Northwest
Oak Harbor, Washington

Final

Aquifer Test, Groundwater Sampling, and Drinking Water Sampling Data Evaluation and Groundwater Modeling Report Per- and Polyfluoroalkyl Substances (PFAS) Outlying Landing Field Coupeville

Naval Air Station Whidbey Island
Oak Harbor, Washington

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Prepared for NAVFAC Northwest
by CH2M HILL, Inc.
Bellevue, Washington
Contract N62470-16-D-9000
CTO 4041

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Acronyms and Abbreviations

°C	degree Celsius
bgs	below ground surface
btoc	below top of casing
CGFM	Coupeville Groundwater Flow Model
CH2M	CH2M HILL, Inc.
CLEAN	Comprehensive Long-term Environmental Action – Navy
CSM	conceptual site model
DTW	depth to water
EVS	Environmental Visualization Software
gpm	gallon per minute
GWE	groundwater elevation
IDW	investigation-derived waste
KHW	Keystone Hill well
LHA	lifetime health advisory
LIDAR	light imaging, detection, and ranging
mg/L	milligram per liter
mS/cm	millisiemen per centimeter
mV	millivolt
NAD83	1983 Washington State Plant Coordinate System, North Zone
NAS	Naval Air Station
NAVD88	North American Vertical Datum of 1988
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NTU	nephelometric turbidity unit
OLF	Outlying Landing Field
PEST	parameter estimation
PFAS	per- and polyfluoroalkyl substance
PFBS	perfluorobutane sulfonate
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
ppt	parts per trillion
psi	pound per square inch
PVC	polyvinyl chloride
QC	quality control
QSM	Quality Systems Manual
RMS	root mean square
ROI	radius of influence
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
TOC	top of casing

USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WQP	water quality parameter

SECTION 1

Introduction and Site Description

The Department of the Navy (Navy) Environmental Restoration Program at Naval Air Station (NAS) Whidbey Island, which is within the Naval Facilities Engineering Command (NAVFAC) Northwest Division, contracted with CH2M HILL, Inc. (CH2M) to perform an expedited site investigation at the NAS Whidbey Island Outlying Landing Field (OLF) Coupeville. Activities for this investigation included installation of new groundwater monitoring wells, aquifer testing, and sampling of the Keystone Hill water-supply well and nearby groundwater monitoring wells at OLF Coupeville. This document provides an analysis of the data collected during monitoring well installation, aquifer testing, and groundwater sampling at OLF Coupeville. This document also includes a description of the groundwater flow model that was developed for the OLF Coupeville site as a part of the analysis. This work is being performed under Comprehensive Long-term Environmental Action—Navy (CLEAN) 9000 Contract N62470-16-D-9000, Contract Task Order 4041.

CH2M conducted field investigation activities at OLF Coupeville in December 2017 and January 2018. OLF Coupeville is an active Navy installation near the Town of Coupeville, Washington. The locations of the NAS Whidbey Island installations including OLF Coupeville are shown on **Figure 1-1**.

1.1 Purpose and Objectives

The Town of Coupeville operates a community drinking water well, the Keystone Hill well (KHW), located approximately 200 feet west of OLF Coupeville. To satisfy anticipated increased demand, the Town of Coupeville completed a water system plan in which the pumping rate of the KHW will be increased from 150 gallons per minute (gpm) to 300 gpm to support an expanded drinking water distribution system. However, perfluorooctanoic acid (PFOA), a per- and polyfluoroalkyl substance (PFAS), was detected in groundwater at three on-Base wells at concentrations above the United States Environmental Protection Agency's (USEPA's) lifetime health advisory (LHA). PFOA has recently been detected in drinking water samples collected from the KHW at concentrations near the LHA. The Town of Coupeville is concerned that increasing extraction rates may result in higher PFAS concentrations in water produced by the KHW. Information regarding the impact of pumping rates at the KHW on groundwater conditions at the OLF Coupeville is necessary to evaluate the feasibility of expanding the Town of Coupeville's drinking water distribution system. This information is also necessary to support the Navy's evaluation of potential new drinking water sources for nearby properties where drinking water from private water supply wells contains perfluorooctanesulfonic acid (PFOS) and/or PFOA above the USEPA's LHA.

The objectives of this investigation were to:

- Determine the radius of influence (ROI) and extent of hydraulic capture of the KHW when operating under normal (150 gpm) pumping conditions.
- Determine the ROI and extent of hydraulic capture through numerical modeling of the KHW when production is increased to the Town of Coupeville's proposed 300 gpm.
- Determine the current PFAS concentrations in the KHW and in specific monitoring wells at OLF Coupeville.

Data collected as part of this effort have also been used to improve understanding of the hydraulic characteristics of the aquifer system beneath OLF Coupeville and the degree of hydraulic connection across the vertical extent of the aquifer system at the site and with KHW.

1.2 Site and Background and Description

OLF Coupeville is a military airfield associated with NAS Whidbey Island. The OLF is 2 miles southeast of the Town of Coupeville, Washington, in Island County (**Figure 1-1**). OLF Coupeville is located on a broad plateau of Smith Prairie in southern Whidbey Island at an elevation of approximately 195 feet above the North American Vertical Datum of 1988 (NAVD88). The paved runway is approximately 5,400 feet long and is bordered by grass

maintained by mowing operations extending to the public roads (Navy, 1994). A runway safety area extends approximately 3,300 feet south of the runway footprint and is bordered by trees and residential parcels. Washington State Route 20 runs north-south along or near the eastern Base boundary and east-west near the northern boundary; Keystone Hill Road runs north-south along a portion of the western boundary. Portions of the airfield are within, and are bordered by, Ebey's Landing National Historical Reserve. The southernmost portion of the airfield is wooded and slopes steeply downward toward Admiralty Bay.

OLF Coupeville was commissioned for use by the Navy in 1943, and provides support for day and night Field Carrier Landing Practice operations by the Navy for aircraft based out of NAS Whidbey Island. Such operations allow aviators and crew to fly in patterns as well as practice touch-and-go, simulating carrier landings and take offs.

1.2.1 Geologic Setting

Whidbey Island lies within the Puget Lowland, a topographic and structural depression between the Olympic Mountains and the Cascade Range. The geology of the area is heavily influenced by glacial advances and retreats. The geologic units on Whidbey Island thus consist of a sequence of Quaternary-age (less than 2 million years old) glacial and interglacial deposits that may be over 3,000 feet thick (USGS, 1982). The near-surface deposits are mostly glacial sediment of the most recent Fraser glaciation (10,000 to 20,000 years old).

The glacial and post-glacial sediments make up most of the surface and near-surface soil underlying the Base. In general, these stratigraphic units consist of relatively impermeable clay, silt, and silty fine sand and gravels (Everson glaciomarine drift and Vashon till), with interbedded layers of sands and gravels. Interbedded sands and gravels were deposited by retreating glaciers. Along the island shoreline these sediments have been reworked into sandy beach deposits. Low-permeability Cretaceous or Tertiary bedrock (older than 30 million years) underlies the unconsolidated Quaternary deposits (USGS, 1988).

Surficial geology at OLF Coupeville consists of the Partridge Gravel, which was deposited by glacial meltwaters and is composed of sand, gravel, and sand-gravel mixtures with minor interlayered silt and silty sand (Polenz et al., 2005). Based on soil borings completed in 2017, the Partridge Gravel generally extends to depths of 180 to 200 feet below ground surface (bgs) at OLF Coupeville and is characterized by fine to medium sand with intermittent occurrences of gravel and laterally discontinuous layers of silt and clay (NAVFAC, 2017). Pleistocene deposits, including Vashon till, lie beneath the Partridge Gravel. In the vicinity of OLF Coupeville, these deposits consist of heterogeneous clay, claystone, and silt and frequently contain organic material, such as plant material and peat.

1.2.2 Hydrogeologic Setting

The unconfined groundwater table at OLF Coupeville generally occurs within the Partridge Gravel between 90 and 130 feet bgs. Perched groundwater may be present above the water table controlled by local occurrences of low permeability silt and clay layers. With depth, localized layers of silt and clay may promote semiconfined to confined aquifer conditions within the Partridge Gravel. Many local water supply wells are screened in the lower portion of the Partridge Gravel. These wells are typically screened below 150 feet bgs in transmissive sand and gravel.

An April 2017 groundwater elevation study of 27 monitoring wells located within the OLF Coupeville boundary (NAVFAC, 2017) indicated groundwater elevation fluctuations during a 48-hour monitoring period ranged up to 0.6 foot. Study monitoring wells were typically screened within three general elevation intervals, which were categorized based on their elevation relative to mean sea level: "shallow" (screened above 50 feet NAVD88), "intermediate" (screened 0 to 50 feet NAVD88), and "deep" (screened near or below sea level NAVD88). The shallow, intermediate, and deep screen interval designations do not indicate three discrete aquifers or water-bearing zones. Rather, with the exception of some shallow wells possibly screened within localized areas of perched groundwater, all of the shallow, intermediate, and deep screen intervals are located within the single aquifer system that most local water supply wells (including the KHW) are completed in.

R:\ENBG\00_Proj\N\Navy\CLEAN\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4041\Coupeville\Aquifer\Figure_1-1_Coupeville_Base_Location.mxd6/4/2018SSAVAGE1

Legend

- City
- Secondary Road
- Local Connecting Road
- Important Local Road
- Base Boundary

N

0 1 2 Miles

1 inch = 2 miles

Figure 1-1
Base Location Map
Outlying Landing Field Coupeville
Naval Air Station Whidbey Island
Coupeville, Washington

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SECTION 2

Field Activities Summary

This section documents the field activities that were performed at OLF Coupeville in December 2017 and January 2018. The following field activities were performed as part of this investigation:

- Monitoring well installation
- Aquifer test and groundwater level survey
- Drinking water and groundwater sample collection

The following sections detail the field activities that were completed during this investigation.

2.1 Monitoring Well Installation

Four groundwater monitoring wells (WI-CV-MW15S, WI-CV-MW15M, WI-CV-MW16S, and WI-CV-MW16M) were installed near the KHW to observe the impact of KHW pumping on localized groundwater flow. Well installation and development occurred between December 5 and December 22, 2017. Locations of groundwater monitoring wells are shown on **Figure 2-1**.

2.1.1 Borehole Advancement

The four new groundwater monitoring wells were installed using sonic drilling techniques in accordance with the Standard Operating Procedure (SOP) *Installation of Monitoring Wells by Sonic Drilling*, included in the Sampling and Analysis Plan (SAP) (CH2M, 2017). Because of the possible presence of contaminants in the aquifer system, a telescoping isolation casing system was used during drilling to limit the potential for vertical cross-contamination in the borehole during drilling and well construction. Continuous soil cores were collected for lithologic classification. Soil cores were closely examined for signs of saturation and the presence of fine-grained beds that could indicate the presence of perched groundwater conditions. Lithology observed in the soil cores was logged in accordance with SOP-I-E *Soil and Rock Classification*, included in the SAP (CH2M, 2017). Soil boring logs are included in **Appendix A**.

2.1.2 Well Construction

Each monitoring well was constructed of 2-inch inside-diameter schedule 40 polyvinyl chloride (PVC) riser with centralizers spaced at 20-foot intervals. Blank riser was connected to a 2-inch inside-diameter, factory-slotted PVC screen. Additionally, 5 feet of blank casing with a bottom cap was installed below the screen interval to serve as a sump. Ten feet of screen was used for all wells. The selectedscreened intervals were determined based on the lithology observed during drilling. Well construction information is included in **Table 2-1**.

A silica sand filter pack was placed around the annular space of the sump and well screen from the bottom of the borehole extending to a minimum height of 2 feet above the top of the well screen. A bentonite seal, at least 2 feet thick, was placed in the borehole annular space above the top of the sand pack. After the bentonite seal had been hydrated, bentonite grout was placed in the borehole annular space to the ground surface.

All monitoring wells were finished with flush-mount completions that included a metal well vault and concrete pad. A locking watertight cap was placed on the top of the PVC casing. The wells were labeled on the exterior of the well vault with a metal stamp indicating the well identification. Well completion diagrams for all newly installed monitoring wells are provided in **Appendix B.**

Table 2-1. Monitoring Well Construction Summary

Monitoring Well	Completion Date	Ground Elevation (ft NAVD88)	TOC Elevation (ft NAVD88)	Total Depth (ft bgs)	Measured Total Depth (ft btoc)[1]	Screen Length (ft)	Sump Length (ft)	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Screen Top Elevation (ft NAVD88)	Screen Bottom Elevation (ft NAVD88)	Pump Intake Depth (ft btoc)	Screen Interval	Northing (ft NAD83)	Easting (ft NAD83)
WI-CV-MW15M	12/17/2018	193.66	193.35	179	178.90	10	5	164	174	29.66	19.66	101.68	M	440404.38	1200504.87
WI-CV-MW15S	12/19/2018	193.18	192.92	149	148.17	10	5	132	142	61.18	51.18	101.46	S	440393.08	1200505.47
WI-CV-MW16M	12/11/2018	192.58	192.27	179	179.92	10	5	164	174	28.58	18.58	101.14	M	440104.82	1200484.09
WI-CV-MW16S	12/14/2018	192.54	192.16	145	144.90	10	5	130	140	62.54	52.54	101.08	S	440094.70	1200484.48

Notes:

[1] total depth measurement taken after well development

btoc = below top of casing

ft = feet

M = intermediate screen interval

NAD83 = 1983 Washington State Plant Coordinate System, North Zone

S = shallow screen interval

TOC = top of casing

2.1.3 Well Development

New groundwater monitoring wells were developed following installation. Development began on December 20, 2017 and was completed on December 22, 2017. Wells were developed using surge and purge methods. Wells were surged by making 10-foot sweeps of the screened interval with a metal surge block for 20 to 30 minutes, then bailed using a stainless-steel bailer until most of the sediment had been removed. Well purging was then attempted using a submersible pump; however, the pump proved unable to lift groundwater to the surface. Purging was ultimately completed by over-pumping with a manual lift pump until 10 well volumes had been purged. Well development logs are provided in **Appendix C**.

Monitoring wells were surveyed by a professional land surveyor licensed in the State of Washington. The survey report is included as **Appendix D**.

2.2 Aquifer Test

The OLF Coupeville aquifer test consisted of monitoring normal pumping rates (that is, pump on/off cycles) and groundwater levels at the KHW as well as groundwater levels at several surrounding monitoring wells over the course of approximately 11 days. Since the KHW is an active municipal drinking water supply well for the Town of Coupeville, it operates on a predictable schedule and the regular pumping cycle provided for suitable pumping and recharge periods. The test was designed so that, upon review of the data, a time interval with suitable data could be selected for analysis.

2.2.1 Continuous Groundwater Level Monitoring

A total of 12 wells were instrumented with data logging pressure transducers to provide a continuous record of groundwater level response (that is, drawdown and recovery) to pumping on/off cycles at the KHW during the aquifer test. This information was used during transient calibration of the groundwater flow model, described in **Section 4**. Instrumented wells included:

- KHW
- Four newly installed monitoring wells: WI-CV-MW15M, WI-CV-MW15S, WI-CV-MW16M, and WI-CV-MW16S
- Seven existing monitoring wells: WI-CV-MW02S, WI-CV-MW04M, WI-CV-MW04S, WI-CV-MW05M, WI-CV-MW07M, WI-CV-MW07S, and WI-CV-MW14M

The selected wells provide coverage of multiple depth intervals in the local aquifer as well as good spatial coverage across the OLF Coupeville site. The locations of instrumented wells are shown on **Figure 2-1**.

The 11 monitoring wells were instrumented with vented data-logging electronic pressure transducers with maximum pressure ratings of 5 pound per square inch (psi) to monitor groundwater levels. A 15-psi rated data-logging transducer was deployed at the KHW because groundwater level fluctuations were expected to be greater within the pumping well.

Transducer deployment began on December 23, 2017. All of the transducers were deployed and programmed on this date except for the WI-CV-MW02S and WI-CV-MW05M transducers, which were deployed on December 28, 2017. Transducers were programmed to log data at 1-minute intervals. Readings were recorded as a depth to water (DTW) in feet below top of well casing (btoc). Data was downloaded periodically using an In-Situ RuggedReader. During groundwater sampling (**Section 2.3.1**), transducer data logging at the well being sampled was suspended, and the transducer was removed to allow the intake pump to be lowered to proper depth. The transducer was replaced, and data logging resumed immediately after sampling of the well was completed.

Graphs showing the KHW ultrasonic flow meter data and the transducer data from monitored wells are provided as **Appendix E**.

