depths at each site and will be retained at the Material Lab in Renton for 2 years.

Upon reaching the borehole completion depth, all of the monitoring wells were constructed in accordance with [Washington Administrative Code \(WAC\) 173-160, Part Two, General Requirements for Resource Protection Well Construction and Geotechnical Soil Borings](#). The bottom of each boring was backfilled with bentonite grout up to the desired depth. A two-inch diameter schedule 80 PVC well casing and screen was then lowered into each boring to the predetermined depth (note: well VAS\_w-65 was drilled with air rotary and has a 6-inch steel casing). Each well was completed with a 20’ of factory slotted 0.010” screen and with a 10’ deep sump below the well screen interval to allow for finer material to settle at the bottom of the well without affecting the screened interval. A sand pack was then placed around the well screen and casing to above the screen. The well was then sealed above the sand pack with bentonite grout to within two feet of the ground surface. The remainder of the well was capped with concrete and a steel cover to protect the wellhead from damage. In addition, locks have been placed on or in the well monuments depending on the surface completion to provide additional wellhead security. The following sections provide more detail about each individual site. Complete boring log as are presented in Appendix A. Specifications of the wells are summarized in Table 1.

#### 2.1.1 North Vashon: VAS\_w-60

This site is located off of Vashon Highway near SW 145<sup>th</sup> Place, Figure 2. The drilling activity at this site lasted approximately one week and was completed on October 24<sup>th</sup>, 2005. The log of the monitoring well installation is provided in Appendix A.

Soil samples were taken every five feet until 35’ below land surface (bls). Samples were then collected every 10’ down to 125’ bls. Below this depth, soil samples were collected every 20’ or when the material changed. Total depth of the boring was 270’.

The well was completed with 20' of screen at a depth from 220 to 240' bls with a 10' deep sump below the well screen interval. The surface completion of this well was originally planned to be above grade with a 3' stick-up monument and three bollards. However, due to road safety concerns, the well monument was re-completed to an "at grade" completion, sometime known as a flush mounted completion, on December 6<sup>th</sup>, 2005.

A summary of the surficial geology of this site is as follows:

0 - 1 feet bls	sod and topsoil
1 - 73 feet bls	till (Qvt)
73 – 256 feet bls	sand +/- gravel (Qva)
256 – 270 feet bls	silt +/- clay (Qpff)

### 2.1.2 Valley Center: VAS\_w-61

This site is located in the Valley Center Park & Ride off Vashon Highway near SW 204<sup>th</sup> Street, Figure 2. The drilling activity at this site lasted approximately one week and was completed on October 31<sup>st</sup>, 2005. The log of the monitoring well installation is provided in Appendix A.

Soil samples were taken every five feet until 35' bls. Then, samples were collected every 10' down to 85' bls. Below this depth, soil samples were collected every 20' or when the material changed. Total depth of the boring was 179'.

The well was completed with 20' of screen at a depth from 135 to 155' bls. A 10' sump was installed below the well screen interval. The surface completion of this well is above grade with a 3' stick-up monument & 3 bollards.

A summary of the surficial geology of this site is as follows:

0 - 0.5 feet bls	sod and topsoil
0.5 - 63 feet bls	till (Qvt)
63 – 175 feet bls	sand +/- gravel (Qva)
175 + feet bls	silt +/- clay (Qpff)

### 2.1.3 Maury Island: VAS\_w-62

This site is located off of Pt. Robinson Road at 63<sup>rd</sup> Ave SW, Figure 2. The drilling activity at this site lasted approximately 11 days and was completed on November 10<sup>th</sup>, 2005. The log of the monitoring well installation is provided in Appendix A.

Soil samples were taken every five feet until 35' bls, then every 10' down to 65' bls. Below this depth soil samples were collected every 20' or when the material changed. Total depth of the boring was 323'.

The well was completed with 20' of screen at a depth from 223 to 243' bls. A 10' sump was installed below the well screen interval. The surface completion of this well is above grade with a 3' stick-up monument and three bollards.

A summary of the surficial geology of this site is as follows:

0 – 101 feet bls	sand +/- gravel (Qva)
101 – 137 feet bls	silt (Qpff)
137 – 268 feet bls	sand +/- gravel (Qpfc)
268 – 323 feet bls	Alternating silt +/- clay and sand layers (Qpfnf ?)

#### 2.1.4 West Vashon: VAS\_w-63

This site is located on SW Redding Beach Road near Wax Orchard Rd, Figure 2. The drilling activity at this site lasted approximately one week and was completed on November 22<sup>nd</sup>, 2005. The log of the monitoring well installation is provided in Appendix A.

Soil samples were taken every five feet until 105' bls. Samples were collected every 10' down to 145' bls. Below this depth, soil samples were taken every 20' or when the material changed. Total depth of the boring was 283'.

The well was completed with 20' of screen at a depth from 125 to 145' bls. A 10' sump was installed below the well screen interval. The surface completion of this well was completed as a flush mounted well monument.

A summary of the surficial geology of this site is as follows:

0 - 1 feet bls	sod and topsoil
1 - 123 feet bls	till (Qvt)
123 – 128 feet bls	sand (Qva)
128 – 142 feet bls	clay (Qpf)
142 – 152 feet bls	sand (Qpfc)
152 – 160 feet bls	silt (Qpff)
160 – 240 feet bls	sand (Qpfc)
240 – 283 feet bls	silt +/- clay (Qpff)

### 2.1.5 South Vashon: VAS\_w-64

This site is located on Wax Orchard Road near Vashon Highway, Figure 2. The drilling activity at this site lasted approximately two weeks and was completed on December 19<sup>th</sup>, 2005. The log of the monitoring well installation is provided in Appendix A.

Soil samples were taken every five feet until 50' bls then every 10' down to 130' bls. Below this depth, soil samples were collected every 20' or when the material changed. Total depth of the boring was 308' bls.

The well was completed with 20' of screen at a depth from 224 to 244' bls. A 10' sump was installed below the well screen interval. The surface completion of this well was completed as a flush mounted well monument.

A summary of the surficial geology of this site is as follows:

0 - 1 feet bls	crushed surfacing top course
1 - 160 feet bls	till and till-like units (Qvt)
160 - 297 feet bls	sand, gravel and sand & gravel (Qva)
297 - 308 feet bls	Silt +/- clay & sand (Qpff)

### 2.1.6 Valley Center: VAS\_w-65

This site is located in the Valley Center Park & Ride off Vashon Highway near SW 204<sup>th</sup> Street, Figure 2. The drilling activities at this site were conducted by Tacoma Pump and Well Drilling Co. They lasted approximately three days and were completed on December 1<sup>st</sup>, 2005. The log of the monitoring well installation is provided in Appendix A. This well was installed approximately 30' north of VAS\_w-61.

Tacoma Pump and Well Drilling employed an air rotary drill to advance the well and 6-inch diameter casing was used to support the open borehole. The well drilling procedure began by drilling a 12-inch diameter hole, 20' in depth, and backfilling it with bentonite chips to form the sanitary seal. A 6-inch diameter well casing was then drilled through the sanitary seal. When the well was drilled to 155', a 20-foot long 5-inch stainless steel well screen consisting of 0.010-inch wide slots was lowered into place. The blank casing was withdrawn to expose the screen to the formation. A packer at the top of the screen formed a seal between the casing and the screen.

Soil samples were grabbed every 10 feet. The well was completed with 20' of screen at a depth from 135 to 155' bls. The surface completion of this well is above grade with a 3' stick-up monument and three bollards.

A summary of the surficial geology of this site is as follows:

0 - 0.5 feet bls	sod and topsoil
------------------	-----------------

0.5 - 63 feet bls	till (Qvt)
63 - 155 feet bls	sand +/- gravel (Qva)

## 2.2 Water Level Data

The depth to water (DTW), also known as water level (WL), measurements were taken at all sites after well development was completed. Typically, well development occurred several weeks after the well installation. Water level measurements were taken at numerous times for these sites in 2005. Continuous water levels meters (Leveloggers™) will be installed in these locations in 2006. The locations of these monitoring wells are shown in Figure 2 and the WL data are presented in Table 2.

## 3.0. PUMP TEST

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A pump test was incorporated into the tasks of monitoring wells due to the lack of abundant data. The VMI modeling report (King County, 2005) outlined that about 6 pump tests have been reported on the island. It was our plan to obtain more data about the “main” aquifer hydraulic parameters by performing this pump test. The original scoping of the work had the pump test located near the Redding Beach or Wax Orchard site, however the location and the stratigraphy was not best suited for the 3-day pump test. Instead, the Valley Center Park & Ride site was selected.

### 3.1 Overview

The pump test was conducted over a 3 day period in the 6” test well by the subcontractor, Tacoma Pump and Well Drilling, in early December. Appendix B contains the outline of instructions for the pump test procedures. The test consisted of a pumping and a recovery portion. Each portion of the test lasted for 3 days. The pumping portion began on December 6<sup>th</sup> and ended on the 8<sup>th</sup>. The recovery portion of the test immediately started after the pumping and continued until the 11<sup>th</sup>. These steps will also be discussed in greater detail in the following sections.

### 3.2 Pumping Well

The pumping well was the 6” well at the Valley Center Park & Ride with KC well id # of VAS\_w-65. The levellogger data was collected on a logarithmic scale for the pumping and recovery portions of the test. The rate of discharge was measured on a regular basis to help maintain a constant pumping rate. After initial fluctuations at the start, the pumping rate was held near 37 gallons per minute (GPM), see Appendix B. The levellogger was stopped and data downloaded before the end of the pumping portion of the test. The levellogger was re-started and deployed before turning off the pump and starting the recovery portion of the test. Manual depth to water (DTW) measurements were also taken hourly during the test, see section 3.4 and Appendix B for results.

### 3.3 Observation well

The 2-inch well at the Valley Center Park & Ride, with KC well id # of VAS\_w-61, was installed as the observation well. Data was recorded at this location at the same time as at the pumping well. The levellogger data was collected on a logarithmic scale for the pumping and recovery portions of the test. Manual DTW measurements were also recorded during the test. Having an additional location recording data during the pump test allows for more data interpretation via different tests, see next section for results.

## 3.4 Results

The data for these tests (pump and recovery) were collected via manual measurements and continuous recorders. Figures 3 & 4 are the manual (depth to water) measurements plotted versus time shown on a log scale for the pumping well.

The analyses used were the Jacob straight line method (log time vs. drawdown - Figure 5) for the pumping portion of the test and Theis's recovery method ( $\log(t/t')$  vs. drawdown - Figure 6) for the recovery portion for the test.

In using these methods there are limitations and assumptions. They are:

- Confined conditions rather than unconfined
- Fully penetrated screened zones
- No leakage from units above or below the pumping unit.

Each of these methods yields a transmissivity (T) for the aquifer. This value is a calculation (EQ 1) of the hydraulic conductivity (K) multiplied by the thickness of the aquifer (b).

$$\text{EQ 1:} \quad T = K * b \quad \text{units} = \text{Length}^2/\text{time}$$

With a known thickness of the aquifer, the hydraulic conductivity can be calculated from the transmissivity. For the pumping test, drawdown analysis, the transmissivity is calculated to be 439 sq ft / day, see Figure 5. The thickness of the aquifer is estimated to be about 100' from the well log, Appendix A. Using the transmissivity and the thickness stated above, hydraulic conductivity is about 4.4 ft/d.

The recovery analysis yields a somewhat higher transmissivity value of 804 ft<sup>2</sup>/d, see Figure 6. With the same thickness of 100', this would estimate hydraulic conductivity close to 8 ft/d.

Both analyses used late time data which is more representative of a larger section of the aquifer. The earlier time data yield a higher transmissivity (or conductivity). This is likely due to the coarser layer that was found at the top of the Qva, see well logs in Appendix A. This coarse layer of the aquifer probably dewateres first and helps create the two line plot, Figure 4. The higher recovery T is probably due to that same layer refilling.

### 3.4.1 Comparison to other data

The hydraulic conductivity (and the transmissivity) values calculated from the pump test are within the range of other estimates calculated on Vashon-Maury Island, see Table 3. The range of values calculated from other work is from 0.6 to 33 feet/day, as compared to current work of 4.4 and 8.0 feet/day.

Another source for comparison is the Phase I (steady state) model of the island done in 2004-2005. This work started with a uniform hydraulic conductivity of 10 feet/day and through many iterations resulted in a value of 2.5 feet/day.

## 4.0. SUMMARY

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Six monitoring wells were drilled and installed in the Fall of 2005. Figure 2 shows the locations of the completed wells. These locations were chosen based on data gaps and/or closest available location. Well completion information is presented in Table 1 and Appendix A

The purpose of these wells is to have dedicated monitoring locations for water quality and water quantity (water levels) for long term monitoring of groundwater conditions on Vashon-Maury Island. Continuous recording devices, Leveloggers®, were later installed at all sites to expand the data collection effort to monitor water levels across VMI. Table 2 presents the water level data collected in 2005 at the monitoring well locations. Dedicated water quality sampling setups will be installed (early 2007) in each of the wells to detect selected parameters at substantially lower levels than current monitoring efforts.

A pump test was conducted in December to determine the hydraulic conductivity of the Qva aquifer. This work will add to the limited data on the aquifer properties for sites on Vashon-Maury Island. The test consisted of a 3-day pumping test followed by a 3-day recovery period. The hydraulic conductivity calculated from these test yielded a range of values of 4.4 feet/day for the pumping test results and approximately 8.0 feet/day for the recovery test.

The hydraulic conductivity (and the transmissivity) values calculated from the pump test are within the range of other estimates calculated for Vashon-Maury Island, see Table 3. The range of values calculated from other work is from 0.6 to 33 feet/day, as compared to current work of 4.4 and 8.0 feet/day.

## 5.0. REFERENCES

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Rongey and Assocs. 1992. Heights Water Corporation – Construction & Testing, Well No. 3. Nov. 20, 1992.

# Figures

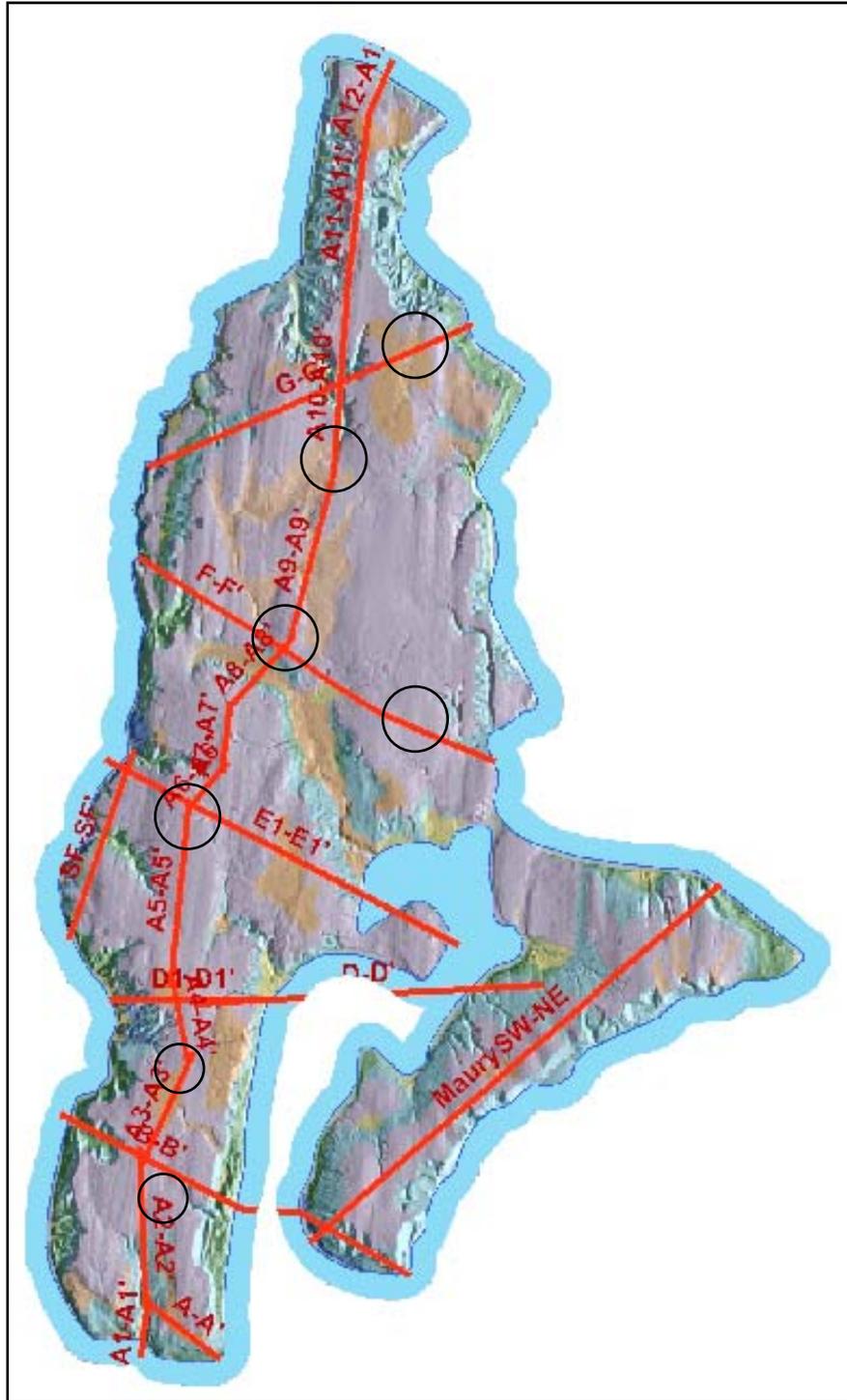


Figure 1. Stratigraphic cross-sections and data gaps for the geologic mapping done by GeoMapNW in 2004. The redlines are the stratigraphic cross-sections identifiers. The black circles represent those areas where data gaps exist.

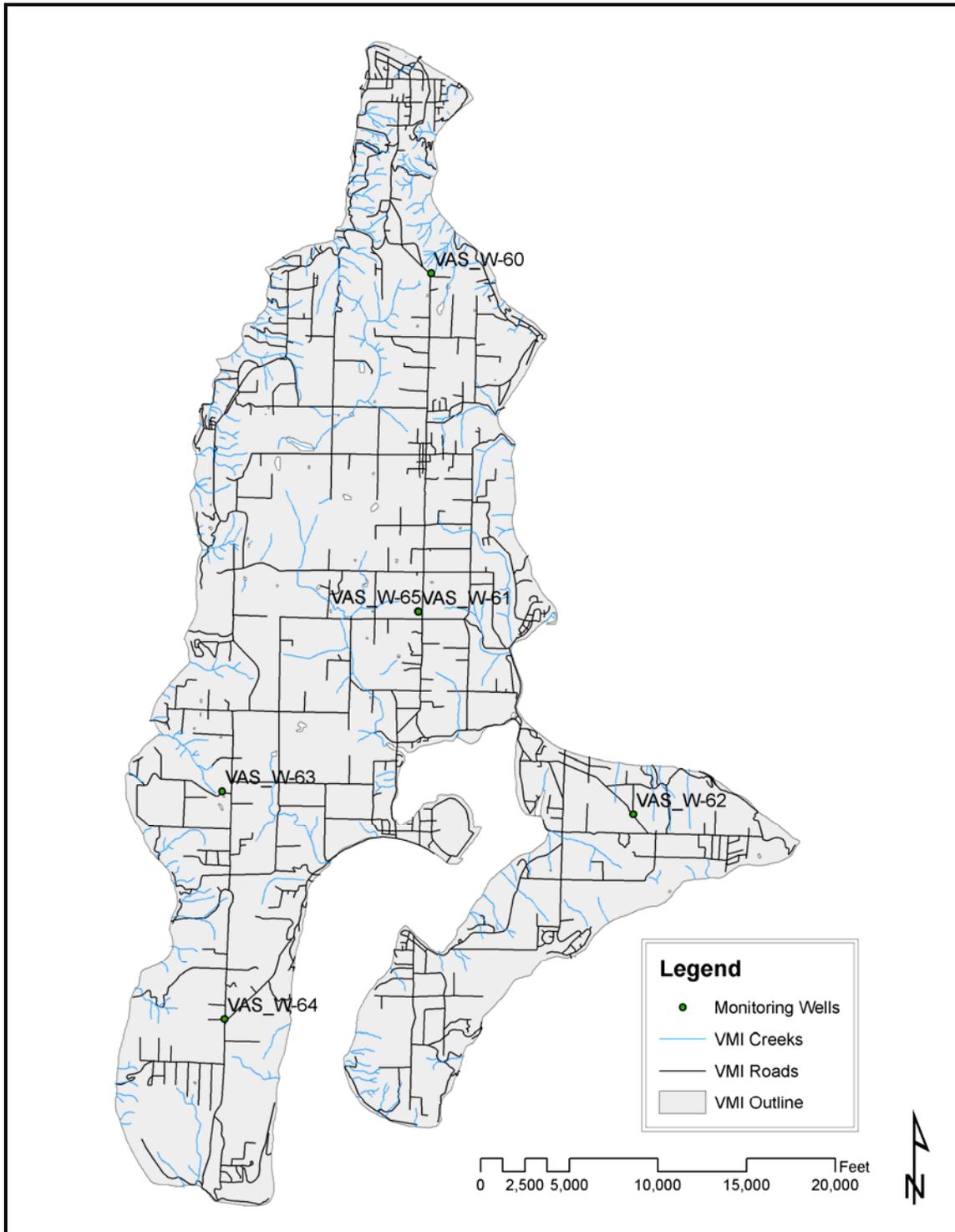


Figure 2. Map of monitoring well locations for Vashon-Maury Island. The Valley Center Park & Ride has two wells at this location; VAS\_w-61 and VAS\_w-65.

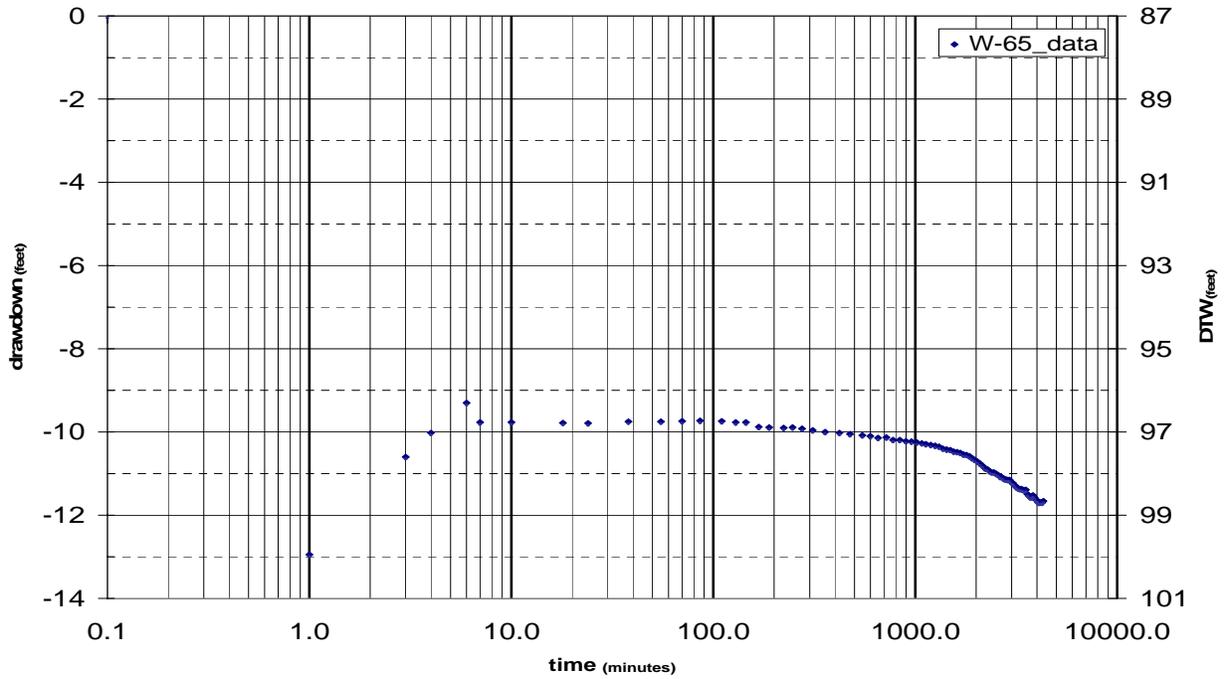


Figure 3. Drawdown (and depth to water) measurements versus time (log scale) at VAS\_w-65, the pumping well. The drawdown measurements are calculated from the depth to water measurements as change from the starting water table surface. The scale on the right side is the depth to water (DTW) measurements.