2.2.2 Manual Groundwater Level Surveys

Manual groundwater level measurements were taken periodically during the aquifer test as a check on transducer readings. Additionally, two rounds of manual groundwater level measurements were taken at all on-Base monitoring wells. Round 1 occurred on December 27 and 28, 2017, and Round 2 occurred on January 8, 2018. Groundwater levels were used to generate updated groundwater elevation contour maps and as targets for the steady-state calibration of the groundwater flow model (**Section 4**). Measurements were taken with a Solinst PFAS-free water level indicator. Well total depths were also measured and recorded when possible. The results of the manual groundwater level surveys are presented in **Tables 2-2 and 2-3**.

2.2.3 Keystone Hill Well Flow Measurements

Volumetric flow rate was recorded at the KHW beginning December 23, 2017 and continued through January 2, 2018. A Seametrics J-Wave strap-on ultrasonic flow meter was used to measure flow rate. Ideal installation specifications require 5 feet (pipe diameter x 15) of straight pipe upstream and 2 feet (pipe diameter x 5) of straight pipe downstream. However, due to the configuration of the KHW plumbing, the ideal installation requirements were not attainable. The flow meter was installed on an approximately 2.5-foot section of vertical pipe, which was the longest length of straight pipe that was accessible. Photographs of the ultrasonic flow meter setup are provided in **Appendix F**. During the aquifer test, periodic checks were made on the accuracy of the flow readings using the analog totalizer permanently installed at the KHW.

2.3 Groundwater and Drinking Water Sampling

Drinking water samples and groundwater samples were collected from the KHW and on-Base monitoring wells, respectively, to assess concentrations of 14 PFAS compounds. Drinking water and groundwater sampling methods are outlined in the SAP (CH2M, 2017) and applicable SOPs.

2.3.1 Groundwater Sampling at Monitoring Wells

Groundwater samples were collected between December 29, 2017 and January 5, 2018. Groundwater was sampled for PFAS at 11 groundwater monitoring wells under low flow and low stress conditions with the sample pump intake placed at the middle of the screen interval. PFAS-free bladder pumps were used for sampling in accordance with the SAP.

Depth to groundwater readings and groundwater quality parameters (WQPs) (specific conductance, pH, turbidity, temperature, dissolved oxygen, and oxidation-reduction potential) were measured and recorded at approximately every 3 to 5 minutes using a water quality meter. The water quality meter was calibrated daily. If excessive drawdown was created at the minimum acceptable flow rate for low flow and low stress sampling conditions, the pump intake was raised to within a few feet of the top of the groundwater column and a minimum of three well volumes was purged. If the well went dry before purging three well volumes, a sample was collected after recharge had taken place within 24 hours of purging.

Table 2-2. Manual Groundwater Elevations at Instrumented Wells

Monitoring Well ID	TOC Elevation (ft NAVD88)	12/21/2017		12/22/2017		12/23/2017		12/28/2017		12/29/2017		12/30/2017		1/2/2018		1/3/2018	
		DTW (ft btoc)	GWE (ft NAVD88)	DTW (ft btoc)	GWE (ft NAVD88)	DTW (ft btoc)	GWE (ft NAVD88)	DTW (ft btoc)	GWE (ft NAVD88)	DTW (ft btoc)	GWE (ft NAVD88)	DTW (ft btoc)	GWE (ft NAVD88)	DTW (ft btoc)	GWE (ft NAVD88)	DTW (ft btoc)	GWE (ft NAVD88)
WI-CV-MW02S	193.17	--	--	--	--	--	--	93.1	100.1	--	--	93.4	99.8	--	--	93.2	100.0
WI-CV-MW04M	193.19	--	--	--	--	123.2	70.0	--	--	--	--	123.4	69.8	123.4	69.8	--	--
WI-CV-MW04S	193.20	--	--	--	--	106.6	86.6	--	--	--	--	106.9	86.3	106.9	86.3	--	--
WI-CV-MW05M	190.64	--	--	--	--	--	--	123.2	67.5	--	--	123.8	66.8	--	--	123.2	67.4
WI-CV-MW07M	199.57	--	--	--	--	129.0	70.5	--	--	--	--	129.4	70.1	--	--	129.2	70.4
WI-CV-MW07S	200.02	--	--	--	--	126.6	73.5	--	--	--	--	126.8	73.3	--	--	126.6	73.5
WI-CV-MW14M	191.61	122.8	68.8	--	--	122.7	68.9	--	--	--	--	123.2	68.4	122.4	69.2	--	--
WI-CV-MW15M	193.35	--	--	124.6	68.8	123.8	69.5	--	--	--	--	125.0	68.4	--	--	124.6	68.8
WI-CV-MW15S	192.92	--	--	124.2	68.7	124.0	68.9	--	--	--	--	124.5	68.5	--	--	123.7	69.2
WI-CV-MW16M	192.27	--	--	124.6	67.7	124.3	68.0	--	--	124.3	68.0	--	--	123.0	69.3	--	--
WI-CV-MW16S	192.16	--	--	124.5	67.6	124.2	68.0	--	--	122.9	69.2	--	--	124.2	68.0	--	--
Keystone Hill well	194.74	133.9	60.9	--	--	126.2	68.6	--	--	--	--	135.0	59.7	--	--	134.7	60.1

Notes:

-- = groundwater level not taken

GWE = groundwater elevation

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Table 2-3. Manual Groundwater Elevations

Monitoring Well ID	TOC Elevation (ft NAVD88)	Round 1 12/27/2017		Round 1 12/28/2017		Round 2 1/8/2018	
		DTW (ft btoc)	GWE (ft NAVD88)	DTW (ft btoc)	GWE (ft NAVD88)	DTW (ft btoc)	GWE (ft NAVD88)
WI-CV-MW01D	194.58	141.22	53.36	--	--	140.93	53.65
WI-CV-MW01M	194.61	123.85	70.76	--	--	123.70	70.91
WI-CV-MW02M	193.11	123.20	69.91	--	--	123.08	70.03
WI-CV-MW02S	193.17	93.25	99.92	--	--	93.08	100.09
WI-CV-MW03D	193.07	143.02	50.05	--	--	142.52	50.55
WI-CV-MW03M	193.14	123.20	69.94	--	--	123.05	70.09
WI-CV-MW04M	193.19	123.27	69.92	--	--	123.76	69.43
WI-CV-MW04S	193.20	106.71	86.49	--	--	107.51	85.69
WI-CV-MW05M	190.64	123.24	67.40	--	--	123.03	67.61
WI-CV-MW05S	190.38	120.29	70.09	--	--	120.65	69.73
WI-CV-MW06M	197.87	--	--	146.42	51.45	146.43	51.44
WI-CV-MW06S	197.97	--	--	134.71	63.26	134.69	63.28
WI-CV-MW07M	199.57	--	--	129.07	70.50	129.71	69.86
WI-CV-MW07S	200.02	--	--	126.48	73.54	126.55	73.47
WI-CV-MW08M	205.21	--	--	121.65	83.56	122.04	83.17
WI-CV-MW08S	205.17	--	--	117.91	87.26	117.94	87.23
WI-CV-MW09M	187.23	--	--	125.46	61.77	125.49	61.74
WI-CV-MW09S	187.15	--	--	dry	n/a	dry	n/a
WI-CV-MW10D	188.25	--	--	141.11	47.14	141.19	47.06
WI-CV-MW10M	188.33	--	--	136.10	52.23	136.03	52.30
WI-CV-MW11M	202.14	--	--	131.17	70.97	131.55	70.59
WI-CV-MW11S	202.01	--	--	130.99	71.02	130.90	71.11
WI-CV-MW12D	186.85	--	--	160.31	26.54	160.16	26.69
WI-CV-MW12S	186.97	--	--	105.99	80.98	106.07	80.90
WI-CV-MW13M	189.11	--	--	126.94	62.17	126.74	62.37
WI-CV-MW13S	189.28	--	--	109.99	79.29	110.01	79.27
WI-CV-MW14M	191.61	122.49	69.12	--	--	122.83	68.78
WI-CV-MW15M	193.35	123.56	69.79	--	--	124.53	68.82
WI-CV-MW15S	192.92	123.47	69.45	--	--	124.13	68.79
WI-CV-MW16M	192.27	123.06	69.21	--	--	124.61	67.66
WI-CV-MW16S	192.16	122.90	69.26	--	--	124.53	67.63
Keystone Hill well	194.74	126.4	68.3	--	--	--	--

Notes:
-- = groundwater level not taken

WQPs were considered stabilized for three consecutive readings as follows:

- Specific conductance readings remained within 0.01 millisiemens per centimeter (mS/cm) if < 1 or 0.02 mS/cm if > 1
- pH readings remained within 0.1 pH unit
- Turbidity readings were less than 10 nephelometric turbidity units (NTUs) or agreed within 10 percent
- Temperature readings remained within 0.1 degree Celsius (°C)
- Dissolved oxygen remained within 0.05 milligram per liter (mg/L) if < 1 or 0.2 mg/L if > 1
- Oxidation-reduction potential remained within 10 millivolts (mV)

Groundwater samples were taken at all wells where transducers were deployed (see **Figure 2-1**). Stabilized WQPs recorded before sample collection are recorded in **Table 2-4**. Depth to water, WQPs, and total well depth measurements were recorded on Groundwater Sampling Data Sheets included as **Appendix G**.

Table 2-4. Groundwater Quality Parameters

Location ID	Sample Date	Sample Time	pH	Conductivity (mS/cm)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (mV)	Turbidity (NTU)
WI-CV-MW02S	1/3/2018	14:50	8.28	0.480	10.88	0.18	169	3.86
WI-CV-MW04M	1/2/2018	14:04	8.90	0.285	9.85	0.00	-201	24.20
WI-CV-MW04S	1/4/2018	14:40	7.89	0.268	8.39	6.99	151	7.02
WI-CV-MW05M	1/5/2018	10:40	7.95	0.354	8.84	8.20	228	3.80
WI-CV-MW07M	1/4/2018	12:25	8.40	0.381	8.59	0.00	-136	5.21
WI-CV-MW07S	1/4/2018	12:45	7.83	0.684	8.02	0.00	6	0.00
WI-CV-MW14M	1/5/2018	12:10	8.18	0.334	10.17	0.00	-123	12.00
WI-CV-MW15M	12/30/2017	11:05	8.48	0.444	9.65	0.00	-240	13.60
WI-CV-MW15S	12/30/2017	13:40	8.40	0.401	10.08	0.87	19	27.90
WI-CV-MW16M	12/29/2017	14:25	8.22	0.405	9.38	4.79	198	7.92
WI-CV-MW16S	12/29/2017	14:49	7.89	0.365	8.31	0.00	34	27.70

During sample collection, quality control (QC) samples were collected at a rate of one field duplicate sample for every 10 samples and one set of matrix spike/matrix spike duplicates sample for every 20 samples collected. One equipment blank was collected each day of sampling from decontaminated pump equipment.

Groundwater samples were shipped in an ice-chilled cooler under chain-of-custody protocols to Vista Analytical Laboratories in El Dorado Hills, California. Samples were analyzed for PFAS by liquid chromatography–mass spectrometry (LCMS)compliant with Department of Defense Quality Systems Manual (QSM) version 5.1 Table B-15.

2.3.2 Drinking Water Sampling at Keystone Hill Well

Since the KHW is classified as a drinking water supply well, the well was sampled using protocols for drinking water sampling and analyzed via EPA Method 537. The sample was collected on December 30, 2017. The sample point was a spigot in the pumphouse just west of the well vault. Prior to sampling, the spigot was turned on, and water was allowed to run for approximately 5 minutes to purge any stagnant water from the line.

2.4 Investigation-derived Waste Management and Disposal

Wastes generated during the field activities were characterized as investigation-derived waste (IDW) and managed in accordance with the SAP and applicable SOPs. Solid IDW generated from soil cuttings was containerized in one 20 cubic yard roll-off box with a lid and secondary containment. Liquid IDW, which included well development and purge water, decontamination water, and residual drilling mud was stored in a 20,000-gallon steel fractionation tank with secondary containment. Soil and aqueous IDW was characterized as non-hazardous and is currently awaiting disposal.

R:\ENBG\00_Proj\N\Navy\CLEAN\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4041\Coupeville\Aquifer\Figure_2-1_OLF_MW_Locations.mxd6/4/2018SSAVAGE1

Legend

- Shallow Elevation Interval Monitoring Well
- Middle Elevation Interval Monitoring Well
- Deep Elevation Interval Monitoring Well
- Keystone Hill Well
- Base Supply Well
- Aquifer Test Observation Well
- Base Boundary

Note:
Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation.
OLF = Outlying Landing Field

N

0 0.15 0.3 Miles

1 inch = 0.3 mile

Imagery Source: Esri

Figure 2-1
OLF Groundwater Monitoring Well Locations
Naval Air Station Whidbey Island
Coupeville, Washington

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SECTION 3

Data Analysis and Results

This section presents the analysis and results of the data collected during the field investigation detailed in **Section 2** and provides an updated conceptual site model (CSM) for the OLF Coupeville site.

3.1 Updated Conceptual Site Model

The initial CSM for OLF Coupeville was described in the *Final Technical Memorandum: Evaluation of Per- and Polyfluoroalkyl Substances in Groundwater Outlying Landing Field Coupeville* (NAVFAC, 2018). The initial CSM is provided in the SAP (CH2M, 2017). The CSM was updated with additional information collected during the December 2017-January 2018 investigation.

The aquifer at OLF Coupeville has been previously discussed in the context of three general elevation intervals: "shallow" (screened above 50 feet NAVD88), "intermediate" (screened 0 to 50 feet NAVD88), and "deep" (screened near or below 0 feet NAVD88). These designations are reflected in the well names by the designation "S," "M," or "D". While these designations are accurate for depicting the relative depths of individual wells within a cluster, these descriptors do not necessarily correlate across the site because the surface elevations at each well cluster vary. In other words, an "M" well at one location may have a significantly different well screen elevation than an "M" well at another location. The true well screen elevations for all wells at the site were compared and evaluated during the model layering effort and wells were assigned to model layers based on true well screen elevation rather than well name designations (**Figure 3-1**). The elevation intervals described above do not indicate three discrete aquifers or water-bearing zones. With the exception of shallow perched groundwater bearing units that may occur locally, all three well elevation groupings present at the site occur within a single aquifer system and are in hydraulic connection with one another. The terms shallow, intermediate, and deep are used to convey depth information within the aquifer system at the site for the purposes of discussing variability in flow directions, PFAS presence or absence, or other characteristics that may vary with depth.

The first encountered groundwater in the northern portion of the site is between 90 and 130 feet bgs. Selected shallow wells may represent localized perched groundwater, but the available data do not confirm this. A discontinuous clay and silt layer is present at some well cluster locations but pinches out in the southern portion of the site. The underlying intermediate elevation interval is likely semiconfined, with confined conditions in some areas of the northern portion of the site and unconfined conditions in the southern portion, near wells WI-CV-MW10M and WI-CV-MW12S/D. The potentiometric surface for the intermediate elevation interval is at approximately 60 to 85 feet NAVD88, or 120 to 130 feet bgs. A heterogeneous clay, claystone, and silt confining layer underlies the intermediate elevation interval and is interpreted to define the bottom of the Partridge Gravel. Organic material (for example, plant material and peat) was frequently observed in this interval. Transmissive sand zones are present within and beneath the organic silt and clay unit. Borings completed at the site were typically terminated in the organic clay zone or sand zones within or beneath it. For this assessment, these sand zones are considered part of the deep elevation interval.

3.2 Aquifer Test Results Summary

Up to 9 feet of drawdown was recorded at the KHW during the aquifer test period when the well was periodically pumped at rates ranging from approximately 120 to 150 gpm. Groundwater levels observed at nearby monitoring wells during the aquifer test indicate that several locations in the surrounding aquifer are hydraulically impacted by pumping at the KHW. Groundwater level fluctuations in response to KHW pumping at WI-CV-MW14M (approximately 500 feet away) were approximately 0.5 foot or less. Larger responses were observed at wells WI-CV-MW15M/S and WI-CV-MW16M/S (approximately 370 and 190 feet from the KHW, respectively) where drawdown in response to pumping was 1 to 1.5 feet. Hydrographs are provided in **Appendix E** for the wells monitored during the KHW aquifer test.

Groundwater drawdown measured in wells monitored during the KHW aquifer test ranged from 0 to 1.5 feet. The maximum drawdown of 1.5 feet occurred at monitoring well WI-CV-MW16M, located closest to the KHW (distance of approximately 190 feet). Groundwater contour maps have been generated for both the intermediate and deep elevation intervals based on groundwater level data collected on January 8, 2018 and included as **Figures 3-2 and 3-3,** respectively. **Figure 3-2** indicates the presence of a groundwater mound in the intermediate elevation interval located in the northeast portion of the site, with groundwater flowing radially outward from the center of the mound. In the deeper elevation interval (**Figure 3-3**), the groundwater flow directions are similar to the intermediate interval; however, the available monitoring well infrastructure can only define flow directions to the south and east of the site. Note that data collected at WI-CV-MW06M were excluded from the contouring because the water level in that well was anomalously low compared to surrounding data.