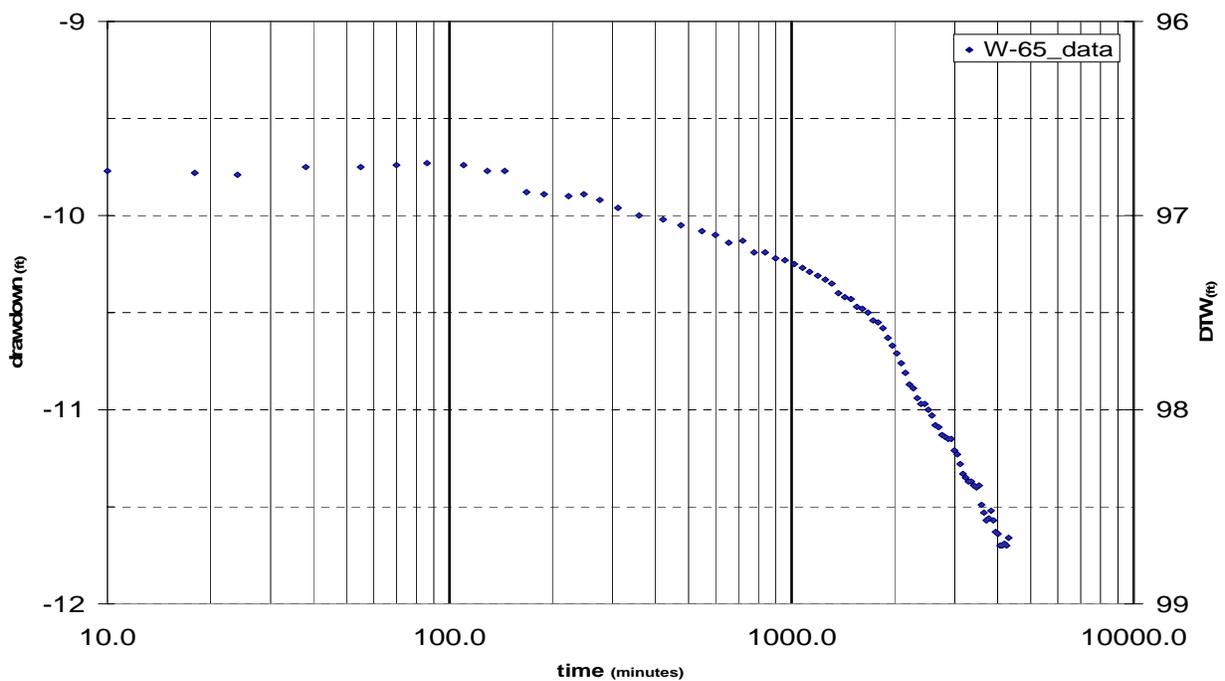


Figure 4. Drawdown and DTW measurements versus time from 10 to 10,000 minutes into the pumping test. This graph shows the data from the later part of the pumping test.

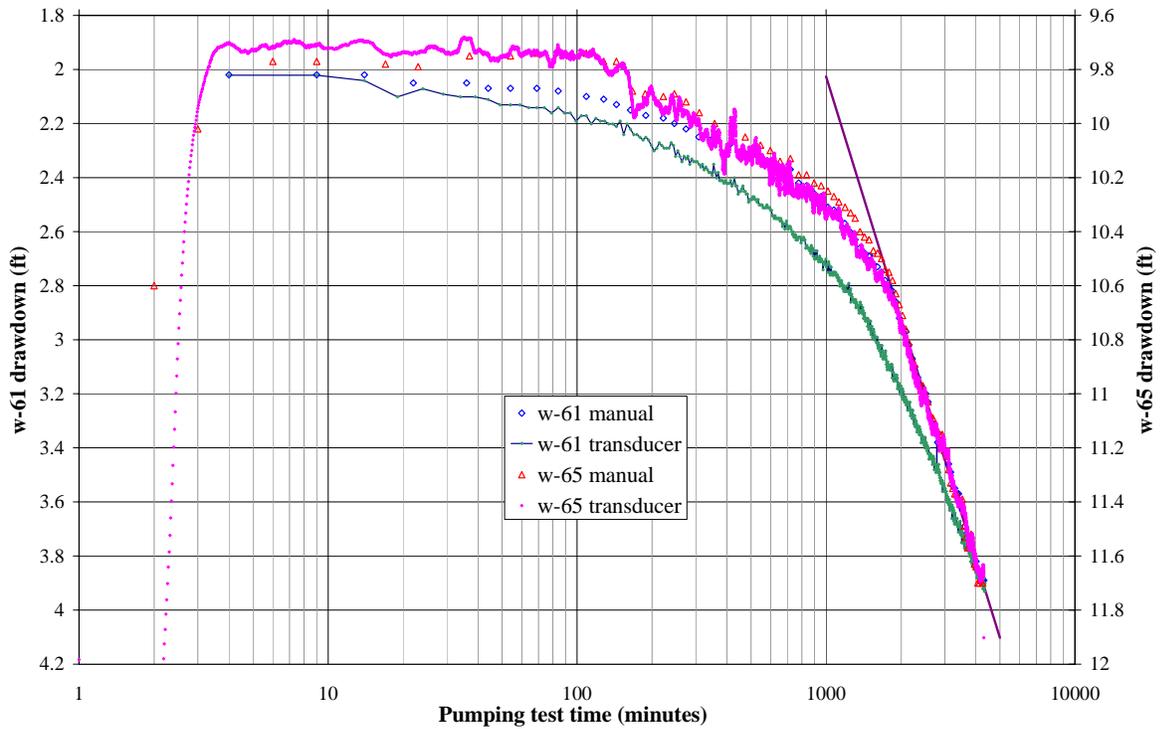


Figure 5. Drawdown, in feet, versus time, in minutes, during the pumping test for both wells; VAS\_w-65 – the pumping well and VAS\_w-61 – the observation well. The best fit lines are shown for both wells.

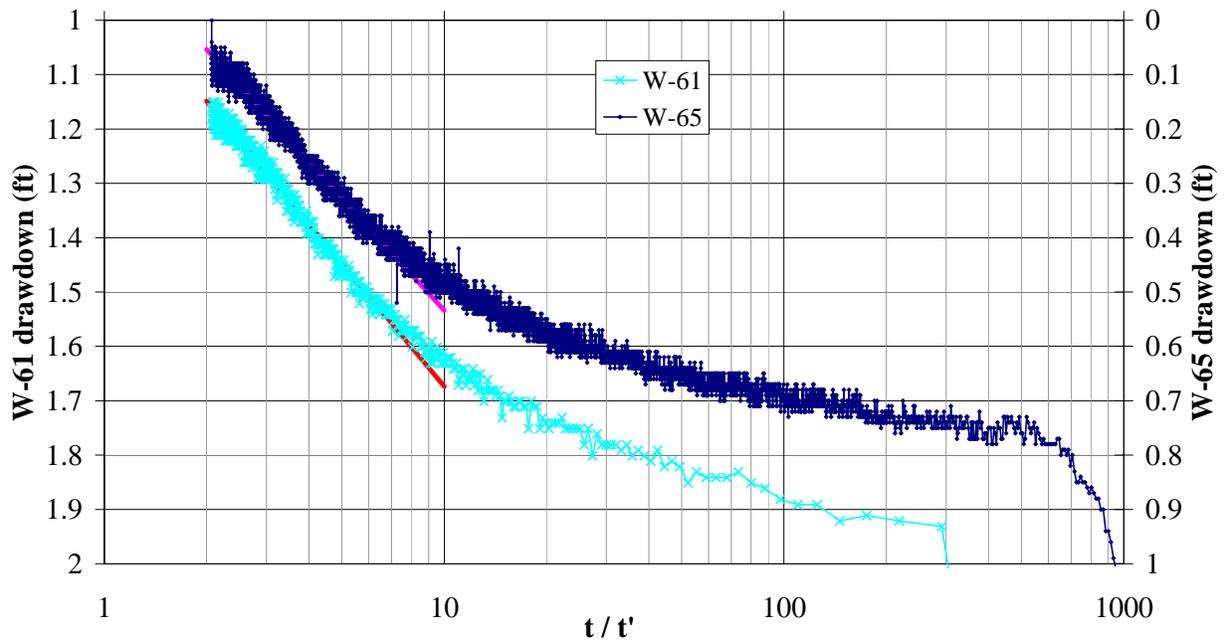


Figure 6. Drawdown, in feet, versus time, as  $t/t'$ , for the recovery portion of the pump test. Well, VAS\_w-65, is the pumping well and VAS\_w-61 is the observation well. The best fit lines are shown for both wells.

# Tables

**Table 1. Well completion data for the monitoring wells on Vashon-Maury Island (VMI).**

Well ID	Well Depth <sup>1</sup> (ft, bls)	Casing Diameter (inch)	Surface Elevation <sup>2</sup> (ft, MSL)	Boring Depth (ft, bls)
VAS_w-60	240	2	400	270
VAS_w-61	155	2	325	175
VAS_w-62	243	2	330	323
VAS_w-63	145	2	290	283
VAS_w-64	244	2	380	308
VAS_w-65	155	6	325	155

<sup>1</sup> = well depth is to the bottom of the screen. All 2" wells have a 10' sump below the bottom of the screen.

<sup>2</sup> = surface elevation based on LiDAR elevations - - not surveyed (GPS) at the time of the report.

**Table 2. Water level measurements at the dedicated groundwater monitoring wells on VMI.**

<b>WELL ID</b>	<b>Site Name</b>	<b>Date Measured</b>	<b>Depth to water (feet)</b>
VAS_w-60	Vashon Hwy SW, near 145th Pl	10/31/2005	205.50
		11/16/2005	210.10
		12/01/2005	223.80
		12/12/2005	180.45
		12/13/2005	197.63
VAS_w-61	Valley Center Park & Ride 2" well	10/31/2005	81.10
		11/16/2005	84.80
		12/05/2005	85.08
		12/06/2005	84.81
		12/12/2005	85.53
		12/13/2005	85.73
VAS_w-62	Maury Island - 63rd Ave SW	11/16/2005	dry*
		12/05/2005	dry*
		12/12/2005	dry*
VAS_w-63	SW Redding Beach Rd	12/13/2005	109.83
VAS_w-65	Valley Center Park & Ride 6" well	12/05/2005	85.25
		12/06/2005	85.05
		12/12/2005	87.45
		12/13/2005	85.85

dry\* = These measurements were below the screen zone inferring no water flowing into the well.

**Table 3. Hydraulic Conductivity estimates of the Qva. Other VMI data adapted from Table 3 in the VMI modeling report (King County 2005).**

Source	Well / locale	Citation	Aquifer	Hydraulic conductivity (ft/d)
Drawdown test	VAS_w-65 & VAS_w-61	This report	Qva	4.4
Recovery test	VAS_w-65 & VAS_w-61	This report	Qva	8.0
<b><u>Values directly measured on Vashon-Maury Island</u></b>				
KCWD #19	Morgan Hill	AGI (1997a)	Qva	8*
Heights Water	Well #3	Rongey (1992)	Qva	33
King Co DNRP, Solid Waste Division	7 Monitoring Wells on landfill site (13 slug tests)	Berryman & Henigar (2004)	Qva	6 (median) 0.6 – 6.8

\* Calculated from published transmissivity (T), equal to the horizontal hydraulic conductivity of a layer times the thickness of the layer, and the reported screen length  
ft/d = feet per day

# Appendix A

## Well Logs

# KEY TO SYMBOLS

Symbol Description

## Strata symbols

	Topsoil
	Silty sand
	Silt
	Poorly graded sand
	Poorly graded gravel
	Well graded sand
	Low plasticity clay
	Low plasticity organic silts
	Crushed Surfacing Base Course
	Silty gravel

## Misc. Symbols

	Bottom of Boring
	Boring continues

Symbol Description

Water table during drilling

## Soil Samplers

	Standard penetration test
	No recovery
	Grab sample

## Monitor Well Details

	flush-mount cover
	recessed cover set in concrete
	pipe set in cement grout w/ protective casing
	bentonite slurry
	silica sand, blank PVC
	slotted pipe w/ sand
	no pipe, sealed
	riser with cover and protective casing

## Notes:

1. The test wells were drilled and sampled between October 17, 2005 and December 16, 2005 using a truck mounted Mobile B-65 drill. The borings were advanced with a tricone bit and supported with drilling fluid. Well VAS\_W-65 was drilled with a truck mounted air rotary drill.
2. The borings were located by measuring from nearby roads and intersections. The boring elevations were extrapolated from USGS 1 : 24,000 quadrangle maps.
3. These logs are subject to the limitations, conclusions, and recommendations in this report.

# KEY TO SYMBOLS

Symbol Description

## Monitor Well Details



bentonite pellets



concrete seal



6 inch diameter well casing.



6 inch diameter 0.010  
Stainless steel well screen.