3.3 Sampling Results Summary

Groundwater and drinking water samples were analyzed for 14 PFAS constituent analytes. Groundwater and drinking water sample results for perfluorobutane sulfonate (PFBS), PFOS, and PFOA are presented in **Table 3-1** and shown on **Figure 3-4**. Comprehensive laboratory results are presented in **Appendix H**. The following is a summary of the drinking water (KHW) and groundwater (monitoring wells) results from samples collected in December 2017 and January 2018:

- **PFBS** – PFBS was detected in six groundwater samples, ranging from 10 parts per trillion (ppt) in the sample taken from WI-CV-MW14M to 533 ppt in the sample taken from WI-CV-MW05M. None of the detections of PFBS exceeded the Regional Screening Level (RSL) of 380,000 ppt (USEPA, 2016a). PFBS was also detected in the drinking water sample collected from the KHW at a concentration of 12.9 ppt.
- **PFOS** – PFOS was detected in six samples, ranging from an estimated 1.24 ppt in the sample taken from WI-CV-MW14M to 87.8 ppt in the sample taken from WI-CV-MW02S. The sample taken from WI-CV-MW02S exceeded the USEPA LHA of 70 ppt for PFOS.
- **PFOA** – PFOA was detected in six groundwater samples ranging from 8.86 ppt in the sample taken from WI-CV-MW14M to 1,220 in the sample taken from WI-CV-MW05M. Samples from five wells, WI-CV-MW02S, WI-CV-MW05M, WI-CV-MW15S, WI-CV-MW16M, and WI-CV-MW16S, exceeded the USEPA PFOA LHA of 70 ppt. PFOA was also detected in the drinking water sample collected at the KHW, but the estimated concentration of 54.1 ppt did not exceed the USEPA LHA for PFOA.

Figure 3-4 presents the PFBS, PFOS, and PFOA results from samples collected in February/March 2017 (December 2016 for the KHW) and December 2017/January 2018. As shown on **Figure 3-4**, wells that were sampled during both events include: WI-CV-MW02S, WI-CV-MW04S/M, WI-CV-MW05M, WI-CV-MW-7S/M, WI-CV-MW14M, and the KHW. PFBS, PFOS, and/or PFOA concentrations were generally lower in wells along the western OLF Coupeville boundary and were generally higher in wells in the central and eastern portion of OLF Coupeville during the recent sampling event than in February/March 2017. The highest combined PFOA and PFOS concentration measured during the December 2017/January 2018 event, 1,222.8 ppt, was from well WI-CV-MW05M. Samples from WI-CV-MW02S, WI-CV-MW15S, WI-CV-MW16M, and WI-CV-MW16S also exceeded the LHA but to a lesser degree.

Table 3-1 Groundwater Sampling Results for PFAS Analytes

Sample ID	Sample Location	Sample Date	PFAS Analytes														
			PFBS	PFOS	PFOA	PFOS+PFOA	EtFOSAA	MeFOSAA	PFHpA	PFHxS	PFNA	PFDA	PFDoA	PFHxA	PFTeDA	PFTrDA	PFUnA
WI-CV-1RW23-1217	Keystone Hill Well	12/30/2017	**12.9**	4.7 U	**54.1 J**	**54.1**	4.7 U	4.7 U	**8.45 J**	**59.2 J**	4.7 U	4.7 U	4.7 U	**27**	4.7 UJ	4.7 U	4.7 U
WI-CV-MW02S-0118	WI-CV-MW02S	1/3/2018	**390**	**87.8**	**1010**	**1097.8**	5.48 U	5.48 U	**234**	**7700**	5.48 U	5.48 UJ	5.48 U	1010	5.48 U	5.48 U	5.48 U
WI-CV-MW04M-0118	WI-CV-MW04M	1/2/2018	5.34 U	**1.25 J**	5.34 U	**1.3**	5.34 U	5.34 U	5.34 U	5.34 U	5.34 U	5.34 U	5.34 U	5.34 U	5.34 U	5.34 U	5.34 U
WI-CV-MW04S-0118	WI-CV-MW04S	1/4/2018	5.3 U	5.3 U	5.3 U	ND	5.3 U	5.3 U	5.3 U	5.3 U	5.3 U	5.3 UJ	5.3 U	5.3 U	5.3 U	5.3 U	5.3 U
WI-CV-MW05M-0118	WI-CV-MW05M	1/5/2018	**533**	**2.84 J**	**1220**	**1222.8**	5.34 U	5.34 U	**263**	**1070**	5.34 U	5.34 UJ	5.34 U	**1240**	5.34 U	5.34 U	5.34 U
WI-CV-MW07M-0118	WI-CV-MW07M	1/4/2018	5.34 U	5.34 U	5.34 U	ND	5.34 U	5.34 U	5.34 U	5.34 U	5.34 U	5.34 UJ	5.34 U	5.34 U	5.34 U	5.34 U	5.34 U
WI-CV-MW07S-0118	WI-CV-MW07S	1/4/2018	5.17 U	5.17 U	5.17 U	ND	5.17 U	5.17 U	5.17 U	5.17 U	5.17 U	5.17 UJ	5.17 U	5.17 U	5.17 U	5.17 U	5.17 U
WI-CV-MW14M-0118	WI-CV-MW14M	1/5/2018	**10**	**1.24 J**	**8.86**	**10.1**	5.43 U	5.43 U	**3.19 J**	**11.1**	5.43 U	5.43 UJ	5.43 U	**18.9**	5.43 U	5.43 U	5.43 U
WI-CV-MW15M-1217	WI-CV-MW15M	12/30/2017	5.25 U	5.25 U	5.25 U	ND	5.25 U	5.25 U	5.25 U	5.25 U	5.25 U	5.25 U	5.25 U	5.25 U	5.25 U	5.25 U	5.25 U
WI-CV-MW15S-1217	WI-CV-MW15S	12/30/2017	**15.8**	5.21 U	**253**	**253.0**	5.21 U	5.21 U	**3.32 J**	**363**	5.21 U	5.21 U	5.21 U	**52.9**	5.21 U	5.21 U	5.21 U
WI-CV-MW16M-1217	WI-CV-MW16M	12/29/2017	**34.8**	**2.63 J**	**373**	**375.6**	5.17 U	5.17 U	**30.9**	**149 J**	5.17 U	5.17 U	5.17 U	**104 J**	5.17 U	5.17 U	5.17 U
WI-CV-MW16S-1217	WI-CV-MW16S	12/29/2017	**36.6**	**3.47 J**	**297**	**300.5**	5.3 U	5.3 U	**34.8**	**216**	5.3 U	5.3 U	5.3 U	**106**	5.3 U	5.3 U	5.3 U
USEPA LHA (May 2016)			--	70	70	70	--	--	--	--	--	--	--	--	--	--	--
USEPA RSL (November 2017)			400,000	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:
J - analyte present, value is estimated
U - not detected
-- - no screening criteria available
EtFOSAA - N-ethylperfluoro-1-octanesulfonamidoacetic acid
KHW - Keystone Hill Well
LHA - lifetime health advisory
MeFOSAA - n-methylperfluoro-1-octanesulfonamidoacetic acid
ppt - parts pertrillion
PFBS - perfluorobutansulfonate
PFDA - perfluorodecanoic acid
PFDoA - perfluorododecanoic acid
PFHpA - perfluoroheptanoic acid
PFHxA - perfluorohexanoic acid
PFHxS - perfluorohexanesulfonic acid
PFNA - perfluorononanoic acid
PFOS - perfluorooctanioc sulfonate
PFOA - perfluorooctanioc acid
PFTeDA - perfluorotridecanoic acid
PFTrDA - perfluorotridecanoic acid
PFUnA - perfluoroundecanoic acid
RSL - regional screening level
Shading indicates exceedance of USEPA Lifetime Health Advisory
Bolded text indicates detection

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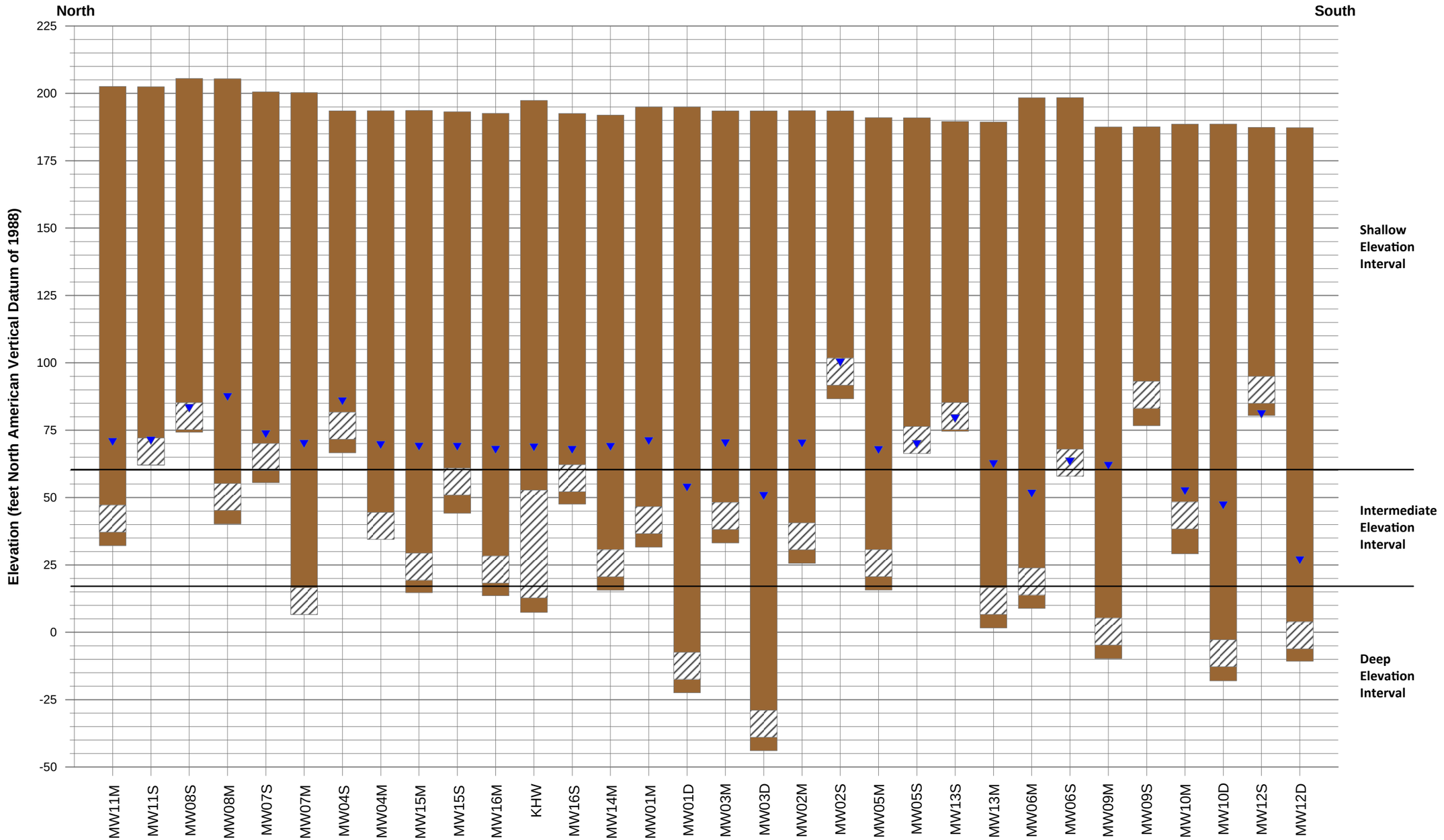
3.4 Data Validation

Data validation was performed on groundwater and drinking water samples collected December 29, 2017 through January 4, 2018 from OLF Coupeville. The data validation report is included in **Appendix I**. The data validation included a review for systematic errors or patterns that are found in the distribution of data qualifiers.

The groundwater samples were analyzed for PFAS by LCMSMS Compliant with QSM 5.1 Table B-15 and drinking water samples were analyzed by USEPA Method 537 as specified in the SAP (CH2M, 2017). The data packages were then reviewed by an independent data validator based on the criteria outlined by *National Functional Guidelines for Superfund Organic Data Review* (USEPA, 2016b). Excluding field QC samples, 210 distinct data points were generated, and 20 results were qualified with J-qualifiers (because of the low sample concentrations), and 158 were U-qualified (because of blank contamination).

All results are usable as qualified. The overall conclusion is that the data set generated is acceptable and appropriate for its intended use.



LEGEND

- ▼ January 2018 Groundwater Elevation
- Screen Interval
- Blank Casing Interval

Notes:

1. KHW = Keystone Hill Well
2. Sample IDs WI-CV-1RW23-1217 and WI-CV-1RW23P-1217 are for the KHW.

Figure 3-1.
Aquifer and Well Screen Elevation Intervals
Naval Air Station Whidbey Island
Coupeville, Washington

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Legend

- Groundwater Well Location
- OLF Coupeville Supply Well
- Community Drinking Water Well
- 5-foot Contour Interval (dashed where inferred)
- Direction of Intermediate-Screened Interval Groundwater Flow
- Building Location
- Base Boundary

Notes:
1. NAVD88 = North American Vertical Datum of 1988
2. Intermediate elevation interval wells are typically screened between approximately 10 and 60 feet NAVD88.
3. Groundwater elevations shown in feet NAVD88
4. Groundwater level measurements used to generate this contour map were collected on 1/8/2018.
5. Data from well MW06M was not used in the contouring.
6. Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation

N

0 0.1 0.2 Miles

1 inch = 0.2 mile

Imagery Source: Esri

Figure 3-2
Groundwater Elevation Contour Map
Intermediate Elevation Interval
Naval Air Station Whidbey Island
Coupeville, Washington

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Legend

- Monitoring Well Location
- OLF Coupeville Supply Well
- Community Drinking Water Well
- 5-foot Contour Interval (dashed where inferred)
- Direction of Deep-Screened Interval Groundwater Flow
- Building Location
- Base Boundary

Notes:
1. NAVD88 = North American Vertical Datum of 1988
2. Deep elevation interval wells are typically screened between approximately 17 and 50 feet NAVD88.
3. Groundwater elevations shown in feet NAVD88
4. Groundwater level measurements used to generate this contour map were collected on 1/8/2018.
5. Data from well MW03D was not used in the contouring.
6. Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation.