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-60

**PROJECT: Vashon-Maury Island Groundwater Study**  
**BORING LOCATION: North Vashon**  
**DRILL METHOD: Mud Rotary**  
**DRILLER: Holocene Drilling**  
**DEPTH TO - Water: 206 ft**

**DATE: October 17, 2005**  
**START: 10/17/05**  
**FINISH: 10/24/05**  
**LOGGER: D. Armstrong**  
**DATE CHECKED: 10/31/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
400 0		SM	Sod and a thin topsoil.				
	4,4,4	ML	Brown silty sand with gravel, moist, loose.				
390 10	12,21,25	SM	Gray and brown silt with sand and gravel, wet, loose.				
	8,12,16		Gray silty sand with gravel, moist, medium dense to very dense.				
380 20	16,27,35						
	18,19,23						
370 30	26,50/4"						
	15,20,31						
360 40	32,50/5"						
350 50	17,39,50/5"		Soil mottles found in sample.				
340 60	20,26,44						
330 70							

*The Boring is located on the north side of Vashon Highway near the street address of 14435 Vashon Highway.  
 Department of Ecology well identification number: ALP 301 (R 45336)*

PLATE 1

# LOG OF MONITOR WELL INSTALLATION

WELL NO. VAS\_W-60

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **North Vashon**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **206 ft**

DATE: **October 17, 2005**  
 START: **10/17/05**  
 FINISH: **10/24/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **10/31/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">320 — 80</div> <div style="margin-bottom: 10px;">310 — 90</div> <div style="margin-bottom: 10px;">300 — 100</div> <div style="margin-bottom: 10px;">290 — 110</div> <div style="margin-bottom: 10px;">280 — 120</div> <div style="margin-bottom: 10px;">270 — 130</div> <div style="margin-bottom: 10px;">260 — 140</div> </div>		<p>SP</p> <p>GP</p> <p>SP</p>	<p>Gray brown poorly graded sand with gravel, moist, very dense. Few lenses of silty sand. Transitional beds at base of the till.</p> <p>Brown poorly graded gravel with sand, moist, very dense.</p> <p>Gray poorly graded sand with gravel, moist, very dense.</p> <p>Slight increase in the silt content. Increase in coarse gravel content.</p>			<p>Cobbles or large gravel at 89 to 91 feet. Caving formation.</p>	

*The Boring is located on the north side of Vashon Highway near the street address of 14435 Vashon Highway. Department of Ecology well identification number: ALP 301 (R 45336)*

PLATE 1

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-60

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **North Vashon**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **206 ft**

DATE: **October 17, 2005**  
 START: **10/17/05**  
 FINISH: **10/24/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **10/31/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
250 150							
240 160		SW	Brown well graded sand with gravel, moist, very dense.				
230 170		GP	Brown poorly graded gravel with sand, moist, very dense.				
220 180		GP	Brown poorly graded gravel with sand, moist, very dense.				
210 190		SP	Gray poorly graded sand, moist, very dense.				
200 200							
190 210							

*The Boring is located on the north side of Vashon Highway near the street address of 14435 Vashon Highway. Department of Ecology well identification number: ALP 301 (R 45336)*

PLATE 1

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-60

**PROJECT: Vashon-Maury Island Groundwater Study**  
**BORING LOCATION: North Vashon**  
**DRILL METHOD: Mud Rotary**  
**DRILLER: Holocene Drilling**  
**DEPTH TO - Water: 206 ft**

**DATE: October 17, 2005**  
**START: 10/17/05**  
**FINISH: 10/24/05**  
**LOGGER: D. Armstrong**  
**DATE CHECKED: 10/31/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
180 220							
	▲ 27.35,38						
170 230			Carbonized organic material in the cuttings.				
		SP	Gray poorly graded sand, wet, very dense.			Slow drilling	
160 240							
	▲ 29.33,40						
150 250							
		ML	Gray sandy silt, moist to wet, very dense.				
140 260							
	▲ 24.50/5.5"						
130 270							
	▲ 30.50/3"	CL	Gray lean clay, moist, hard.				
120 280							

*The Boring is located on the north side of Vashon Highway near the street address of 14435 Vashon Highway.  
 Department of Ecology well identification number: ALP 301 (R 45336)*

PLATE 1

# KEY TO SYMBOLS

Symbol Description

Strata symbols

	Topsoil
	Silty sand
	Silt
	Poorly graded sand
	Poorly graded gravel
	Well graded sand
	Low plasticity clay
	Low plasticity organic silts
	Crushed Surfacing Base Course
	Silty gravel

Misc. Symbols

	Bottom of Boring
	Boring continues

Symbol Description

	Water table during drilling
---	-----------------------------

Soil Samplers

	Standard penetration test
	No recovery
	Grab sample

Monitor Well Details

	flush-mount cover
	recessed cover set in concrete
	pipe set in cement grout w/ protective casing
	bentonite slurry
	silica sand, blank PVC
	slotted pipe w/ sand
	no pipe, sealed
	riser with cover and protective casing

Notes:

1. The test wells were drilled and sampled between October 17, 2005 and December 16, 2005 using a truck mounted Mobile B-65 drill. The borings were advanced with a tricone bit and supported with drilling fluid. Well VAS\_W-65 was drilled with a truck mounted air rotary drill.
2. The borings were located by measuring from nearby roads and intersections. The boring elevations were extrapolated from USGS 1 : 24,000 quadrangle maps.
3. These logs are subject to the limitations, conclusions, and recommendations in this report.

# KEY TO SYMBOLS

Symbol Description

## Monitor Well Details



bentonite pellets



concrete seal



6 inch diameter well casing.



6 inch diameter 0.010  
Stainless steel well screen.

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-61

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **North Vashon**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **81 ft**

DATE: **October 25, 2005**  
 START: **10/25/05**  
 FINISH: **10/31/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **10/31/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
0		GP	Sod and a thin topsoil.				
3.4, 4		SP	Brown poorly graded gravel				
		SM	with sand, moist, loose. (Fill)				
		CL	Dark brown poorly graded sand				
4.7, 7			with gravel and wood debris, wet, loose. (Topsoil)				
		SM	Brown silty sand with gravel, moist, loose. Traces of carbonized wood.				
7.6, 5							
			Brown lean clay, wet, stiff.				
			Brown silty sand with gravel, wet, loose to medium dense.				
2.4, 4		SM	Sample contained a few soil mottles.				
			Gray mottled silty sand with gravel, moist to wet, very dense.				
22, 29, 26		SP	Sample was jointed. Iron stains in joints. Soil sample appears disturbed.				
15, 18, 25							
		SM	Brown poorly graded sand, wet, dense.				
			Gray brown silty sand with gravel, moist, dense. (Till Like)				
11, 13, 20		SP	Brown poorly graded sand, moist, very dense. Trace gravel in cuttings.				
20, 31, 33							
		SM	Dark brown silty sand with wood debris and possible void, wet, loose. (topsoil?)				
4, 13, 20		SP					
		GP	Brown poorly graded sand, moist, dense.				
			Dark poorly graded gravel with				

*The Boring is located on west end of the Park and Ride near the intersection of Vashon Highway and SW 204th Street. Department of Ecology well identification number: ALP 304 (R 45339).*

PLATE 2

# LOG OF MONITOR WELL INSTALLATION

WELL NO. VAS\_W-61

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **North Vashon**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **81 ft**

DATE: **October 25, 2005**  
 START: **10/25/05**  
 FINISH: **10/31/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **10/31/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
			<p>sand occasional cobbles, moist, very dense.</p>				
<p>230</p> <p>80</p> <p>220</p> <p>90</p> <p>210</p> <p>100</p> <p>200</p> <p>110</p> <p>190</p> <p>120</p> <p>180</p> <p>130</p> <p>170</p> <p>140</p>	<p>40.50/3"</p> <p>28.50/3"</p> <p>28.50/6"</p> <p>50.50/5"</p> <p>33.50/5"</p>	<p>SP</p>	<p>Gray poorly graded sand, wet, very dense.</p> <p>Sand is getting finer with depth.</p>				

*The Boring is located on west end of the Park and Ride near the intersection of Vashon Highway and SW 204th Street. Department of Ecology well identification number: ALP 304 (R 45339).*

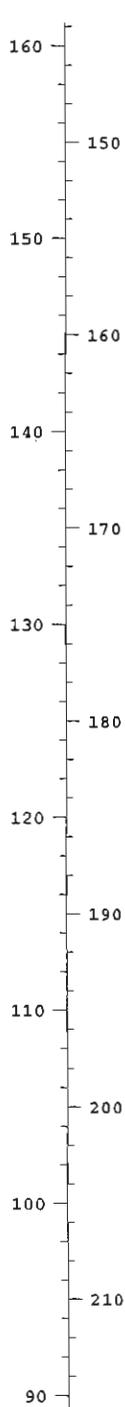
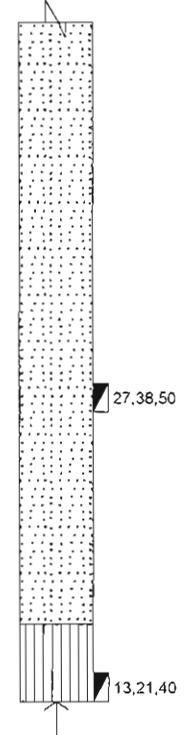
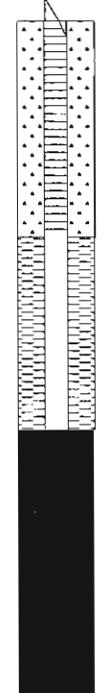
PLATE 2

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-61

**PROJECT: Vashon-Maury Island Groundwater Study**  
**BORING LOCATION: North Vashon**  
**DRILL METHOD: Mud Rotary**  
**DRILLER: Holocene Drilling**  
**DEPTH TO - Water: 81 ft**

**DATE: October 25, 2005**  
**START: 10/25/05**  
**FINISH: 10/31/05**  
**LOGGER: D. Armstrong**  
**DATE CHECKED: 10/31/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
		<p style="text-align: center;">ML</p>	<p style="text-align: center;">Gray silt, moist, very dense.</p>				

*The Boring is located on west end of the Park and Ride near the intersection of Vashon Highway and SW 204th Street. Department of Ecology well identification number: ALP 304 (R 45339).*

**PLATE 2**

# KEY TO SYMBOLS

Symbol Description

## Strata symbols

	Topsoil
	Silty sand
	Silt
	Poorly graded sand
	Poorly graded gravel
	Well graded sand
	Low plasticity clay
	Low plasticity organic silts
	Crushed Surfacing Base Course
	Silty gravel

## Misc. Symbols

	Bottom of Boring
	Boring continues

Symbol Description

Water table during drilling

## Soil Samplers

	Standard penetration test
	No recovery
	Grab sample

## Monitor Well Details

	flush-mount cover
	recessed cover set in concrete
	pipe set in cement grout w/ protective casing
	bentonite slurry
	silica sand, blank PVC
	slotted pipe w/ sand
	no pipe, sealed
	riser with cover and protective casing

## Notes:

1. The test wells were drilled and sampled between October 17, 2005 and December 16, 2005 using a truck mounted Mobile B-65 drill. The borings were advanced with a tricone bit and supported with drilling fluid. Well VAS\_W-65 was drilled with a truck mounted air rotary drill.
2. The borings were located by measuring from nearby roads and intersections. The boring elevations were extrapolated from USGS 1 : 24,000 quadrangle maps.
3. These logs are subject to the limitations, conclusions, and recommendations in this report.

# KEY TO SYMBOLS

Symbol Description

## Monitor Well Details



bentonite pellets



concrete seal



6 inch diameter well casing.



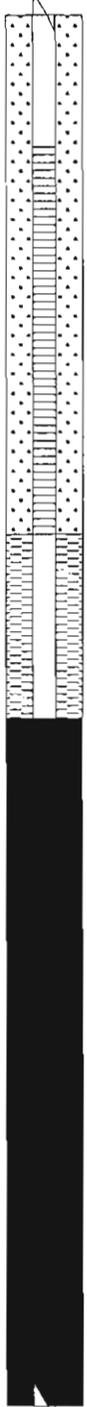
6 inch diameter 0.010  
Stainless steel well screen.

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-62

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **Maury Island**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water:

DATE: **October 31, 2005**  
 START: **10/31/05**  
 FINISH: **11/10/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **N/A**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
110 220		GP	Brown poorly graded gravel with sand, moist, very dense.				
100 230							
90 240		SP	Gray poorly graded sand with occasional gravel, moist, very dense. Some layering apparent based on the drilling rate changes.			Slow drilling.	
80 250							
70 260							
60 270		ML	Gray silt with sand, moist, very dense.				
50 280		SP	Gray poorly graded sand, moist, very dense.				
		CL					

*The Boring is located on the west side of 63 Ave. SW, at the intersection with SW Point Robinson Rd. Groundwater was not encountered during drilling. Department of Ecology Well Identification number: ALP 303 (R45338).*

PLATE 3

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-62

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **Maury Island**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water:

DATE: **October 31, 2005**  
 START: **10/31/05**  
 FINISH: **11/10/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **N/A**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
330 0		SM	Brown silty sand with gravel,			A sample was not attempted at 2.5 feet due to large gravel at this interval.	
		GP	moist, loose to medium dense.				
		SP	Brown poorly graded gravel with sand, moist, dense.				
320 10	13,23,15		Brown poorly graded sand with gravel, moist, dense.				
	17,43,50/5"	GP	Brown poorly graded gravel with sand, moist, very dense.				
	6,12,29						
310 20	15,22,29						
	16,30,42						
300 30	13,39,50/5"		Material transition zone.				
290 40	324,27,32	SP	Brown poorly graded sand, moist, very dense.				
280 50	19,30,41						
270 60	28,43,47						
260 70							

*The Boring is located on the west side of 63 Ave. SW, at the intersection with SW Point Robinson Rd. Groundwater was not encountered during drilling. Department of Ecology Well Identification number: ALP 303 (R45338).*

PLATE 3

# LOG OF MONITOR WELL INSTALLATION

WELL NO. VAS\_W-62

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **Maury Island**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water:

DATE: **October 31, 2005**  
 START: **10/31/05**  
 FINISH: **11/10/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **N/A**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">250 80</div> <div style="margin-bottom: 10px;">240 90</div> <div style="margin-bottom: 10px;">230 100</div> <div style="margin-bottom: 10px;">220 110</div> <div style="margin-bottom: 10px;">210 120</div> <div style="margin-bottom: 10px;">200 130</div> <div style="margin-bottom: 10px;">190 140</div> </div>							
		GP	Brown poorly graded gravel with sand and occasional cobbles, moist, very dense.				
		SP	Brown poorly graded sand, moist, very dense.				
		CL	Gray lean clay with silt and sand, moist, hard.				
		SP	Gray poorly graded sand with gravel, moist, very dense.				

*The Boring is located on the west side of 63 Ave. SW, at the intersection with SW Point Robinson Rd. Groundwater was not encountered during drilling. Department of Ecology Well Identification number: ALP 303 (R45338).*

PLATE 3

# LOG OF MONITOR WELL INSTALLATION

WELL NO. VAS\_W-62

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **Maury Island**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water:

DATE: **October 31, 2005**  
 START: **10/31/05**  
 FINISH: **11/10/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **N/A**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">180 — 150</div> <div style="margin-bottom: 10px;">170 — 160</div> <div style="margin-bottom: 10px;">160 — 170</div> <div style="margin-bottom: 10px;">150 — 180</div> <div style="margin-bottom: 10px;">140 — 190</div> <div style="margin-bottom: 10px;">130 — 200</div> <div style="margin-bottom: 10px;">120 — 210</div> </div>			<p>Occasional gravel.</p> <p>Gray poorly graded gravel with sand, moist, very dense</p> <p>Gray poorly graded sand, moist, very dense.</p>				

*The Boring is located on the west side of 63 Ave. SW, at the intersection with SW Point Robinson Rd. Groundwater was not encountered during drilling. Department of Ecology Well Identification number: ALP 303 (R45338).*

PLATE 3



# KEY TO SYMBOLS

Symbol Description

## Strata symbols

	Topsoil
	Silty sand
	Silt
	Poorly graded sand
	Poorly graded gravel
	Well graded sand
	Low plasticity clay
	Low plasticity organic silts
	Crushed Surfacing Base Course
	Silty gravel

## Misc. Symbols

	Bottom of Boring
	Boring continues

Symbol Description

	Water table during drilling
---	-----------------------------

## Soil Samplers

	Standard penetration test
	No recovery
	Grab sample

## Monitor Well Details

	flush-mount cover
	recessed cover set in concrete
	pipe set in cement grout w/ protective casing
	bentonite slurry
	silica sand, blank PVC
	slotted pipe w/ sand
	no pipe, sealed
	riser with cover and protective casing

## Notes:

1. The test wells were drilled and sampled between October 17, 2005 and December 16, 2005 using a truck mounted Mobile B-65 drill. The borings were advanced with a tricone bit and supported with drilling fluid. Well VAS\_W-65 was drilled with a truck mounted air rotary drill.
2. The borings were located by measuring from nearby roads and intersections. The boring elevations were extrapolated from USGS 1 : 24,000 quadrangle maps.
3. These logs are subject to the limitations, conclusions, and recommendations in this report.

# KEY TO SYMBOLS

Symbol Description

## Monitor Well Details



bentonite pellets



concrete seal



6 inch diameter well casing.



6 inch diameter 0.010  
Stainless steel well screen.

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-63

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **SW Reddings Beach Road**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **110. ft**

DATE: **November 14, 2005**  
 START: **11/14/05**  
 FINISH: **11/22/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **11/30/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
290 0							
	6,10,15	SM	Sod and a thin topsoil.				
	30, 50/5"	SM	Brown silty sand with gravel and occasional cobbles, moist, medium dense.				
280 10	31,50/6"	SM	Dark brown silty sand with gravel and occasional cobbles, moist, medium dense.				
	39,50/5"	SM	Brown poorly graded sand with gravel, moist, medium dense.				
270 20	50/6"	SM	Gray silty sand with gravel and occasional cobbles, moist, very dense.				
	37,50/3"	SM				Iron stains in soil.	
260 30	50/5"	SM					
	16,18,31	SM	Gray silty sand with gravel, wet, dense to very dense.				
250 40	11,20,20	SM					
	13,25,26	SM				Iron stains in soil.	
240 50	16,28,28	SM	2 foot gravel zone 50 to 52 feet below the surface.				
	8,12,21	SM	2 foot gravel zone 55 to 57 feet below the surface.				
230 60	19,33,35	SM					
	18,23,26	ML	Cobble layer at approximately 66 feet. Gray silt with sand, wet, dense				
220 70							

The Boring is located on the north side of SW Reddings Beach Road 200 feet west of the intersection with Wax Orchard Rd. Department of Ecology Well Identification number: ALP 305 (R4534 0).

PLATE 4

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-63

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **SW Reddings Beach Road**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **110. ft**

DATE: **November 14, 2005**  
 START: **11/14/05**  
 FINISH: **11/22/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **11/30/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
210 - 80	11,20,23 28,33,50 17,23,28 17,23,28 12,21,29 14,24,31 11,22,32		to very dense. Some bedding visible lower in the section.  Bedding visible in sample.  Formation swelled overnight.				
180 - 110	18,32,43		Thicker lenses of sand and till like materials.				
170 - 120	24,41,44	SP	Gray poorly graded sand, moist, very dense.				
160 - 130	15,30,37	CL	Gray lean clay, moist, hard.				
150 - 140		ML	Gray silt with sand, moist, very dense.				
	36,50/6"	SP	Gray poorly graded sand, moist				

*The Boring is located on the north side of SW Reddings Beach Road 200 feet west of the intersection with Wax Orchard Rd. Department of Ecology Well Identification number: ALP 305 (R4534 0).*

PLATE 4

# LOG OF MONITOR WELL INSTALLATION

WELL NO. VAS\_W-63

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **SW Reddings Beach Road**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **110. ft**

DATE: **November 14, 2005**  
 START: **11/14/05**  
 FINISH: **11/22/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **11/30/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">140 150</div> <div style="margin-bottom: 10px;">130 160</div> <div style="margin-bottom: 10px;">120 170</div> <div style="margin-bottom: 10px;">110 180</div> <div style="margin-bottom: 10px;">100 190</div> <div style="margin-bottom: 10px;">90 200</div> <div style="margin-bottom: 10px;">80 210</div> </div>		<p>to wet, very dense.</p> <p>ML</p> <p>Gray silt with sand, moist, very dense. Some bedding visible.</p> <p>SM</p> <p>Gray silty sand, moist, very dense. Lenses of silt apparent based on the drilling rate. Sand lenses are becoming more prevalent.</p> <p>Sand is becoming finer.</p>					
						<p>Did not drive the sampler the full distance because the sample tube was full.</p>	

*The Boring is located on the north side of SW Reddings Beach Road 200 feet west of the intersection with Wax Orchard Rd. Department of Ecology Well Identification number: ALP 305 (R4534 0).*

PLATE 4

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-63

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **SW Reddings Beach Road**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **110. ft**

DATE: **November 14, 2005**  
 START: **11/14/05**  
 FINISH: **11/22/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **11/30/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
70 220	50/5"	SP	Brown poorly graded sand with gravel, moist, very dense.				
60 230			Coarse gravel lens at 239 to 240 feet noted during drilling.				
50 240	22,32,50/6"	ML	Gray silt with lean clay and sand, moist, very dense. Formation appears to be bedded with alternating lenses of clay silt and sand.				
40 250	25,36,30/3"						
30 260						Did not drive the sampler the full distance. Because it was thought that the sample tube was full.	
20 270							
10 280	50/4"	SM	Gray silty sand, moist, very dense.				

*The Boring is located on the north side of SW Reddings Beach Road 200 feet west of the intersection with Wax Orchard Rd. Department of Ecology Well Identification number: ALP 305 (R4534 0).*

PLATE 4

# KEY TO SYMBOLS

Symbol Description

## Strata symbols

	Topsoil
	Silty sand
	Silt
	Poorly graded sand
	Poorly graded gravel
	Well graded sand
	Low plasticity clay
	Low plasticity organic silts
	Crushed Surfacing Base Course
	Silty gravel

## Misc. Symbols

	Bottom of Boring
	Boring continues

Symbol Description

Water table during drilling

## Soil Samplers

	Standard penetration test
	No recovery
	Grab sample

## Monitor Well Details

	flush-mount cover
	recessed cover set in concrete
	pipe set in cement grout w/ protective casing
	bentonite slurry
	silica sand, blank PVC
	slotted pipe w/ sand
	no pipe, sealed
	riser with cover and protective casing

## Notes:

1. The test wells were drilled and sampled between October 17, 2005 and December 16, 2005 using a truck mounted Mobile B-65 drill. The borings were advanced with a tricone bit and supported with drilling fluid. Well VAS\_W-65 was drilled with a truck mounted air rotary drill.
2. The borings were located by measuring from nearby roads and intersections. The boring elevations were extrapolated from USGS 1 : 24,000 quadrangle maps.
3. These logs are subject to the limitations, conclusions, and recommendations in this report.

# KEY TO SYMBOLS

Symbol Description

## Monitor Well Details



bentonite pellets



concrete seal



6 inch diameter well casing.



6 inch diameter 0.010  
Stainless steel well screen.

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-64

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **Wax Orchard Road at Vashon Highway**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **160 ft**

DATE: **December 7, 2005**  
 START: **12/7/05**  
 FINISH: **12/19/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **1/10/06**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
380 0		SM SP	Crushed Surfacing Top Course. ( Shoulder Gravel)				
	14,17,21						
	18,36,50	SM	Brown silty sand with gravel, moist, dense.				
370 10	21,50/6"		Gray poorly graded sand with gravel and occasional cobbles, moist, medium dense.				
	24,42,50/5"	SP	Gray silty sand with gravel, moist to wet, very dense. (Till like)				
360 20	19,34,41		Brown poorly graded sand with gravel, moist, very dense.				
	12,18,18	GP SP	Gray poorly graded gravel with sand, moist, very dense.				
350 30	11,15,15		Gray brown poorly graded sand with gravel, moist, medium dense to dense. Traces of wood debris found in the samples.				
	9,9,11						
340 40	5,5,5	SP	Brown poorly graded sand, wet, medium dense. The upper portion of the unit contains iron stains.				
330 50	7,6,10						
	50/6"						
320 60	13,50/5.5"	GM	Gray silty gravel with sand, moist to wet, very dense.				
310 70							

*The Boring is located on the east side of Wax Orchard Road, 125 feet north of the intersection with Vashon Highway. Department of Ecology Well Identification number: ALP 302 (R 45337).*

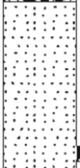
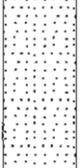
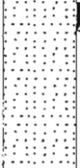
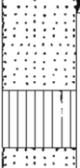
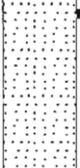
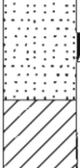
PLATE 5

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-64

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **Wax Orchard Road at Vashon Highway**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **160 ft**

DATE: **December 7, 2005**  
 START: **12/7/05**  
 FINISH: **12/19/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **1/10/06**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
300 80	 33,50/3"						
290 90	 29,50/4"	SP	Brown poorly graded sand, moist, very dense. Bedding visible in the sample.				
280 100	 24,32,39						
270 110	 22,30,35						
260 120	 50/6"	ML	Black silt with sand and gravel, moist, dense.				
250 130	 31,39,46	SP	Brown poorly graded sand, moist, very dense.				
240 140	 31,39,46	CL	Brown lean clay, moist, hard.				
	 31,39,46	ML	Gray silt with sand, moist, very dense.				