N

0 0.1 0.2 Miles

1 inch = 0.2 mile

Imagery Source: Esri

Figure 3-3
Groundwater Elevation Contour Map
Deep Elevation Interval
Naval Air Station Whidbey Island
Coupeville, Washington

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Well ID	MW11S	MW11M
Screened Interval (ft bgs)	130 - 140	155 - 165
Sample Date	2/26/2017	2/26/2017
PFBS	3.91 U	7.66 U
PFOS	**1 J**	1.72 U
PFOA	1.95 U	3.83 U
PFOS + PFOA	**1 J**	ND

Well ID	MW04S		MW04M	
Screened Interval (ft bgs)	112 - 122		149 - 159	
Sample Date	3/1/2017	1/4/2018	2/28/2017	1/2/2018
PFBS	3.91 U	5.3 U	4.03 U	5.3 U
PFOS	0.879 U	5.3 U	0.907 U	**1.25 J**
PFOA	1.95 U	5.3 U	2.02 U	5.3 U
PFOS + PFOA	ND	ND	ND	**1.25 J**

Well ID	WI-CV-WL01
Well Depth (ft bgs)	162
Sample Date	9/19/2016
PFBS	10 U
PFOS	10 U
PFOA	3 U
PFOS + PFOA	ND

Well ID	MW07S		MW07M	
Screened Interval (ft bgs)	130 - 140		183 - 193	
Sample Date	3/4/2017	1/4/2018	3/4/2017	1/4/2018
PFBS	4.39 U	5.17 U	3.91 U	5.34 U
PFOS	0.987 U	5.17 U	**0.844 J**	5.34 U
PFOA	2.19 U	5.17 U	1.95 U	5.34 U
PFOS + PFOA	ND	ND	**0.844 J**	ND

Well ID	MW08S	MW08M
Screened Interval (ft bgs)	121 - 131	150 - 160
Sample Date	3/2/2017	3/4/2017
PFBS	3.85 U	3.91 U
PFOS	0.865 U	0.879 U
PFOA	1.92 U	1.95 U
PFOS + PFOA	ND	ND

Well ID	MW15S	MW15M
Screened Interval (ft bgs)	132-142	164-174
Sample Date	12/30/2017	12/30/2017
PFBS	**15.8**	5.25 U
PFOS	5.21 U	5.25 U
PFOA	**253**	5.25 U
PFOS + PFOA	**253**	ND

Well ID	MW01M	MW01D
Screened Interval (ft bgs)	148 - 158	202 - 212
Sample Date	2/28/2017	2/28/2017
PFBS	3.94 U	4 U
PFOS	0.886 U	0.9 U
PFOA	1.97 U	2 U
PFOS + PFOA	ND	ND

Well ID	MW16S	MW16M
Screened Interval (ft bgs)	130-140	165-175
Sample Date	12/29/2017	12/29/2017
PFBS	**36.6**	**34.8**
PFOS	**3.47 J**	**2.63 J**
PFOA	**297**	373
PFOS + PFOA	**300**	**376**

Well ID	MW02S		MW02M
Screened Interval (ft bgs)	92 - 102		153 - 163
Sample Date	3/1/2017	1/3/2018	3/1/2017
PFBS	**332**	**390**	3.88 U
PFOS	**54.7**	**87.8**	0.872 U
PFOA	**571**	**1010**	1.94 U
PFOS + PFOA	**626**	**1098**	ND

Well ID	Keystone Hill Well	
Well Depth (ft bgs)	190	
Sample Date	12/6/2016	12/30/2017
PFBS	99 U	12.9
PFOS	43 U	4.7 U
PFOA	**61**	**54.1 J**
PFOS + PFOA	**61**	**54.1 J**

Well ID	MW05S	MW05M	
Screened Interval (ft bgs)	114 - 124	160 - 170	
Sample Date	2/24/2017	2/23/2017	1/5/2018
PFBS	**12.9**	**473**	**533**
PFOS	0.922 U	**3.26 J**	**2.84 J**
PFOA	**9.87**	**1,190**	**1,220**
PFOS + PFOA	**9.87**	**1,193**	**1,223**

Well ID	MW14M	
Screened Interval (ft bgs)	161 - 171	
Sample Date	3/4/2017	1/5/2018
PFBS	**111**	**10**
PFOS	**0.898 J**	**1.24 J**
PFOA	**166**	**8.86**
PFOS + PFOA	**167**	**10.10**

Well ID	MW06S	MW06M
Screened Interval (ft bgs)	130 - 140	174 - 184
Sample Date	2/22/2017	2/21/2017
PFBS	3.97 U	3.91 U
PFOS	0.893 U	0.879 U
PFOA	1.98 U	1.95 U
PFOS + PFOA	ND	ND

Well ID	MW03M	MW03D
Screened Interval (ft bgs)	145 - 155	222 - 232
Sample Date	2/27/2017	2/27/2017
PFBS	3.88 U	3.91 U
PFOS	0.872 U	**0.914 J**
PFOA	1.94 U	1.95 U
PFOS + PFOA	ND	**0.914 J**

Well ID	MW10M	MW10D
Screened Interval (ft bgs)	144 - 154	191 - 201
Sample Date	2/22/2017	2/20/2017
PFBS	**3.07 J**	3.85 U
PFOS	0.938 U	0.865 U
PFOA	2.08 U	1.92 U
PFOS + PFOA	ND	ND

Well ID	MW13S	MW13M
Screened Interval (ft bgs)	105 - 115	173 - 183
Sample Date	3/3/2017	2/22/2017
PFBS	4.07 U	**139**
PFOS	0.915 U	0.872 U
PFOA	2.03 U	**20.4**
PFOS + PFOA	ND	**20.4**

Well ID	MW09S	MW09M
Screened Interval (ft bgs)	96 - 106	182 - 192
Sample Date	NA	2/23/2017
PFBS	NS	**11.2**
PFOS	NS	0.915 U
PFOA	NS	2.03 U
PFOS + PFOA	NS	ND

Well ID	MW12S	MW12D
Screened Interval (ft bgs)	92 - 107	183 - 193
Sample Date	NA	3/1/2017
PFBS	NS	3.97 U
PFOS	NS	0.893 U
PFOA	NS	1.98 U
PFOS + PFOA	NS	ND

Well ID	WI-CV-WL02
Well Depth (ft bgs)	178
Sample Date	9/19/2016
PFBS	**110**
PFOS	10 U
PFOA	**17.5 J**
PFOS + PFOA	**17.5 J**

Notes

Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation.
OLF - Outlying Landing Field
PFBS - perfluorobutanesulfonic acid
PFOS - perfluorooctane sulfonate
PFOA - perfluorooctanoic acid
units - parts per trillion (ppt)
J - analyte detected, concentration is estimated
U - not detected
NA - not applicable
ND - not detected
NS - not sampled
Bold indicates detection
Shading indicates exceedance of USEPA Lifetime Health Advisory (70 ppt)
Where applicable, the higher concentration between the primary and field duplicate samples is shown.
Samples were not collected from MW09-S and MW12-S because the wells were dry at the time of sampling.

Legend

- OLF Coupeville Supply Well
- Monitoring Well with no exceedance of LHA
- Monitoring Well with LHA exceedance
- No detections of PFAS
- Not Sampled (Dry)
- Community Drinking Water Well
- Direction of Groundwater Flow in the Intermediate Elevation Interval of the Aquifer
- Direction of Groundwater Flow in the Deep Elevation Interval of the Aquifer
- Base Boundary

N

0 0.1 0.2 Miles

1 inch = 0.2 mile

Imagery Source: Esri

Figure 3-4
Summary of Groundwater PFAS Concentrations
Naval Air Station Whidbey Island
Coupeville, Washington

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SECTION 4

Groundwater Flow Model

The data collected during the KHW aquifer test were used to inform the construction and calibration of a three-dimensional (3D) numerical groundwater flow simulation model. This section documents the approach used to develop the model. The model is referred to as the Coupeville Groundwater Flow Model (CGFM).

4.1 Modeling Objectives

The general objective for developing a numerical groundwater flow model was to provide a tool to investigate groundwater behavior at OLF Coupeville and potentially assist future alternatives analysis for PFAS remediation. The following are more specific, short-term objectives:

- Evaluate the capture zone of the KHW under current pumping rates.
- Evaluate the capture zone of the KHW under proposed increased pumping rates.
- Evaluate potential migration paths from areas where PFAS contamination has been detected.

The following sections describe the activities associated with the modeling effort to achieve these objectives.

4.2 Model Design and Construction

The design of the numerical model resulted from translating the conceptual model, described in **Section 3.1**, into a form suitable for numerical modeling. The following steps were completed when developing the numerical model:

- Select a numerical groundwater flow model code
- Establish a 3D model domain and develop a 3D model grid
- Spatially distribute land-surface elevation values
- Spatially distribute aquifer parameter values (hydraulic conductivity and storage)
- Establish boundary conditions for calibration
- Select an appropriate time discretization

The following subsections describe the methodology used to complete these steps.

4.2.1 Code Selection

The MODFLOW-NWT code (Niswonger et al., 2011; USGS, 2018) was selected for this effort, in conjunction with the Groundwater Vistas Version 7 (ESI, 2017) pre- and post-processing software package. MODFLOW-NWT is an updated formulation of MODFLOW-2005 (Harbaugh, 2005). It is a stand-alone computer code that was developed to provide a more robust solution to the nonlinear unconfined groundwater flow equation. MODFLOW-NWT accommodates developing a physically-based, spatially-distributed numerical model. It includes several packages for simulating 3D groundwater flow. The MODFLOW-NWT code was selected for the following reasons.

- MODFLOW-NWT is based on MODFLOW-2005, which has been used extensively in groundwater evaluations worldwide for many years and is well documented. MODFLOW-NWT contains an improved solution scheme that can better handle complex, variably-saturated conditions.
- MODFLOW-NWT has been benchmarked and verified, so that the numerical solutions generated by the code have been compared with one or more analytical solutions, subjected to scientific review, and used on previous modeling projects. Verification of the code confirms that MODFLOW-NWT can accurately solve the governing equations that constitute the mathematical model.

The CGFM is conceptualized mathematically as a single density subsurface flow regime. The subsurface flow regime includes the hydraulic parameters that control groundwater movement and rates. All model layers are

treated as vertically integrated, unconfined layers to facilitate simulating complex 3D flow conditions. The CGFM also accommodates the standard suite of flow model boundary conditions.

The theory and numerical techniques that are incorporated into MODFLOW-NWT and the CGFM have been scientifically tested. The governing equations for variably saturated subsurface flow are well established and have been solved by several modeling codes over the last few decades on a wide range of field problems. Thus, the scientific bases of the theory and the numerical techniques for solving these equations have been well established. The MODFLOW-NWT user's manual (Niswonger et al., 2011) details the governing equations and the numerical techniques for solving the system of equations.

4.2.2 Model Domain

Areal Characteristics of Model Grid

CH2M developed a numerical model grid that mathematically represents an approximately 50-square-mile area roughly centered around the OLF Coupeville site. **Figure 4-1** illustrates the CGFM grid, which was partitioned into grid blocks (that is, cells) horizontally spaced on 40- to 1,325-foot centers. The model grid was aligned north-south and east-west and georeferenced to the 1983 North American Datum (NAD83) of the Washington State Plane North coordinate system in units of feet. The model domain was aerially discretized into 396 rows and 241 columns resulting in 95,436 total cells per model layer. The model cells that overlie open water were not included in the simulation and were designated as inactive cells, resulting in a total of 85,837 active cells per layer. The locations of the active model domain boundaries were selected to include the entire land mass of Whidbey Island in this area and extending just beyond the shoreline of the island. This definition of the model domain takes advantage of the natural hydrologic boundaries that exist in the local groundwater flow system. Extending the model domain just beyond the shoreline provides for the assignment of boundary conditions along the perimeter of the island that represent the equivalent freshwater head adjacent to the island aquifer system.

Vertical Characteristics of Model Grid

CH2M developed five vertically-stacked layers to provide a 3D representation of the subsurface system. The basis for Model Layers 2 through 4 was largely associated with the approximate elevation ranges of available well screen elevation intervals at OLF Coupeville. These intervals are illustrated on **Figure 4-2**. Note that these intervals are determined by absolute elevation as opposed to the aforementioned shallow, intermediate, and deep intervals determined by depth of well screens bgs. Since surface elevations change drastically throughout the model domain, layer thicknesses outside the OLF Coupeville boundary correspond to the average bgs depths of the screen intervals rather than average elevation ranges. Model Layer 1 was included as a mostly dry layer to facilitate transmission of recharge down to the lower layers. Model Layer 5 was included as a 50-foot-thick basal aquitard. The distribution of model layers is depicted on **Figure 4-2**.

4.2.3 Topography and Bathymetry

The top of Model Layer 1 represents the land surface. Two types of data were used to prepare the land-surface-elevation data sets for the CGFM, including 2001–2002, 6-foot bare Earth light imaging, detection, and ranging (LiDAR) data and 2005, 30-foot State of Washington Oceanography bathymetric data. Data from these sources were combined and processed. The LiDAR data were retained over the portion of the model domain covering the land mass, and the bathymetric data were retained over portions of the model domain covering large water bodies. This combined data set represents the best available topography and bathymetry across the study area. This data set formed the basis for land-surface and sea-bottom elevations that were assigned in the CGFM. **Figures 4-3 and 4-4** illustrate the land-surface and sea-bottom elevations incorporated into the top of the CGFM model grid.

4.2.4 Subsurface Hydraulic Parameters

Hydraulic Conductivity

Initial hydraulic conductivity estimations were made according to lithology. Lithologic information from nearly 500 wells within the model domain were available from Island County. Using environmental visualization software (EVS) – a 3D kriging software – a 3D lithologic model was developed for the model domain. As a QC check, the cross-sections of the EVS lithologic model were compared to cross-sections developed from soil-boring logs for an April 2017 groundwater investigation report (NAVFAC, 2017). Lithologies were translated into conductivity fields by assigning approximate conductivity values to each lithology type (gravel, sand, silt, and clay) and then sampling the lithologic model and discretizing it to the 3D model grid. **Figure 4-5** illustrates the initial distribution of lithology types input to the model.

Storage

The specific yield and storativity of the aquifer system at the site were also included in the calibration effort described in the following subsections, and the final values obtained from the calibration are reported in **Section 4.3**. Initial estimates for these values were 0.10 for specific yield and $1x10^{-5}$ for specific storage; however, these parameters were later adjusted during the Model-Independent Parameter Estimation and Uncertainty Analysis (PEST)[1] autocalibration process to yield 0.012 for specific yield and $5.3x10^{-5}$ for specific storage.

4.2.5 Boundary Conditions

Boundary conditions are mathematical rules that specify head and/or flux at particular times and at particular locations within the model domain. **Figure 4-6** summarizes the transient boundary conditions that were used to calibrate the CGFM. The following three types of boundary conditions were used in the CGFM:

- **Head-dependent flux:** Head and hydraulic-conductance values were assigned to model cells, and groundwater fluxes were computed by the model code across the boundary using an appropriate governing equation.
- **Specified flux:** Volumetric groundwater fluxes were assigned to selected model cells, some of which remained unchanged throughout the simulation; others varied with time. A specified-flux cell is a two-way boundary condition whereby negative values indicate groundwater exiting the model domain, and positive values indicate groundwater entering the model domain.
- **No-flow:** Groundwater can flow parallel to the boundary but not across it.

Head-dependent-flux Boundaries

The active portion of the model covers only the island and immediate off-shore areas. Head-dependent-flux boundaries were assigned as general head boundaries to model cells in immediate off-shore areas as illustrated on **Figure 4-6**. The reference heads were determined by equivalent freshwater heads of the offshore water column. Equivalent freshwater heads were calculated using mean tide levels, offshore bathymetry, and average Puget Sound salinity. The conductance terms were initially assigned based on assumed hydraulic conductivity values for coastal sediments but were further refined during the model calibration process.

Specified-flux Boundaries

Specified-flux boundaries were used to simulate two distinct processes, aerial recharge from precipitation, and pumping from both the KHW and the two water supply wells operating at the Fort Casey Well Field to the southwest of the OLF facility.

To simulate recharge from precipitation, specified-flux boundaries were assigned to cells in Model Layer 1 covering the land surface (**Figure 4-6**). Recharge rate estimates were obtained from a United States Geological

[1] http://pesthomepage.org/

Survey (USGS) study of recharge rates in Island County, Washington for water years 1998 and 1999 (USGS, 2004). This study used average annual precipitation, surficial geology, soil groups, and land cover to simulate average annual recharge using the Deep Percolation Model. Recharge rates were refined during model calibration.

A specified-flux boundary was assigned to a model cell in Model Layer 3 at the coordinates of the KHW. Specified-flux boundary conditions were also assigned to the model in Layer 4 at the location of the two operational water supply wells in the Fort Casey Well Field. Pumping rates at the KHW were obtained from ultrasonic flow meter readings during the KHW aquifer test. Pumping well data from the Fort Casey Well Field wells were provided by the Town of Coupeville.

No-flow Boundaries

As illustrated on **Figure 4-6**, no-flow boundaries were used to delineate the active and inactive portions of the CGFM. The portions of the model domain outside the general head boundaries covering the Strait of Juan de Fuca and Admiralty Inlet (west) and Saratoga Passage (east) were made inactive. No-flow boundaries were also placed at the northwest and southeast segments of the model domain border cutting across the island. Groundwater levels in wells near these boundaries suggest that groundwater generally flows east and west, parallel to the boundary. Therefore, no-flow boundaries are appropriate for these locations.

4.2.6 Time Discretization

A numerical model must describe a field problem at discrete time intervals. The CGFM was designed to simulate the 240-hour pumping test at the KHW. However, due to the irregularity of pumping cycles at the KHW, it was not feasible to discretize the entire duration of the aquifer test. Therefore, a 41-hour simulation period was selected during which the pumping cycle was more regular and pumping rates relatively stable. This period began at 4 p.m. on December 25, 2017 and ended at 9:05 a.m. on December 27, 2017. This 41-hour period was discretized into 12 stress periods. An average pumping rate was calculated over each stress period. A 365-day steady-state stress period was also included to establish initial conditions prior to the initiation of transient observation. An approximated pumping rate of 150 gpm from the KHW was assumed for the 365-day initial stress period. **Table 4-1** summarizes how time was discretized for the transient calibration.