*The Boring is located on the east side of Wax Orchard Road, 125 feet north of the intersection with Vashon Highway. Department of Ecology Well Identification number: ALP 302 (R 45337).*

PLATE 5

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-64

**PROJECT:** Vashon-Maury Island Groundwater Study      **DATE:** December 7, 2005  
**BORING LOCATION:** Wax Orchard Road at Vashon Highway      **START:** 12/7/05  
**DRILL METHOD:** Mud Rotary      **FINISH:** 12/19/05  
**DRILLER:** Holocene Drilling      **LOGGER:** D. Armstrong  
**DEPTH TO - Water:** 160 ft      **DATE CHECKED:** 1/10/06

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
230 - 150	▲ 17,29,39						
220 - 160	▲ 40,50/4"	SP	Gray poorly graded sand, moist, very dense.				
210 - 170	▲ 42,50/5"	GP	Brown poorly graded gravel with sand, moist, very dense.				
200 - 180	▲ 42,50/5"	SP	Brown poorly graded sand, moist, very dense.				
190 - 190	▲ 50/3"	SM	Gray silty sand with gravel and occasional cobbles, moist, very dense. (Till Like)				
180 - 200	▲ 50/3"	GP	Gray poorly graded gravel with sand, moist, very dense. Gravel				

*The Boring is located on the east side of Wax Orchard Road, 125 feet north of the intersection with Vashon Highway. Department of Ecology Well Identification number: ALP 302 (R 45337).*

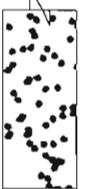
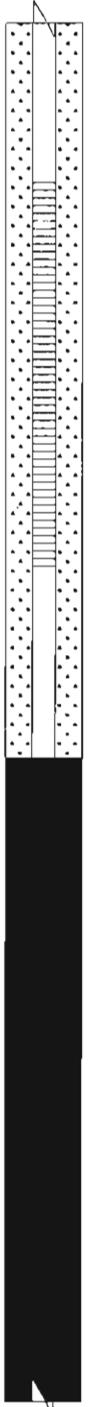
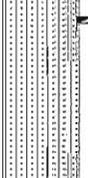
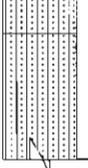
PLATE 5

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-64

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **Wax Orchard Road at Vashon Highway**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **160 ft**

DATE: **December 7, 2005**  
 START: **12/7/05**  
 FINISH: **12/19/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **1/10/06**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
160 - 220			decreasing in size with depth. Some bedding in this section.				
150 - 230	 106/5"	SP	Dark gray poorly graded sand with silt and gravel, moist, very dense.			High mud loss.	
140 - 240		GP	Gray poorly graded gravel with sand, moist, very dense.				
130 - 250	 52/2"	GM	Dark gray silty gravel with sand and occasional cobbles, moist, very dense.				
120 - 260							
110 - 270	 7 1/4"	SM	Gray silty sand with fine gravel, moist, very dense.				
100 - 280	 22,50/5"	SM	Gray and brown silty sand, moist, very dense.				
		SM	Sample is disturbed and has the appearance of slide debris. Gray silty sand, moist, very dense.				

*The Boring is located on the east side of Wax Orchard Road, 125 feet north of the intersection with Vashon Highway. Department of Ecology Well Identification number: ALP 302 (R 45337).*

PLATE 5

# LOG OF MONITOR WELL INSTALLATION

WELL NO. VAS\_W-64

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **Wax Orchard Road at Vashon Highway**  
 DRILL METHOD: **Mud Rotary**  
 DRILLER: **Holocene Drilling**  
 DEPTH TO - Water: **160 ft**

DATE: **December 7, 2005**  
 START: **12/7/05**  
 FINISH: **12/19/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **1/10/06**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
<div style="display: flex; align-items: center;"> </div>							
		ML	Gray brown silt with lean clay moist, very dense.				
		SM	Gray silty sand, moist, very dense.				

*The Boring is located on the east side of Wax Orchard Road, 125 feet north of the intersection with Vashon Highway. Department of Ecology Well Identification number: ALP 302 (R 45337).*

**PLATE 5**

# KEY TO SYMBOLS

Symbol Description

## Strata symbols

	Topsoil
	Silty sand
	Silt
	Poorly graded sand
	Poorly graded gravel
	Well graded sand
	Low plasticity clay
	Low plasticity organic silts
	Crushed Surfacing Base Course
	Silty gravel

## Misc. Symbols

	Bottom of Boring
	Boring continues

Symbol Description

Water table during drilling

## Soil Samplers

	Standard penetration test
	No recovery
	Grab sample

## Monitor Well Details

	flush-mount cover
	recessed cover set in concrete
	pipe set in cement grout w/ protective casing
	bentonite slurry
	silica sand, blank PVC
	slotted pipe w/ sand
	no pipe, sealed
	riser with cover and protective casing

## Notes:

1. The test wells were drilled and sampled between October 17, 2005 and December 16, 2005 using a truck mounted Mobile B-65 drill. The borings were advanced with a tricone bit and supported with drilling fluid. Well VAS\_W-65 was drilled with a truck mounted air rotary drill.
2. The borings were located by measuring from nearby roads and intersections. The boring elevations were extrapolated from USGS 1 : 24,000 quadrangle maps.
3. These logs are subject to the limitations, conclusions, and recommendations in this report.

# KEY TO SYMBOLS

Symbol Description

## Monitor Well Details



bentonite pellets



concrete seal



6 inch diameter well casing.



6 inch diameter 0.010  
Stainless steel well screen.

# LOG OF MONITOR WELL INSTALLATION

## WELL NO. VAS\_W-65

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **North Vashon**  
 DRILL METHOD: **Air Rotary 6 inch casing**  
 DRILLER: **Tacoma Pump and Drilling**  
 DEPTH TO - Water: **82 ft**

DATE: **November 30, 2005**  
 START: **11/30/05**  
 FINISH: **12/1/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **12/2/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
0							
		SM	Sod and a thin topsoil.				
300		SM	Brown silty sand with gravel, moist, loose.				
10			Gray silty sand with gravel, moist, loose.				
290							
20						Bottom of Sanitary Seal	
280							
30		SM	Brown silty sand with gravel, moist, dense.				
270							
40							
260							
50		GP	Brown poorly graded gravel with sand, wet, dense.				
250		SM	Gray silty sand with gravel, wet, loose.				
60							
240							
70		SP	Gray poorly graded sand with gravel.				

*The well is located at west end of the Park and Ride near the intersection of Vashon Highway and SW 204th Street. Department of Ecology well identification number: AKT 262 (WE04516).*

PLATE 6

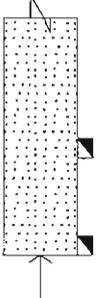
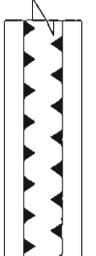


# LOG OF MONITOR WELL INSTALLATION

WELL NO. VAS\_W-65

PROJECT: **Vashon-Maury Island Groundwater Study**  
 BORING LOCATION: **North Vashon**  
 DRILL METHOD: **Air Rotary 6 inch casing**  
 DRILLER: **Tacoma Pump and Drilling**  
 DEPTH TO - Water: **82 ft**

DATE: **November 30, 2005**  
 START: **11/30/05**  
 FINISH: **12/1/05**  
 LOGGER: **D. Armstrong**  
 DATE CHECKED: **12/2/05**

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">160</div> <div style="margin-bottom: 10px;">150</div> <div style="margin-bottom: 10px;">150</div> <div style="margin-bottom: 10px;">160</div> <div style="margin-bottom: 10px;">140</div> <div style="margin-bottom: 10px;">170</div> <div style="margin-bottom: 10px;">130</div> <div style="margin-bottom: 10px;">180</div> <div style="margin-bottom: 10px;">120</div> <div style="margin-bottom: 10px;">190</div> <div style="margin-bottom: 10px;">110</div> <div style="margin-bottom: 10px;">200</div> <div style="margin-bottom: 10px;">100</div> <div style="margin-bottom: 10px;">210</div> <div style="margin-bottom: 10px;">90</div> </div>						<div style="margin-bottom: 10px;">Bottom of well</div>	

*The well is located at west end of the Park and Ride near the intersection of Vashon Highway and SW 204th Street. Department of Ecology well identification number: AKT 262 (WE04516).*

PLATE 6

# Appendix B

## Pump Test Information and Data

# Pumping Test

## Quick procedure

At Vashon Park & Ride monitoring wells

December 5 - 9, 2005

Eric Ferguson, Project Manager

by Ken Johnson, Technical Lead

King Co Dept of Natural Resources & Parks

1. Set up
  - a. equipment
    - water level probe
    - 3 transducers / data loggers
    - baro logger?
    - interface connector (cradle) and downhole direct cable
    - laptop
    - camera
    - stop watch
    - bucket to check flow rates
    - pump / controller
    - generator / power connection
    - hose for water discharge, flow meter (get specs -- units, manufacture, range), valve to adjust flow

**b. installation**

pump / riser pipe in pumping well (foot valve in pump if possible to avoid draining into well right after pump turned off)

probe channels in pumping well

measure water levels, calculate installation depth (as far down as possible while still within measurement range; allowing slight allowance for over-recovery) note drawdown in pumping well may be more than 25'

program transducers, measure depth of installation on cable, drop transducer into channel pipes in pumping well (can also pull temporarily to check that it is measuring as required)

arithmetic in observation well and one in pumping well

log scale in pumping well, e.g., from 0 (step = 10 sec) to 2 min, (30 sec) to 5 min, (1 min) to 15 min, (5 min) to 50 min, (10 min) to 120 min, (30 min) to 5 hrs, (60 min) rest of time.

program / install transducer in observation well

connect meter, valve, and hose to riser pipe -- should run to stream bed as far from pumping site as possible (to avoid feedback from recharge to aquifer): measure distance (to pace accuracy, or document in pictures to allow locations to be estimated via GIS)

**c. measurements**

water levels in both wells (check with previous measurements)

check water levels at beginning and end of setup period (as wide apart as possible) to assure no already occurring water level changes

document well dimensions (e.g., stickup, diameters), pump setting (and diagram and pictures), and transducer depths, pipe diameter and sizes. Important to get accurate measure of distance between wells.

when any pumping change starts & stops, need to take water level measurements approx every 30 sec (to 5 min), (5 min) to 60 min, (20 min) to 120 min, (60 min) to end (as possible) (these measurements are important to have data as test proceeds, and to check recorded water levels, so slightly less important these days with reliable transducers)

Also very important to check flow rate quickly and at regular basis and adjust to keep it as constant as possible, use bucket to check meter. remember that meter is not going to be accurate if it is too close down stream to a perturbation (e.g., the valve, a turn in pipe, or a change in diameter) -- meter or driller should have instructions (I think 5 pipe diameters minimum)

Record all pump on / off times (clock times for every thing).

## 2. Step-Drawdown Test

- a. plan at least 3 target pumping rates (to capacity of pump): e.g., 8 gpm, 15 gpm, 25 gpm. When pump starts up, open valve, check time, flow rate, water levels, note that flow won't be exactly what was expected but try to keep constant at a rate (so start a little low).
- b. Purpose
  - i. estimates capacity of well to deliver over longer run test duration
  - ii. gives estimate of "well loss" or "efficiency" coefficients
  - iii. also serves to prepare for longer-term test
- c. should run each step at a constant rate for about the same time (e.g. 30 min to 2 hrs each)
- d. run each step long enough to where drawdown stabilizes. If drawdown does not stabilize in allowed time then may be exceeding capacity of well -- may need to reduce flow in long term pumping test
- e. take water levels and plot log time (from beginning of entire test) vs. drawdown -- stabilization is when plot becomes straight line (or levels off). Excessive drawdown is indicated by drawdown on extrapolated line will exceed capacity of well
- f. check observation well occasionally, though it is unlikely to show effects during step test.
- g. at end of maximum pumping, turn pump off and measure recovery. Let recovery run as long as feasible, but at least to recovery of 99% of drawdown (or less than 0.01' limit of measurement)
- h. calculate and plot specific capacity (dd/q) vs. flow (q) for each step -- should approximate straight line.
- i. allow long enough time after shutdown that effects are dissipated (ideally overnight, but that is usually not feasible)
- j. calculate feasible pumping rate. Keep some capacity of pump because it may be necessary to increase pumping effort (open valve further). Try to avoid drawing down below top of screen, if possible.

## 3. Pumping test

- a. download transducers and set program (log time one) to restart at specified time when you will start pump
- b. measure water levels again just before start up
- c. assign someone to watch meter and adjust valve to achieve required pumping rate -- especially difficult in first few minutes, and over longer time. All measurements should have an accurate time. Important to check flow occasionally over long term test --

procedure says no variation in pumping more than 5% of design rate. Make sure generator (if used) is refueled.

- d. plot log time vs. drawdown. Should become close to straight line. If there is a deviation late in test, it means something is weird -- e.g., other pumping occurring (shouldn't be any nearby), flow rate is changing, discharge water is going back into aquifer
- e. run test to end of pumping duration. get water levels just before turning pump off. Download and reprogram log-scale transducer just before shut off.
- f. leave pump in pumping well until most drawdown (99% or all but 0.01' again) is recovered. Note time when pump is removed (to explain data gaps / changes).
- g. take water levels again after all operations done, to demonstrate again any non-pumping test trends. Check barologger.

#### 4. Recovery

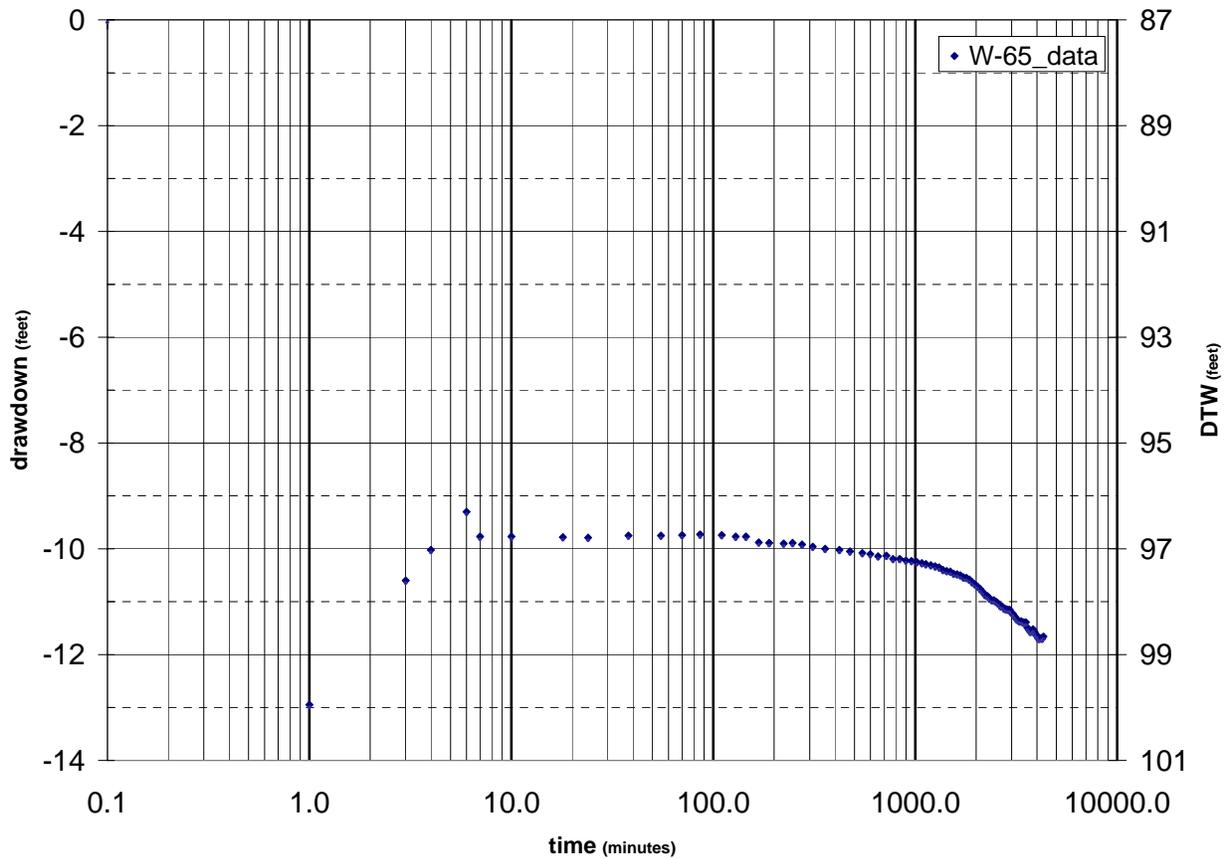
Check data to make sure all was recorded.

Get any data from drillers.

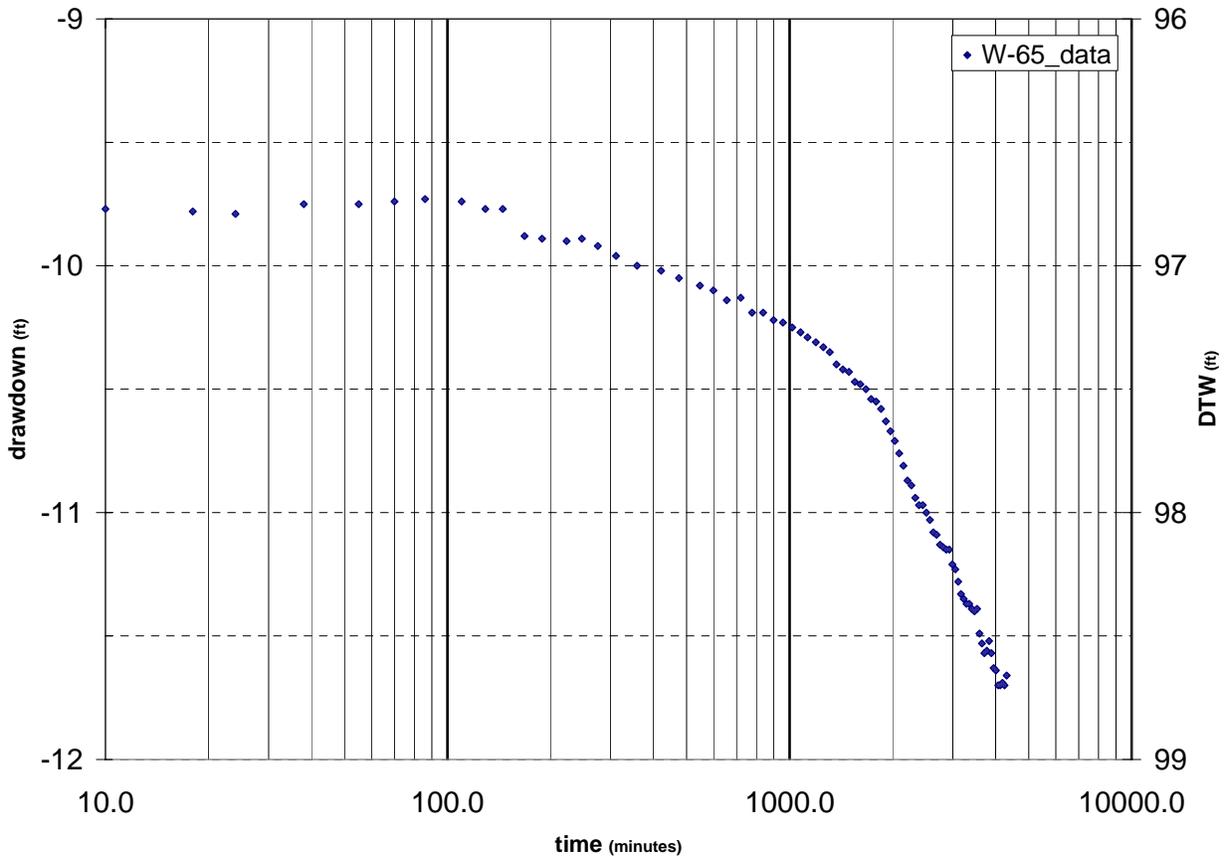
Take water levels (and leave transducers in wells over longer run, if possible).

# Pump Test Data

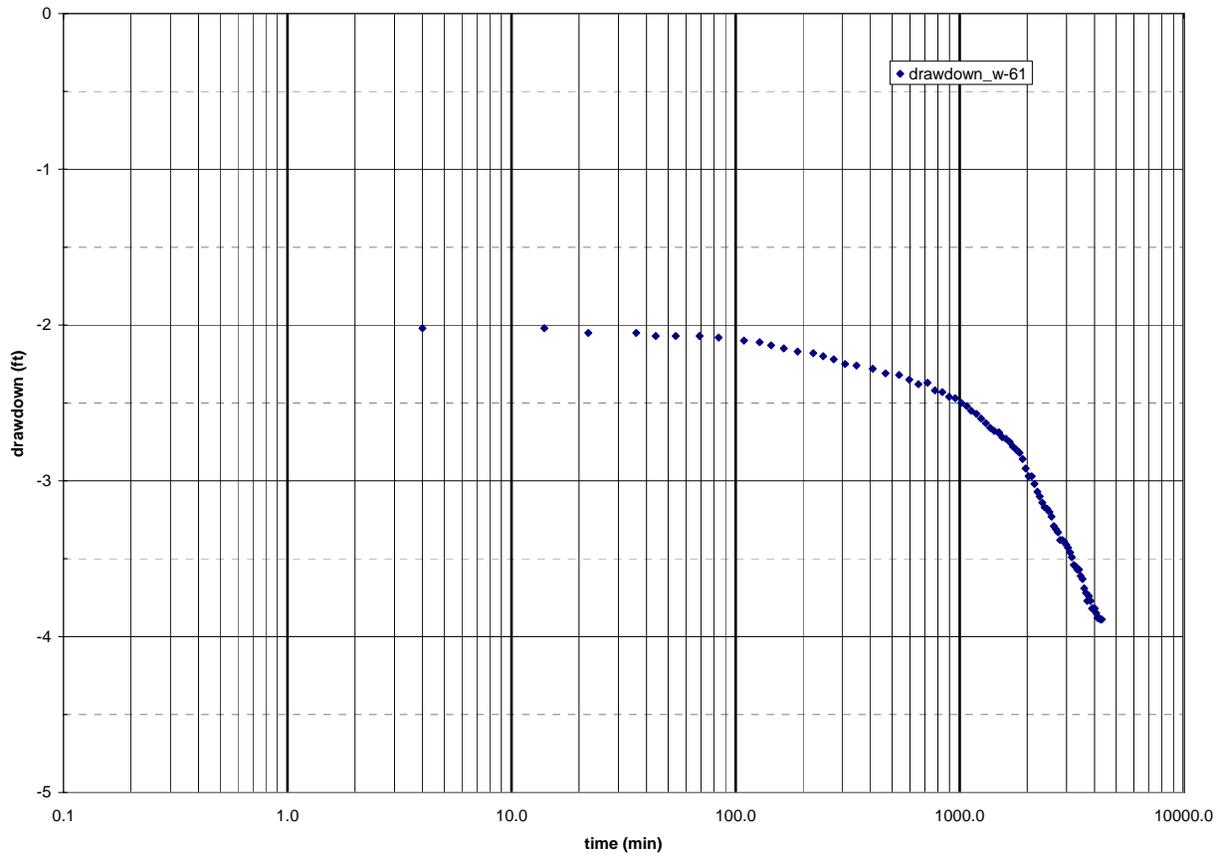
Electronic data is available upon request.