Table 4-1. Summary of Stress Period Durations Used During Model Calibration

Stress Period	Stress Period Duration (days)	Ending Date and Time	Pumping Rate (gpm)	Note
1	365	12/25/2017 16:00	150.0	Steady-state initial conditions
2	0.022	12/25/2017 16:31	0.0	Keystone Hill well off
3	0.177	12/25/2017 20:45	135.1	Keystone Hill well pumping
4	0.175	12/26/2017 0:57	139.9	Keystone Hill well pumping
5	0.176	12/26/2017 5:10	146.7	Keystone Hill well pumping
6	0.157	12/26/2017 9:21	152.3	Keystone Hill well pumping
7	0.167	12/26/2017 13:21	156.5	Keystone Hill well pumping
8	0.033	12/26/2017 14:10	0.0	Keystone Hill well off
9	0.167	12/26/2017 18:10	129.9	Keystone Hill well pumping
10	0.167	12/26/2017 22:10	132.5	Keystone Hill well pumping
11	0.167	12/27/2017 2:11	139.4	Keystone Hill well pumping
12	0.166	12/27/2017 6:10	146.0	Keystone Hill well pumping
13	0.122	12/27/2017 9:05	151.2	Keystone Hill well pumping

4.3 Model Calibration

Model calibration is the process of tuning a numerical model to simulate observed subsurface flow conditions in the field, as described with measured data, to within an acceptable degree of accuracy. This section discusses the calibration targets and results.

4.3.1 Selection of Calibration Targets

Calibration targets are defined as the selected field-measured values that quantify hydrologic conditions of interest with consideration of data quality and reliability. CH2M used both steady-state and transient calibration targets to calibrate the CGFM. This subsection discusses the specific quantitative calibration targets selected for this effort.

Steady-state Groundwater Elevation Targets

The manual groundwater elevations measured in conjunction with the KHW aquifer test (**Section 2.2.2**) served as steady-state calibration targets (**Table 4-2**). Two rounds of groundwater level measurements were performed between December 27, 2017 and January 8, 2018 at the 31 on-Base monitoring wells and the KHW. One well, WI-CV-MW09S, was dry at the time of the groundwater level measurements, so a total of 31 steady-state calibration targets were used. **Figure 4-7** shows the locations and groundwater levels for all steady-state calibration targets based on groundwater levels measured in January 2018. The January 2018 groundwater elevation data set was utilized in the calibration process as these data represent the most current data available.

Table 4-2. Steady-State Calibration Targets

Well ID	Groundwater Elevation (ft NAVD88)
WI-CV-MW01D	53.65
WI-CV-MW01M	70.91
WI-CV-MW02M	70.03
WI-CV-MW02S	100.09
WI-CV-MW03D	50.55
WI-CV-MW03M	70.09
WI-CV-MW04M	69.43
WI-CV-MW04S	85.69
WI-CV-MW05M	67.61
WI-CV-MW05S	69.73
WI-CV-MW06M	51.44
WI-CV-MW06S	63.28
WI-CV-MW07M	69.86
WI-CV-MW07S	73.47
WI-CV-MW08M	83.17
WI-CV-MW08S	87.23
WI-CV-MW09M	61.74
WI-CV-MW10D	47.06
WI-CV-MW10M	52.30
WI-CV-MW11M	70.59

Table 4-2. Steady-State Calibration Targets

Well ID	Groundwater Elevation (ft NAVD88)
WI-CV-MW11S	71.11
WI-CV-MW12D	26.69
WI-CV-MW12S	80.90
WI-CV-MW13M	62.37
WI-CV-MW13S	79.27
WI-CV-MW14M	68.78
WI-CV-MW15M	68.82
WI-CV-MW15S	68.79
WI-CV-MW16M	67.66
WI-CV-MW16S	67.63
Keystone Hill Well[1]	68.57

Note:

All groundwater elevations refer to the January 8, 2018 groundwater level unless otherwise indicated.

[1] Manual groundwater level measured on December 23, 2017

Transient Calibration Targets

Continuous groundwater level monitoring associated with the KHW aquifer test (**Section 2.2.1**) was conducted at 11 on-Base monitoring wells and the KHW. Two monitoring wells (WI-CV-MW02S and WI-CV-MW05M) did not have transducer records for the 41-hour simulation period because transducers were not deployed in these wells until later in the aquifer test. Therefore, data from these wells were not incorporated, and 10 calibration targets were used for the transient calibration. As previously discussed, to replicate the variability in groundwater levels and KHW pumping rates that occurred over the 41-hour transient calibration period, it was necessary to subdivide the 41-hour period into a discrete number of model stress periods. The groundwater elevations and KHW pumping rate was assumed to be constant within each stress period. As shown in **Table 4-3**, the transient aquifer conditions were simulated by subdividing the 41 hours into 12 discrete stress periods. Average groundwater elevations were calculated for each stress period and used as target values for the transient calibration. These average groundwater elevations were applied to the model during their respective stress periods. The groundwater elevations used for transient calibration targets are summarized in **Table 4-3**. The hydrographs depicting the transient groundwater elevation and KHW pumping rate data are included in **Appendix E**.

Table 4-3. Transient Calibration Targets

Stress Period	Average Groundwater Elevations (ft NAVD88)									
	Keystone Hill Well	WI-CV-MW04M	WI-CV-MW04S	WI-CV-MW07M	WI-CV-MW07S	WI-CV-MW14M	WI-CV-MW15M	WI-CV-MW15S	WI-CV-MW16M	WI-CV-MW16S
2	68.55	69.67	86.30	70.36	73.36	69.18	69.87	69.49	69.22	69.26
3	61.59	69.66	86.30	70.36	73.36	68.98	69.31	68.92	67.90	67.94
4	60.83	69.66	86.31	70.33	73.37	68.86	69.18	68.78	67.68	67.72
5	60.39	69.66	86.31	70.30	73.38	68.83	69.13	68.73	67.59	67.62
6	60.04	69.66	86.32	70.32	73.40	68.83	69.12	68.72	67.54	67.57

Table 4-3. Transient Calibration Targets

Stress Period	Average Groundwater Elevations (ft NAVD88)									
	Keystone Hill Well	WI-CV-MW04M	WI-CV-MW04S	WI-CV-MW07M	WI-CV-MW07S	WI-CV-MW14M	WI-CV-MW15M	WI-CV-MW15S	WI-CV-MW16M	WI-CV-MW16S
7	59.73	69.66	86.33	70.30	73.39	68.81	69.07	68.67	67.46	67.50
8	65.10	69.66	86.34	70.30	73.42	68.85	69.39	69.00	68.34	68.35
9	61.93	69.67	86.35	70.32	73.42	68.96	69.31	68.91	67.93	67.96
10	61.28	69.67	86.34	70.34	73.40	68.93	69.23	68.83	67.78	67.81
11	60.82	69.67	86.34	70.33	73.39	68.89	69.17	68.77	67.68	67.71
12	60.38	69.68	86.35	70.30	73.38	68.85	69.11	68.71	67.57	67.61
13	60.06	69.67	86.35	70.30	73.39	68.82	69.08	68.68	67.51	67.55

4.3.2 Calibration Procedure

Auto-calibration of the CGFM was performed using the PEST software program. This program was used to refine model parameters to obtain the best set of parameters to match the steady-state and transient calibration targets. Parameters that were allowed to vary within user-defined ranges during the PEST auto-calibration effort were: horizontal and vertical hydraulic conductivity; aquifer specific yield and storage coefficient; recharge rate to the aquifer system; potential evapotranspiration rate and extinction depth; and hydraulic conductance at the general head boundaries along the island perimeter representing groundwater exchange with the surrounding marine system. During each PEST run, the model was run hundreds of times, with the program independently varying the assumed distributions of the model parameters listed above and seeking to minimize the error between the simulated groundwater elevations and the observed steady-state and transient calibration targets. Because two calibration data sets (steady-state and transient) were used in the model calibration, it was necessary to run both sets of conditions through the model in a single model run so that a single set of aquifer parameters were obtained from PEST that provided the optimal match to both sets of calibration targets. This was achieved by running an initial stress period in the model that simulated steady-state conditions and attempted to match the steady-state calibration targets. This was followed by 12 stress periods assuming transient conditions that attempted to match the change in groundwater levels (that is, drawdown) that were observed during the aquifer test.

4.3.3 Calibration Results

Groundwater Elevations

The results of the steady-state calibration are summarized on **Figure 4-8**. This figure shows the comparison between simulated and observed groundwater levels for all wells within the steady-state calibration data set. A perfect match between simulated and observed groundwater levels would fall on the dark line shown on the figure. As shown on **Figures 4-9a and 4-9b**, the results of the transient calibration yielded simulated groundwater levels for the 10 wells on-Base that were equipped with pressure transducers, closely matching the observed values measured during the recent field program. The calibration statistics are also provided on **Figure 4-8**. The mean error between simulated and observed groundwater levels is 0.84 foot, and the root mean square error is 4.8 feet. A key measure of calibration accuracy often used to evaluate groundwater models is the root mean square (RMS) error divided by the range of groundwater level data used in the calibration. A standard rule of thumb is that for a local scale model, model calibration should achieve an RMS/range value at or below 5 percent and for a regional model such as the CGFM, it should be at or below 10 percent. The calibration of the CGFM yielded an RMS/range of 6.4 percent, well below the target value of 10 percent, showing that the model is well calibrated.

Response to Pumping of the Keystone Hill Well

The second phase of calibration consisted of comparing the simulated and observed drawdown in groundwater levels created by operation of the KHW during the 41-hour transient calibration period. The KHW is screened within the middle elevation interval. The comparisons between simulated and observed drawdowns are summarized on **Figures 4-9a and 4-9b**. It is clear from these figures that the model-predicted drawdowns over the transient calibration period are in very close agreement to those measured in the field during the aquifer test. The only well with significant deviation is the KHW, where simulated drawdowns are less than observed drawdowns. This is to be expected as the KHW was pumping during the aquifer test, and due to well inefficiencies, the drawdown measured in the well casing will be significantly greater than the drawdown in the aquifer outside of the well. The model forecasts do not account for well inefficiency, and therefore the model predicts a smaller magnitude of drawdown than what is measured in the well.

Calibrated Hydraulic Parameters

The calibration process described in the previous section yielded a single set of aquifer parameters and boundary conditions that provided the comparisons shown between simulated and observed groundwater levels. These sets of aquifer parameters and boundary condition properties are summarized as follows.

Figure 4-10 presents the distribution of aquifer horizontal hydraulic conductivity for each of the five model layers. It can be seen from these figures that the majority of the aquifer material falls into the sand and gravelly sand range (> 2 feet per day) with a trend of decreasing overall hydraulic conductivity with depth. This is consistent with observations of greater percentage of fine-grained material deeper within the OLF aquifer system than is seen at shallower depths.

The distribution of magnitude of the deep percolation of precipitation across the model domain, ranging from approximately 1.5 to 14 inches per year, is shown on **Figure 4-11**. As expected, the deep percolation rate is higher in areas surrounding the OLF Coupeville as most, if not all, of the significant vegetation has been removed, reducing the evapotranspiration by vegetation allowing for higher recharge rates. Initial deep percolation rate estimates were obtained from a USGS study of recharge rates in Island County, Washington for water years 1998 and 1999. These initial estimates were then amended within a reasonable range of values during the PEST calibration process. The distribution of active evapotranspiration of shallow groundwater by plants is depicted on **Figure 4-12**. Due to the significant depth to groundwater over much of the model domain, the only areas where groundwater is shallow enough to be transpired directly by plants is around the model perimeter. These areas are clearly depicted on **Figure 4-12**. The final evapotranspiration rate simulated in the model is approximately 30 inches per year with evapotranspiration extinction depths (that is, the depth below which evapotranspiration does not occur) ranging from approximately 5 to 10 feet bgs.

4.4 Model Application

4.4.1 Groundwater Flow Directions and Gradients

Once the groundwater flow model is calibrated to site groundwater levels, it can be used to provide a more detailed depiction of groundwater levels, flow directions, and gradients within the aquifer system than can be obtained from groundwater elevation measurements from monitoring wells alone. **Figures 4-13 and 4-14** present the simulated groundwater elevation contours for the elevation intervals corresponding to Model Layers 3 and 4, respectively.

Groundwater flow conditions in the intermediate elevation interval are somewhat complex, partially due to continued operation of the Keystone Hill well, screened within the intermediate elevation interval, just west of OLF Coupeville. Modeling simulations suggest that a groundwater mound exists in the north-central portion of the OLF Coupeville facility, as is evidenced by high groundwater levels measured in Well WI-CV-MW08M, with groundwater flow directions moving radially outward from the mound. A groundwater mound is expected in this

general area as the OLF Coupeville facility is constructed in an area of relatively higher elevation on the island, and groundwater moves outward from this area toward the island perimeters to the east, west, north, and south. The operation of the KHW creates a local cone of depression in the water table that can be clearly seen on **Figure 4-13**, with groundwater flow directions in proximity to the well oriented toward, and converging on, the production well.

Groundwater flow directions in the deep elevation interval are depicted on **Figure 4-14**. These data indicate a similar range of flow directions within the deeper interval as are present in the intermediate depth interval, but with a diminished influence of KHW pumping on groundwater levels at this depth. Overall, the groundwater flow modeling indicates a groundwater mound present near the north end of the OLF Coupeville runway, with groundwater flowing radially outward toward the island perimeters.

4.4.2 Predictive Simulations of Keystone Hill Well Capture Zones

One of the primary questions related to future operation of the KHW relates to how the extent of the hydraulic capture zone created while operating the well varies with changing flow rates. To help inform this issue, the calibrated groundwater flow model was used to estimate the extent of the hydraulic capture zone of the KHW at two flow rates: the 150 gpm rate that reflects average current operating conditions, and the 300 gpm rate that is being considered by the Town of Coupeville to increase water supplies available to their service area. The results of this analysis are presented on **Figures 4-15 and 4-16**. These figures show the extent of hydraulic capture in each model layer created by KHW pumping for the 150 gpm and 300 gpm flow conditions, respectively. The overall extent of the simulated hydraulic capture zone is largest in Model Layers 2 and 3 under both pumping rates. Under 150 gpm pumping conditions, hydraulic capture ranges from approximately 1,200 feet to the east to 3,000 feet to the northwest from the KHW (**Figure 4-15**). Under 300 gpm pumping conditions, hydraulic capture ranges from approximately 1,600 feet to the east to 4,000 feet to the north from the KHW (**Figure 4-16**).

The results of this analysis suggest that operating the KHW at either flow rate results in full capture of the aquifer elevation intervals exhibiting PFAS exceedances in nearby monitoring wells WI-CV-MW15S and WI-CV-MW16S/M. Additionally, the aquifer elevation interval encompassing the screen of well WI-CV-MW14M, which previously exceeded the LHA for PFOS/PFOA, is within the KHW capture zone under both 150 and 300 gpm pumping rates. While the CGFM predicts a small area of hydraulic capture in the deeper portions of the aquifer system, field data to confirm this model forecast are not available due to lack of monitoring infrastructure at these depths in near the KHW. As shown on **Figure 4-16**, model predictions also indicate a significantly larger capture zone when operating the well at 300 gpm, with the hydraulic capture zone extending out to encompass much of the aquifer near well WI-CV-MW05M; however, not the groundwater at WI-CV-MW05M itself, where recent sampling has indicated exceedances of PFAS.

4.5 Model Assumptions and Limitations

Models are inherently inexact because the mathematical description of the physical realm is imperfect, and the understanding of interrelated physical processes is incomplete. Mathematical models like the CGFM can only approximate subsurface processes, despite their high degree of precision. A major cause of uncertainty in these types of models is the discrepancy between the coverage of measurements needed to understand subsurface conditions and the coverage of measurements generally made under the constraints of limited time and budget. The spatial scale and complex physical environment at and around OLF Coupeville present specific challenges and limitations. A relatively small reservoir of field data has been collected at OLF Coupeville. Therefore, a significant degree of uncertainty exists in the distribution of subsurface conditions. However, the available data were deemed to be sufficient to provide enough detail of the physical system for the CGFM to achieve the modeling objectives described in **Section 4.1**. It is expected that as more data are collected, the model will be refined and improved.

Additionally, the CGFM is a groundwater flow model and is not currently configured to evaluate solute (such as PFAS) fate and transport; however, the CGFM is appropriate for use in evaluation of current/future aquifer hydraulics (such as groundwater flow directions and pumping well capture zones). The CGFM was constructed

using a software platform (MODFLOW) that is compatible with solute transport codes; therefore, such capability can be included as part of future efforts.

Given these assumptions and limitations, numerical groundwater models like CGFM should be considered insight tools and qualitative predictors of future conditions. Therefore, important planning decisions that use output from CGFM must be made with an understanding of the uncertainty in and sensitivity to model input parameters and should consider other site data, professional judgment, and the inclusion of safety factors. No warranties associated with the forecasts, explicit or implied, are provided.