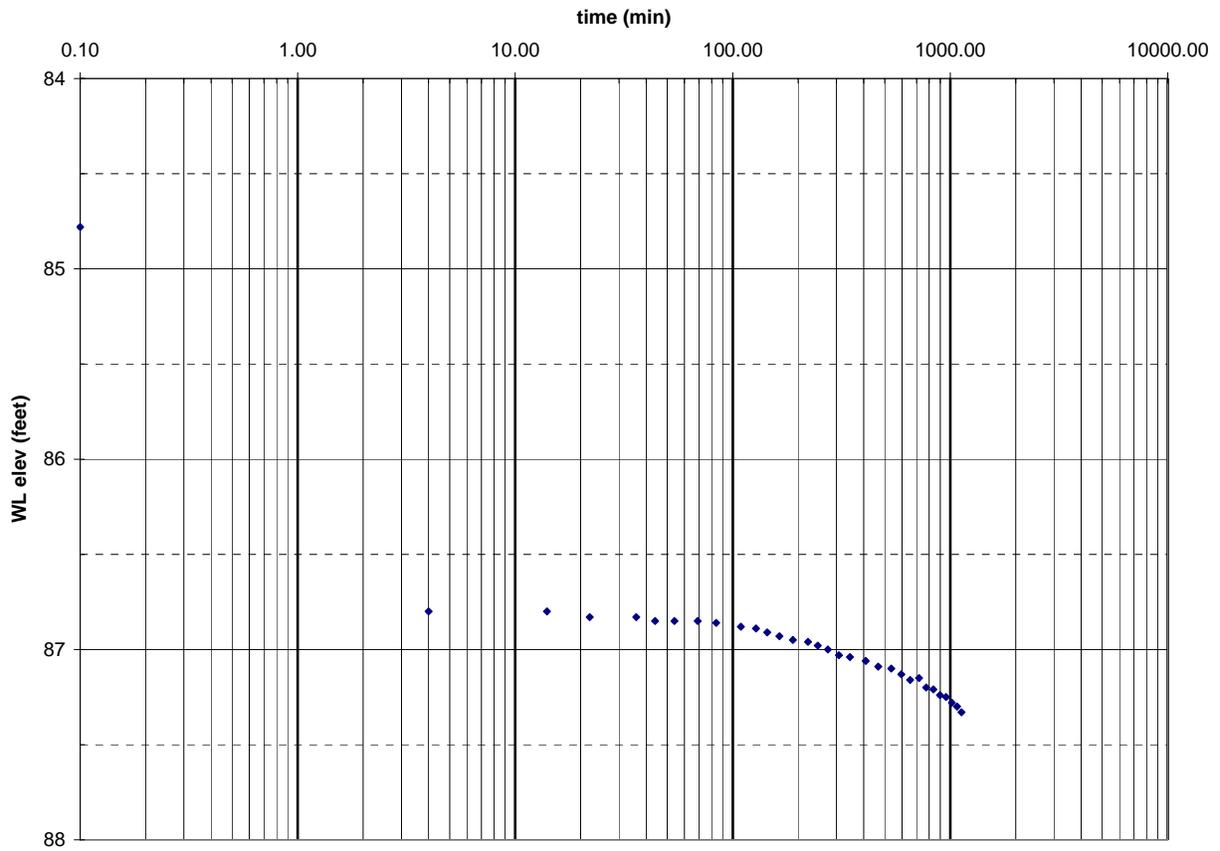
The above graph is for well VAS\_w-65, the pumping well, for drawdown (and depth to water) measurements versus time (log scale) taken during the pump test. The drawdown measurements are calculated from the depth to water measurements as change from the starting water table surface. The scale on the right side is the depth to water (DTW) measurements.



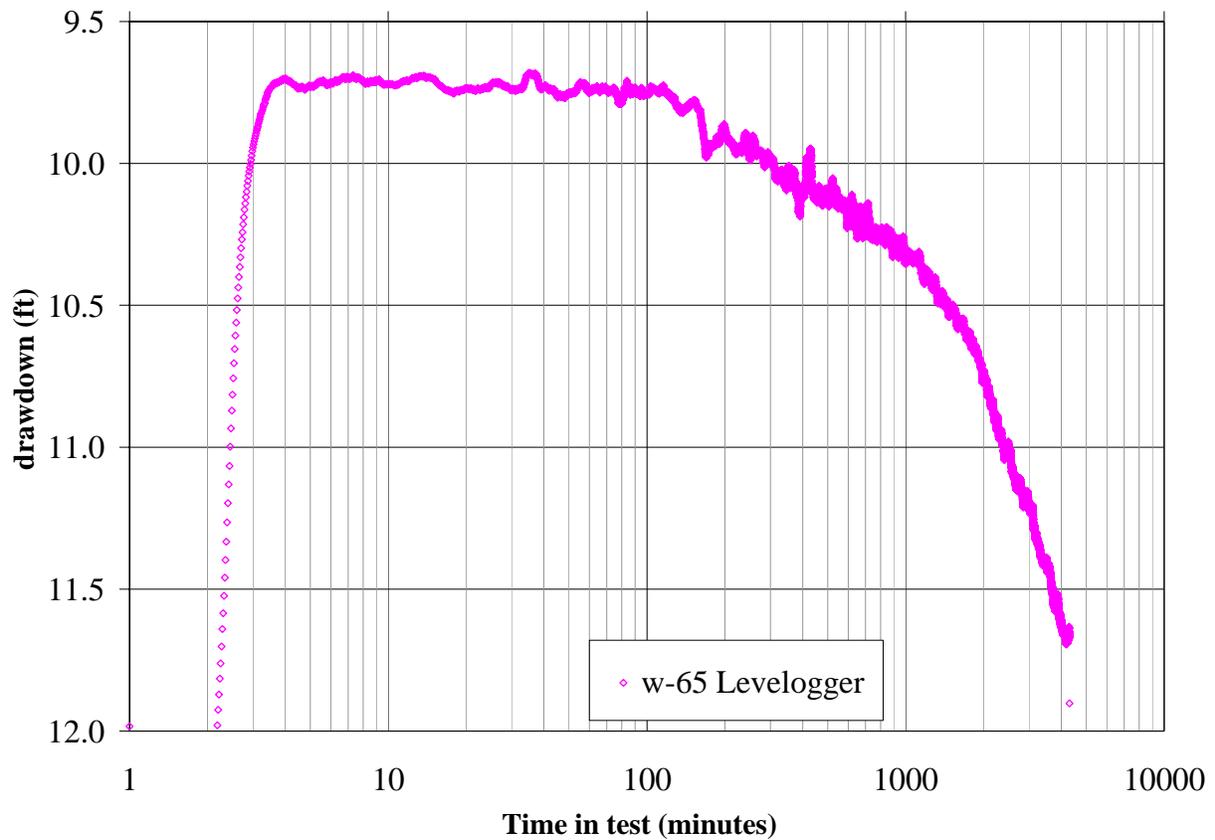
The above graph is for well VAS\_w-65, the pumping well, for a shorter time period (10 minutes to the end of the test). The data are presented as drawdown below land surface and as depth to water measurements versus time in minutes.



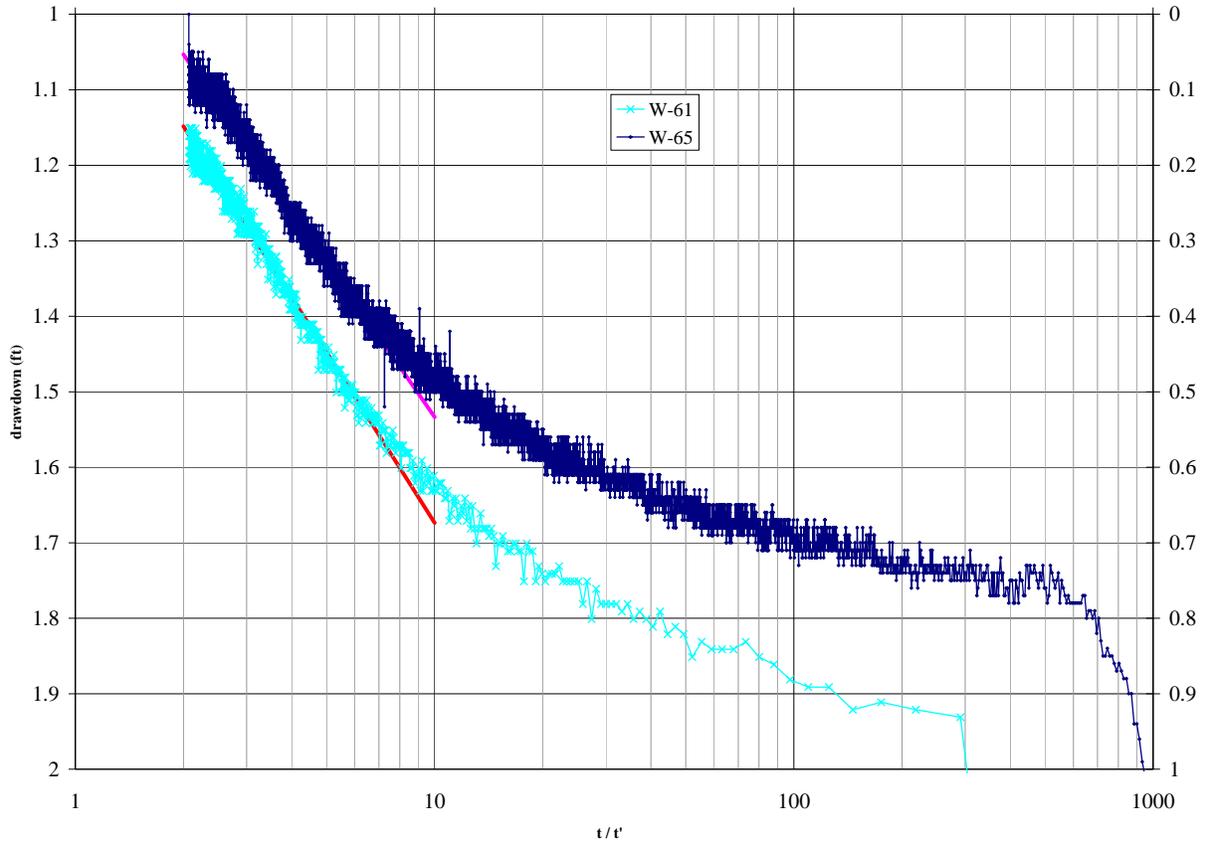
The above graph is for well VAS\_w-61, the monitoring well, for depth to water measurements taken during the pump test. The data are presented as drawdown below land surface versus time in minutes



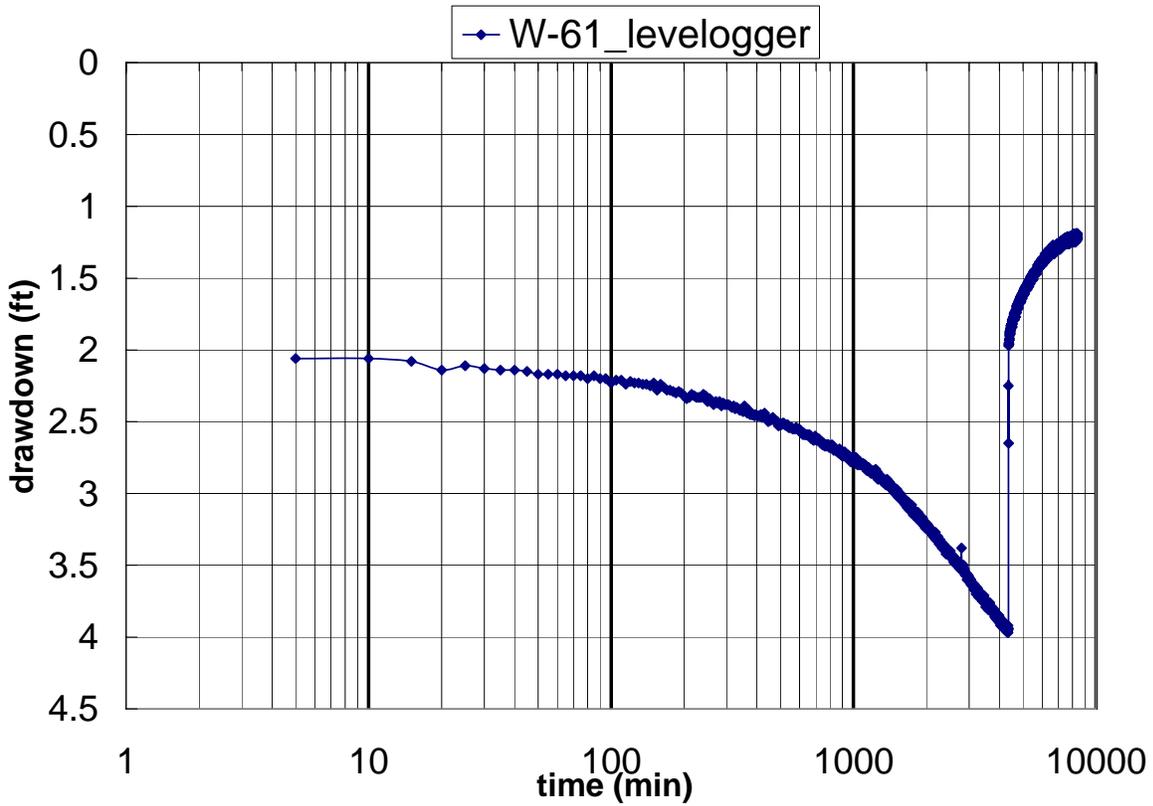
The above graph is for well VAS\_w-61, the monitoring well, for depth to water measurements taken during the pump test. The data are presented as water table elevations versus time in minutes



The above graph is for well VAS\_w-65, the pumping well, for drawdown measurements via levelogger taken during the pump test. The data are presented as drawdown below land surface versus time in minutes.



The above graph is for both wells during the recovery portion of the test. The data are presented as drawdown below land surface versus  $t/t$



The above graph is for well VAS\_w-61, the monitoring well, for drawdown measurements via levelogger taken during the pumping and recovery periods of the test. The data are presented as drawdown below land surface versus time in minutes