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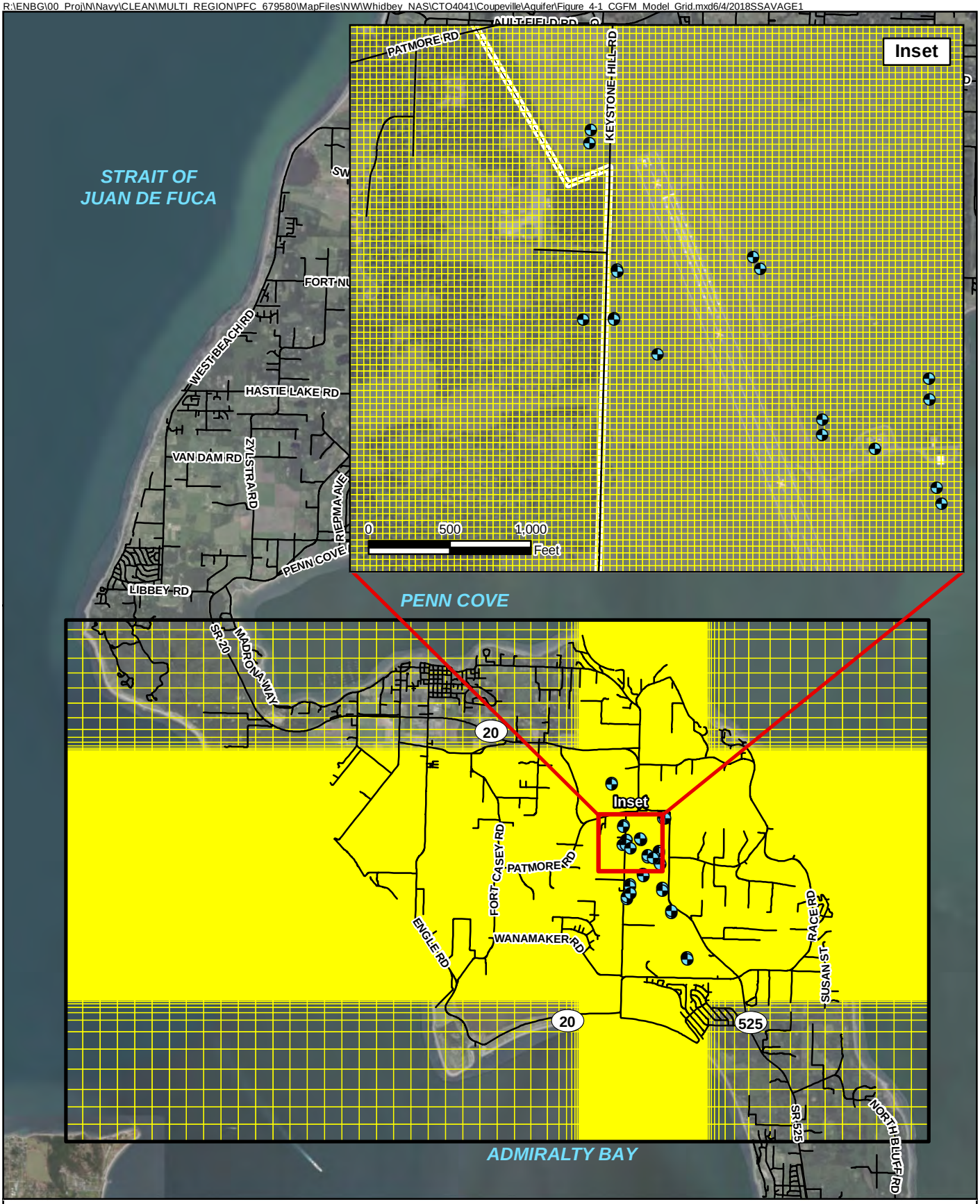


Legend

- OLF Monitoring Wells
- Road
- Model Extent
- CGFM Model Grid Cell
- Outlying Landing Field

Notes:
CGFM = Coupeville groundwater flow model
OLF = Outlying Landing Field

N

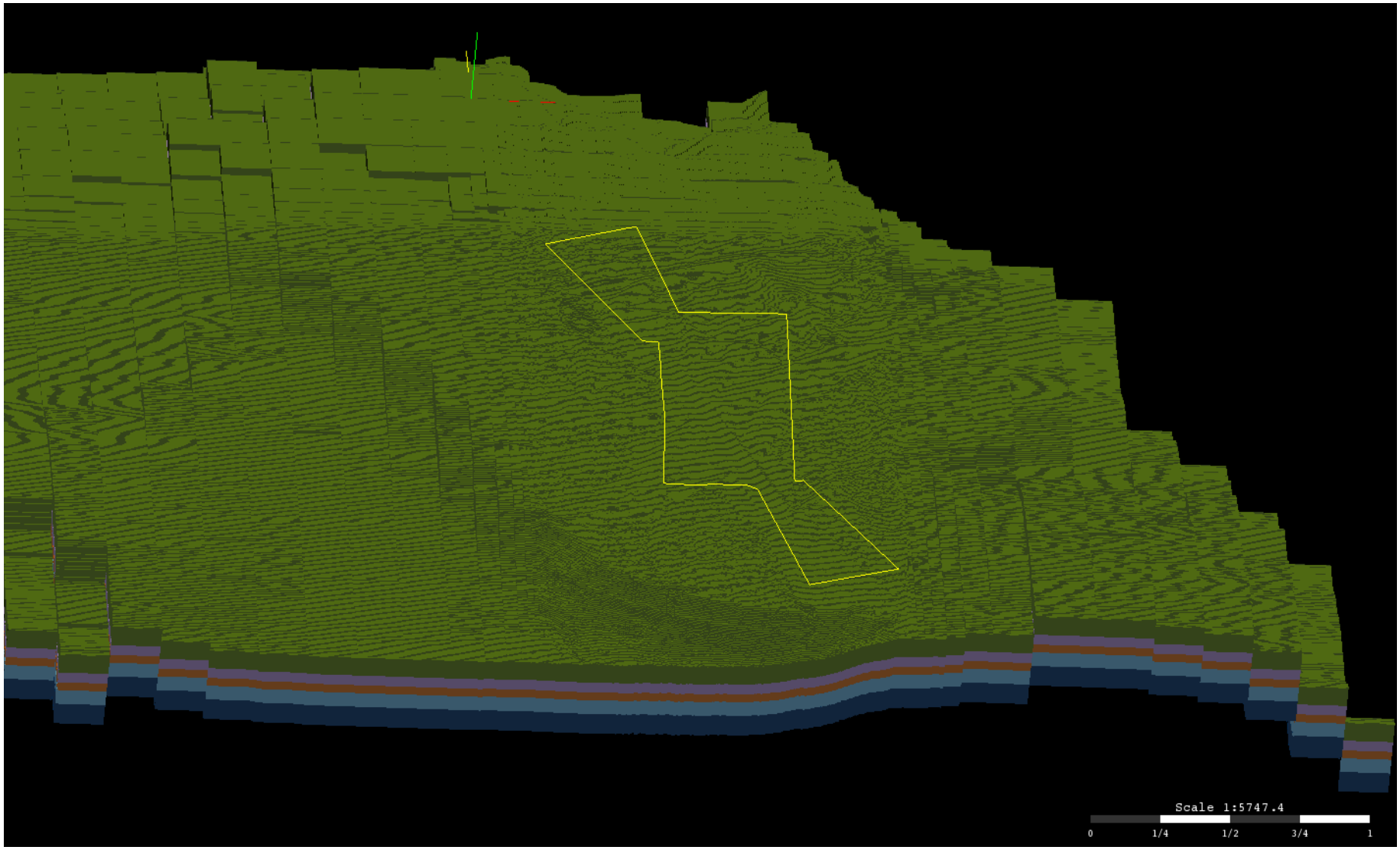
0 1 2 Miles

1 inch = 1.5 miles

Imagery Source: ©2016 ESRI

Figure 4-1
CGFM Model Grid
Naval Air Station Whidbey Island
Coupeville, Washington

For Official Use Only



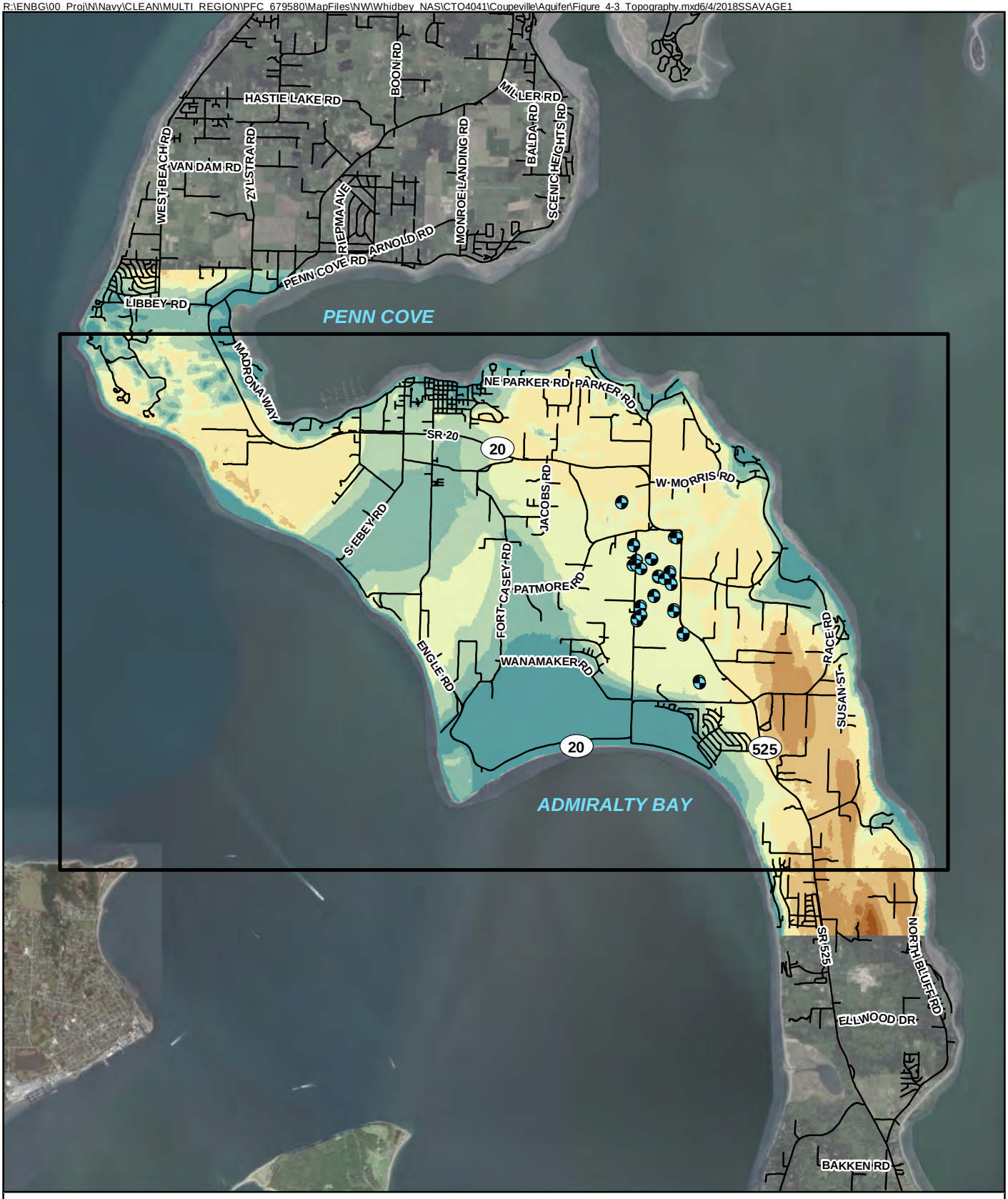
LEGEND

- Model Layer 1
- Model Layer 2
- Model Layer 3
- Model Layer 4
- Model Layer 5

Figure 4-2.
Three-Dimensional View of Groundwater Flow Model Layering
Naval Air Station Whidbey Island
Coupeville, Washington

NG0321181403SEA Fig4-2_3D_Model

R:\ENBG\00_Proj\N\Navy\CLEAN\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4041\Coupeville\Aquifer\Figure_4-3_Topography.mxd6/4/2018SSAVAGE1



Legend

Topographic Elevation (feet NAVD88)

- -1.2 - 0
- 0.1 - 50
- 50.1 - 100
- 100.1 - 150
- 150.1 - 200
- 200.1 - 250
- 250.1 - 300
- 300.1 - 350
- 350.1 - 400
- 400.1 - 450
- OLF Monitoring Wells
- Road
- Model Extent
- Outlying Landing Field

Notes:
NAVD88 = North American Vertical Datum of 1988
OLF = Outlying Landing Field

0 1 2 Miles

1 inch = 1.5 miles

N

Imagery Source: ©2016 ESRI

Figure 4-3
Topography
Naval Air Station Whidbey Island
Coupeville, Washington

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Legend

Bathymetric Elevation (feet NAVD88)

- -403 - -400
- -399.9 - -350
- -349.9 - -300
- -299.9 - -250
- -249.9 - -200
- -199.9 - -150
- -149.9 - -100
- -99.9 - -50
- -49.9 - 0

- OLF Monitoring Wells
- Road
- Model Extent
- Outlying Landing Field

0 1 2 Miles

1 inch = 1.5 miles

N

Imagery Source: ©2016 ESRI

Notes:
NAVD88 = North American Vertical Datum of 1988
OLF = Outlying Landing Field

Figure 4-4
Bathymetry
Naval Air Station Whidbey Island
Coupeville, Washington

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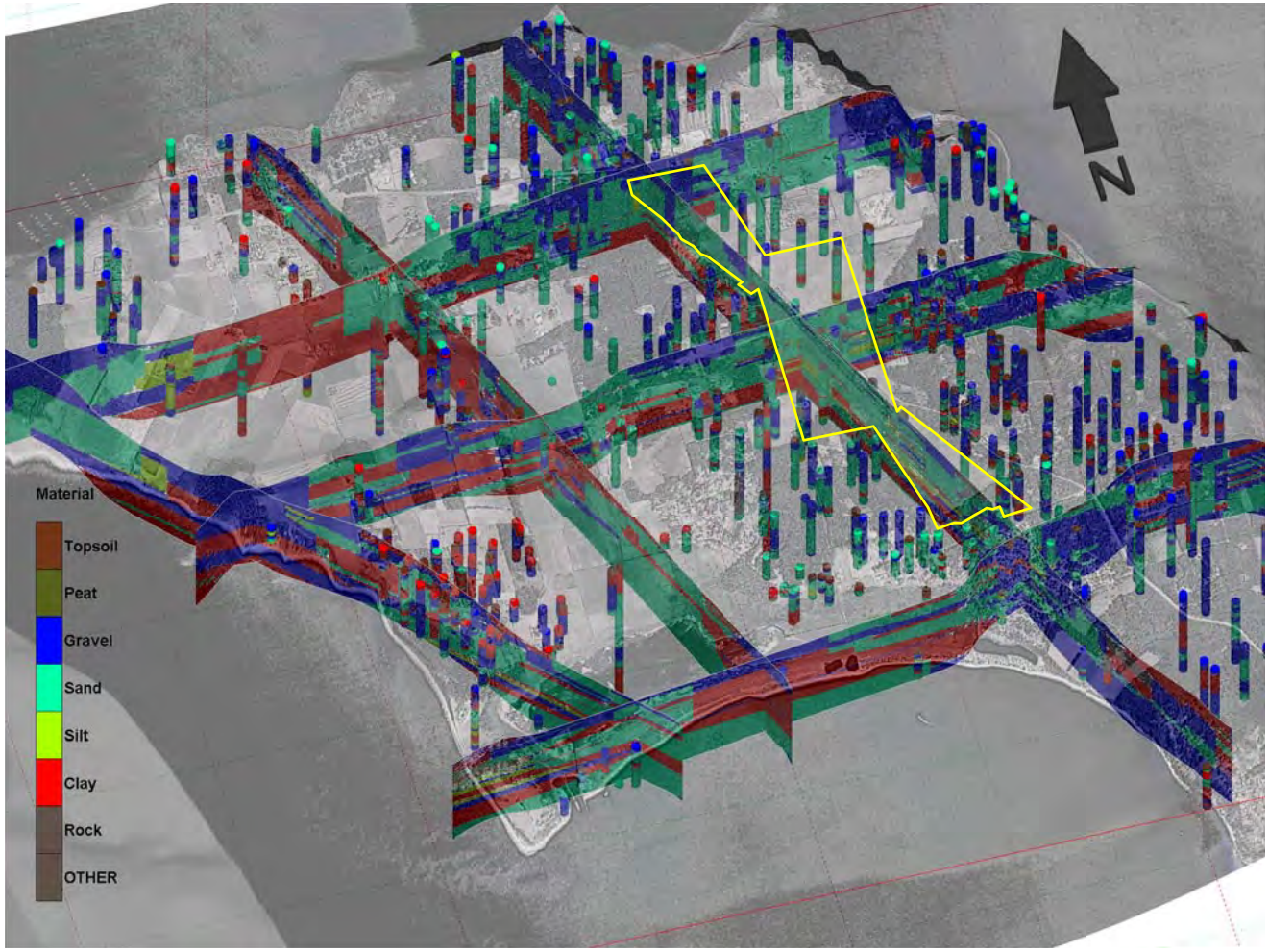
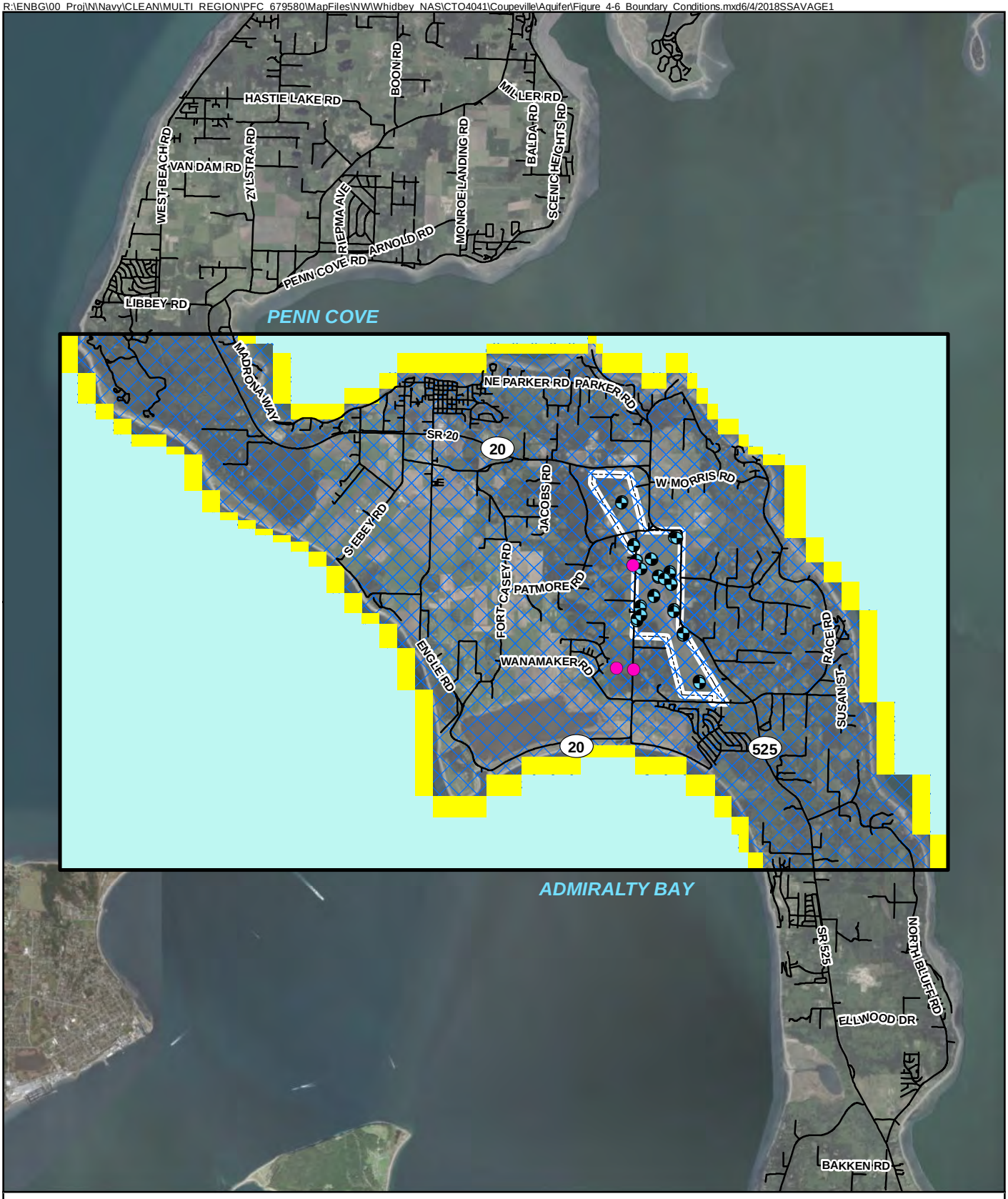


Note: Image uses 10x vertical exaggeration.

Figure 4-5.
Lithologic Classifications; Profile View
Naval Air Station Whidbey Island
Coupeville, Washington

R:\ENBG\00_Proj\N\Navy\CLEAN\MULTI_REGION\PFC_679580\MapFiles\NW\Whidbey_NAS\CTO4041\Coupeville\Aquifer\Figure_4-6_Boundary_Conditions.mxd6/4/2018SSAVAGE1



Legend

- OLF Monitoring Wells
- Well Boundary Cell
- Road
- Model Extent
- No Flow Boundary Cell
- General Head Boundary Cell
- Recharge and Evapotranspiration Cell
- Outlying Landing Field

Notes:
NAVD88 = North American Vertical Datum of 1988
OLF = Outlying Landing Field

N

0 1 2 Miles

1 inch = 1.5 miles

Imagery Source: ©2016 ESRI

Figure 4-6
Boundary Conditions
Naval Air Station Whidbey Island
Coupeville, Washington

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Legend

- Shallow Elevation Interval Monitoring Well
- Middle Elevation Interval Monitoring Well
- Deep Elevation Interval Monitoring Well
- Base Supply Well
- Base Boundary

Notes:
1. Groundwater elevations data are relative to feet above the North American Vertical Datum of 1988
2. Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation.

N

0 0.15 0.3 Miles

1 inch = 0.3 mile

Imagery Source: Esri

Figure 4-7
Steady-State Groundwater Elevation Targets
Naval Air Station Whidbey Island
Coupeville, Washington

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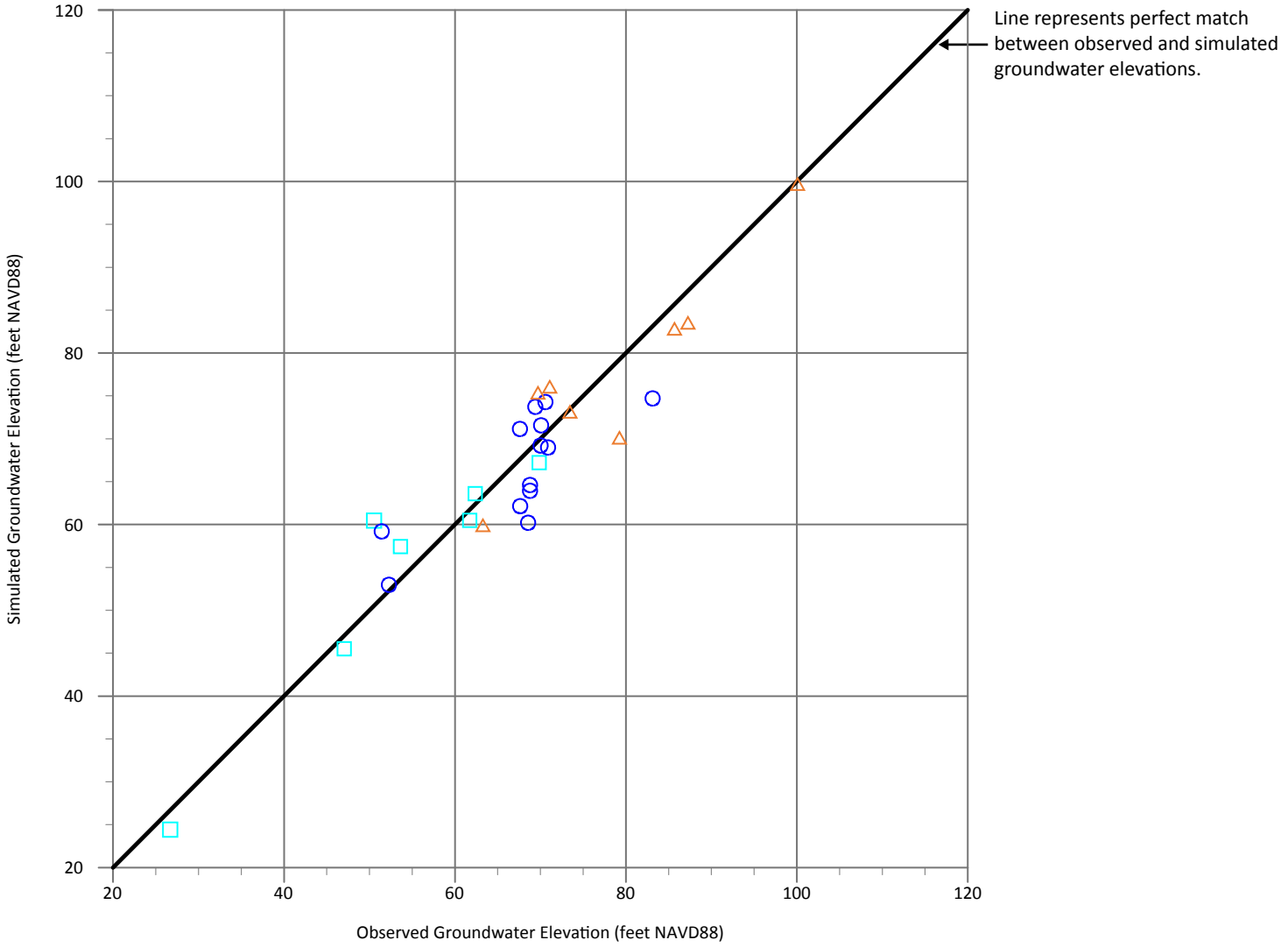


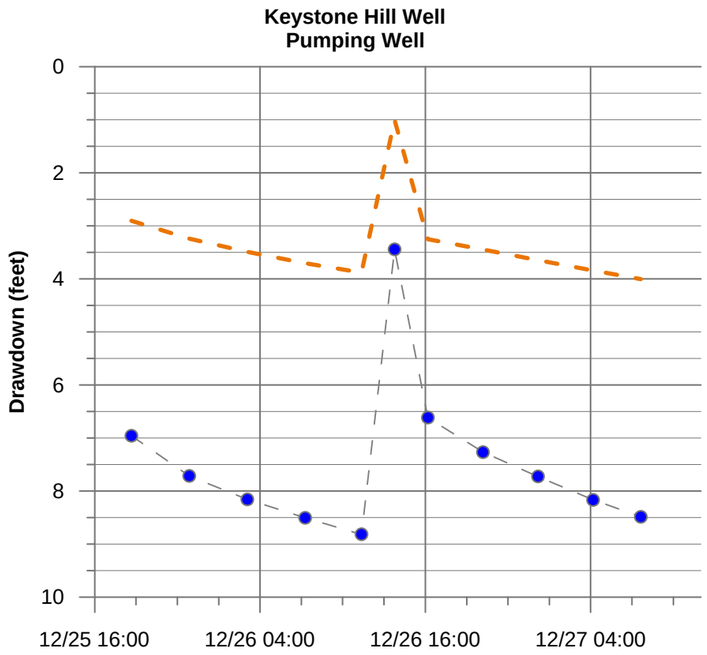
LEGEND

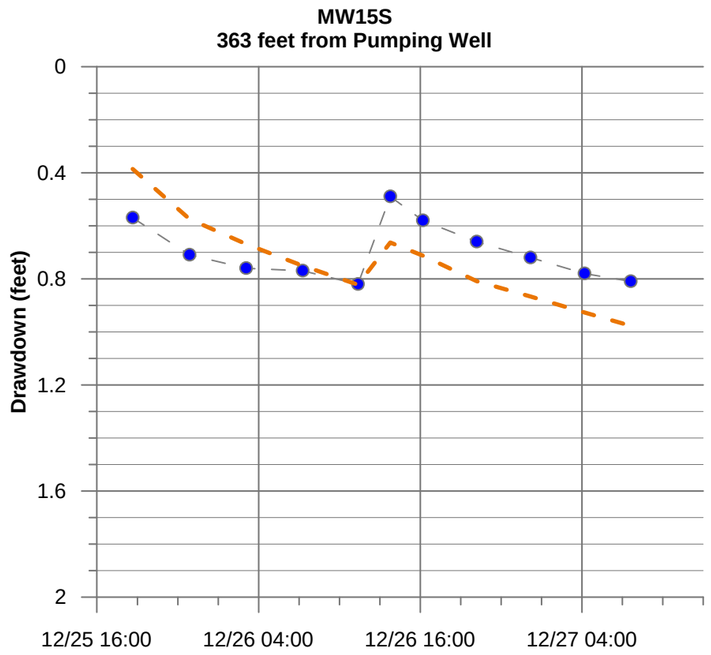
- Wells in Model Layers 1 and 2
- Wells in Model Layer 3
- Wells in Model Layer 4

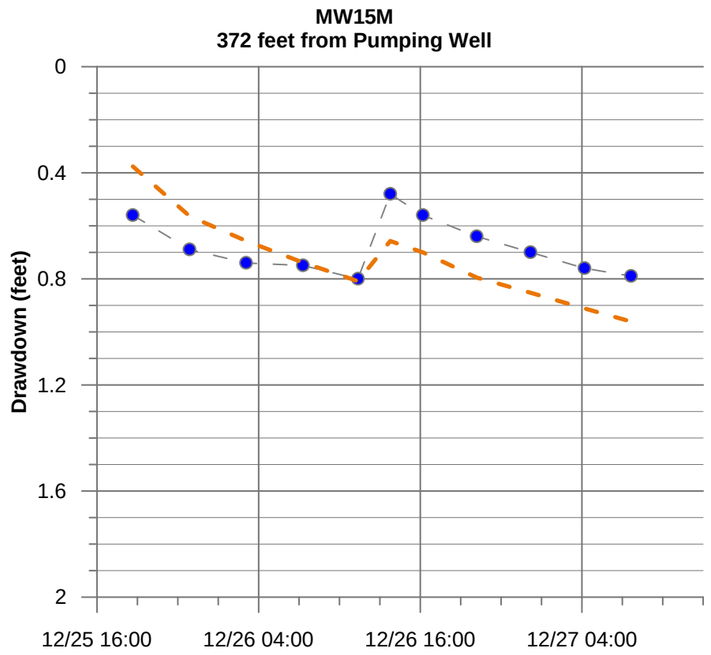
Notes:

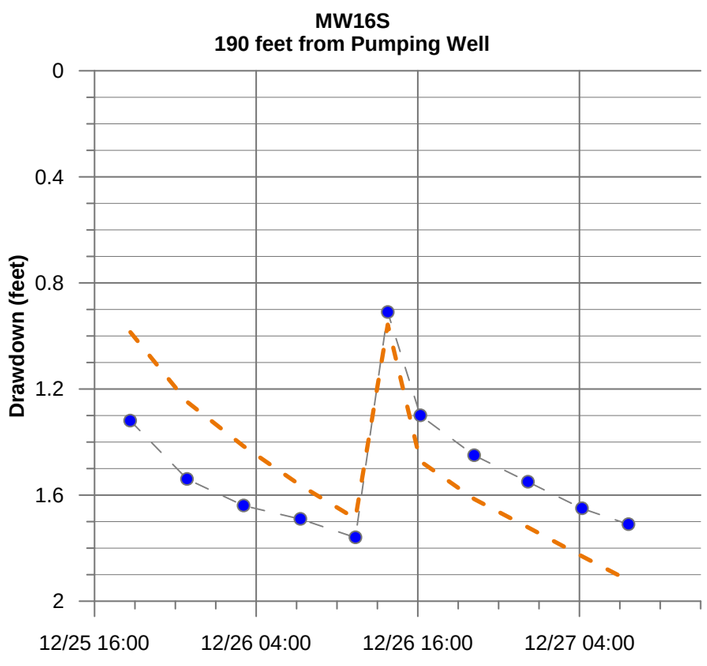
1. NAVD88 = North American Vertical Datum of 1988
2. Mean error = 0.84 foot
3. Range in observed elevations = 73.4 feet
4. Root mean squared error (RMS) = 4.8 feet
5. RMS/Range = 6.5%

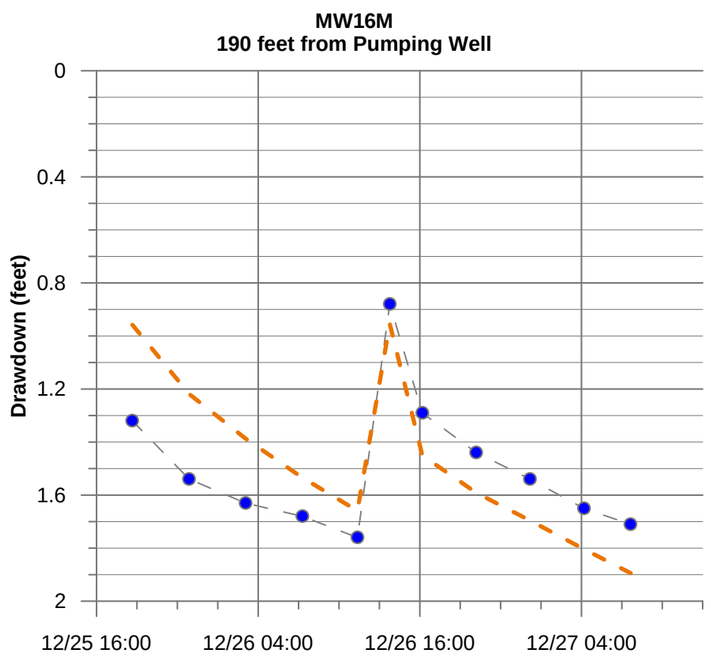
Figure 4-8.
Steady-State Simulated versus Observed Groundwater Elevations
Naval Air Station Whidbey Island
Coupeville, Washington











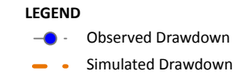
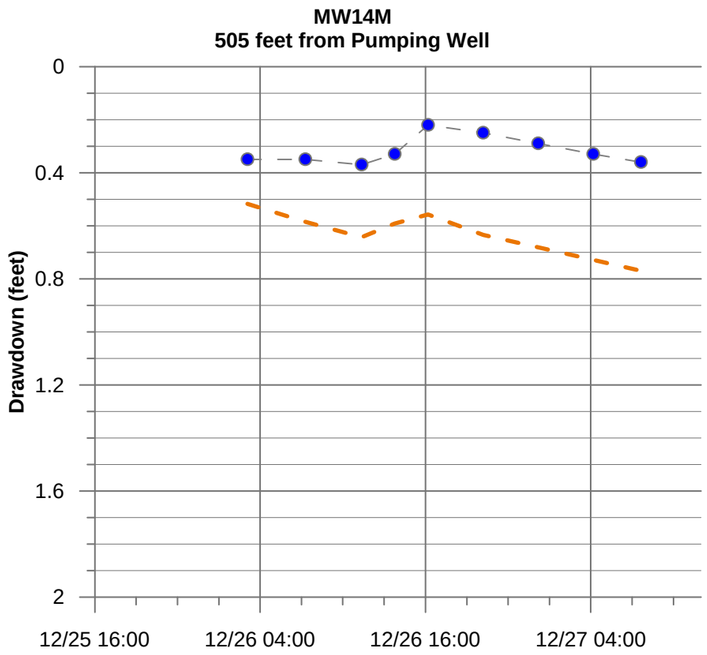
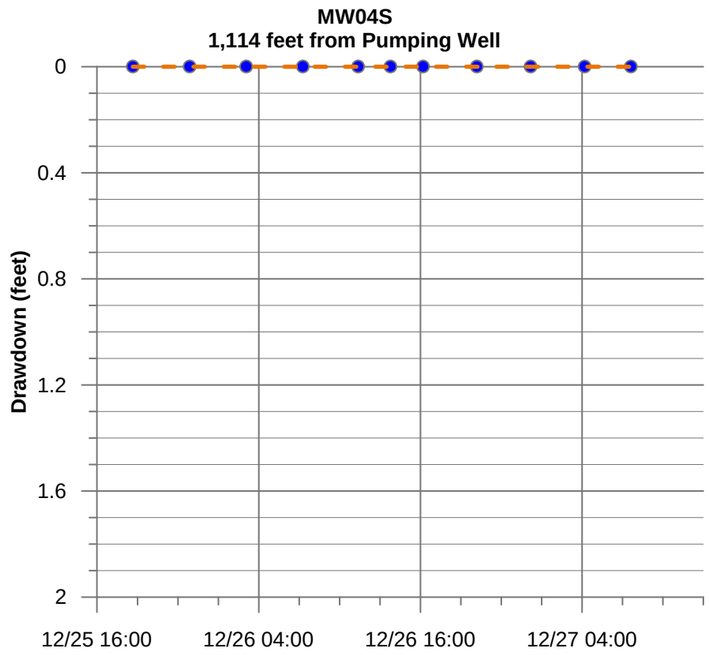
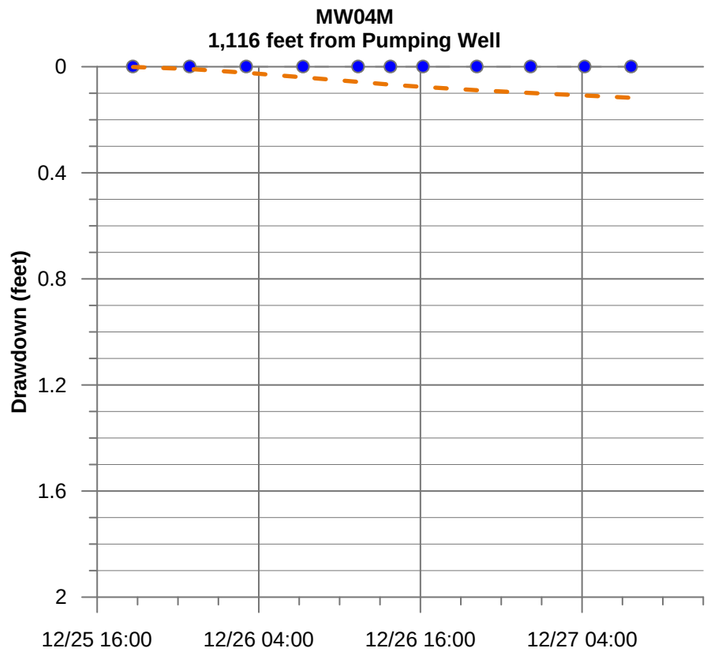
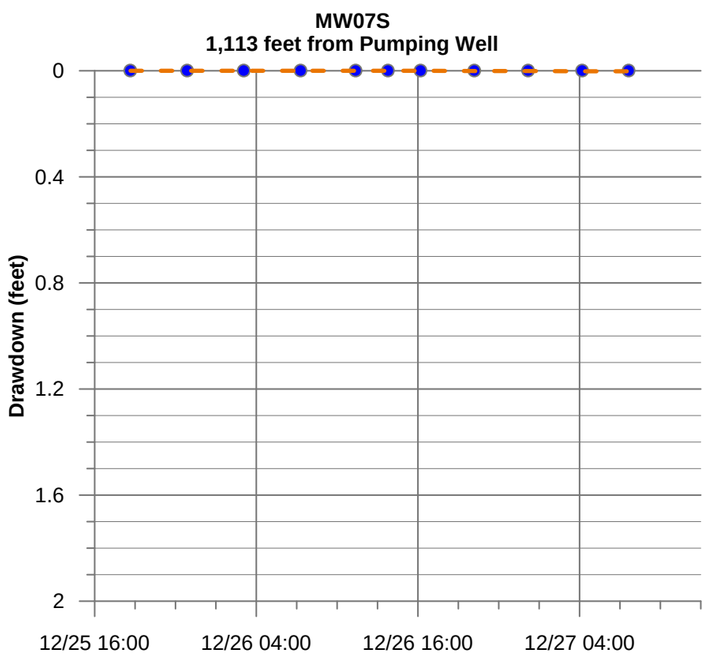


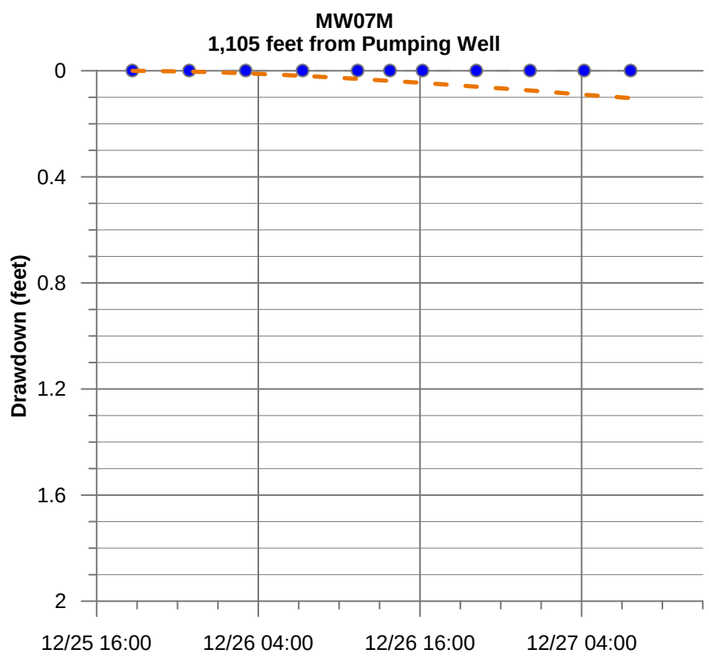
Figure 4-9a.
Simulated versus Observed Response to Pumping of the Keystone Well
Naval Air Station Whidbey Island
Coupeville, Washington











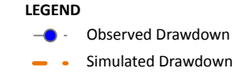


Figure 4-9b.
Simulated versus Observed Response to Pumping of the Keystone Well
Naval Air Station Whidbey Island
Coupeville, Washington

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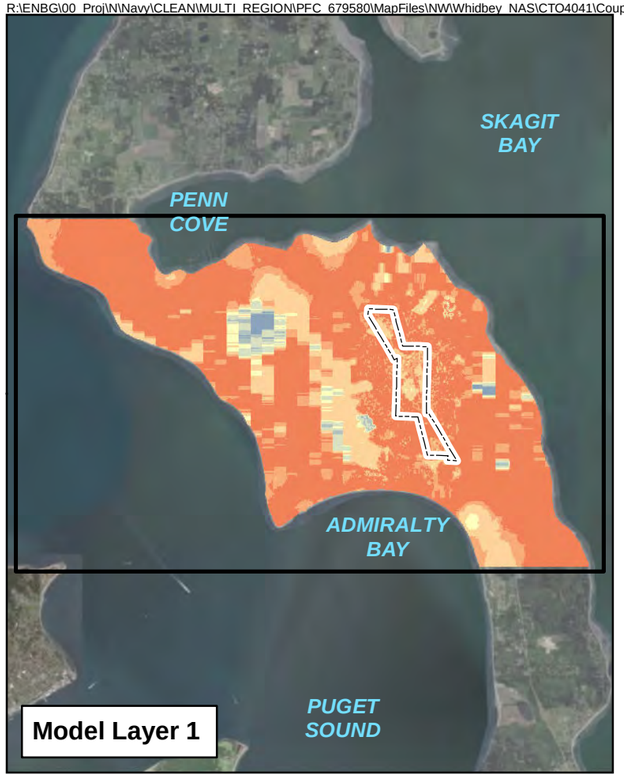

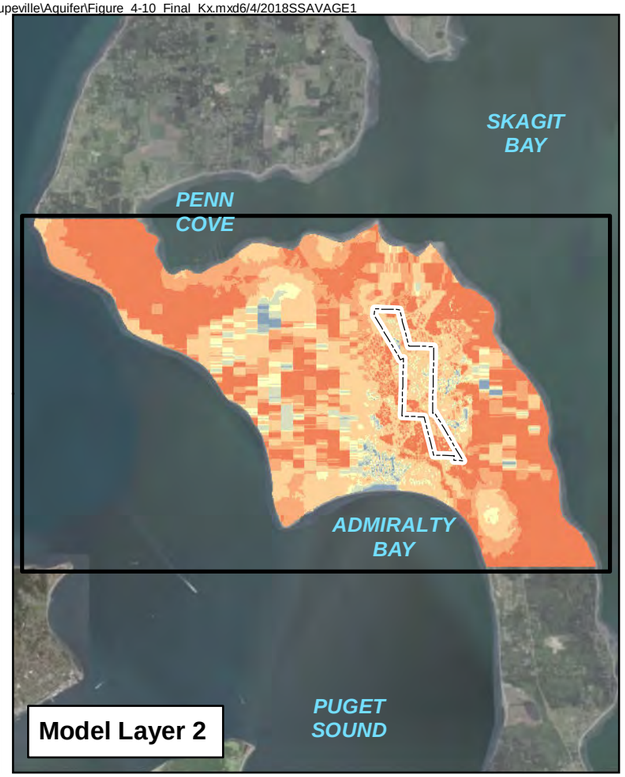

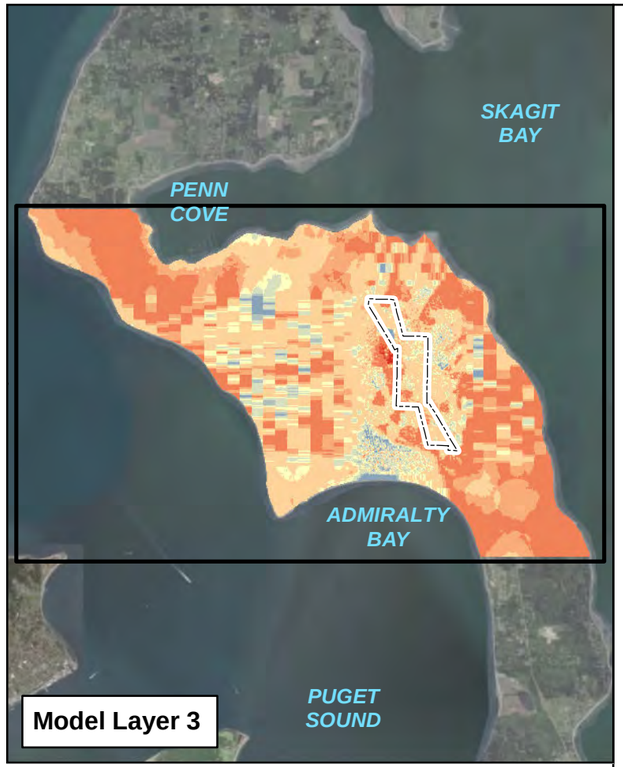

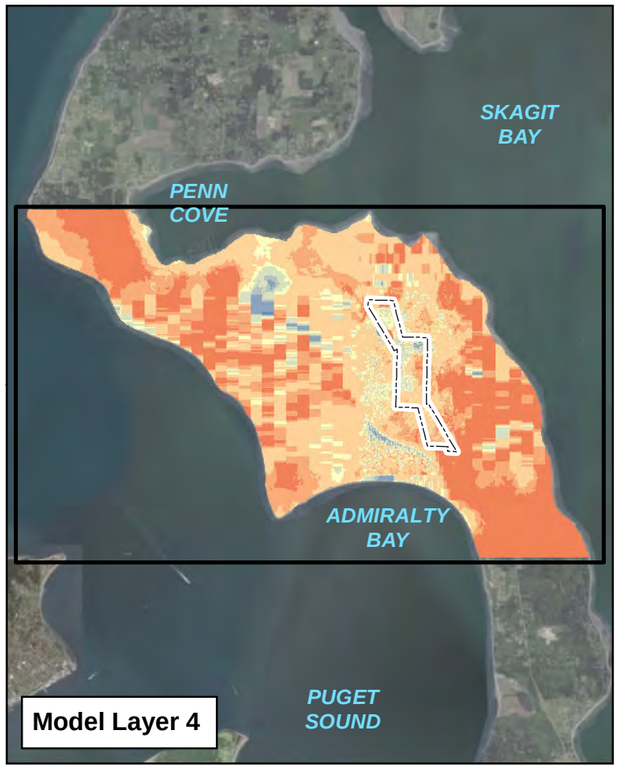

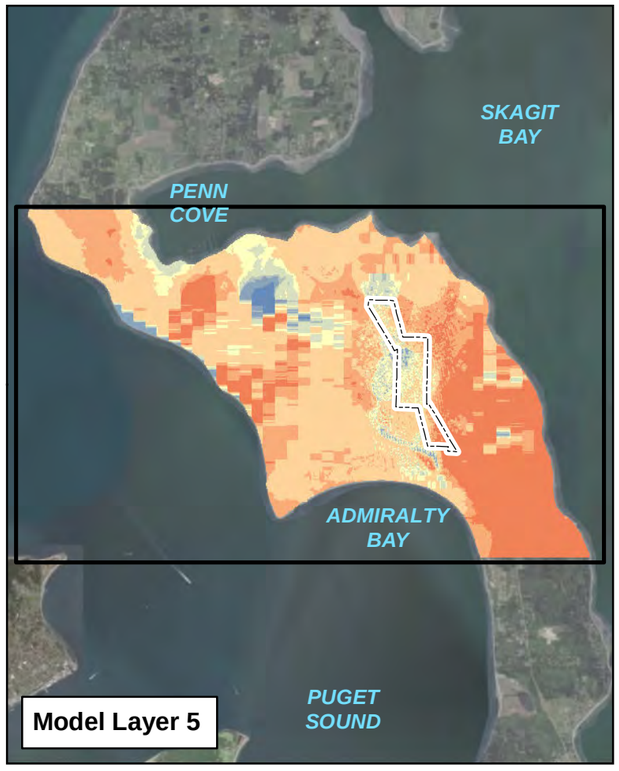

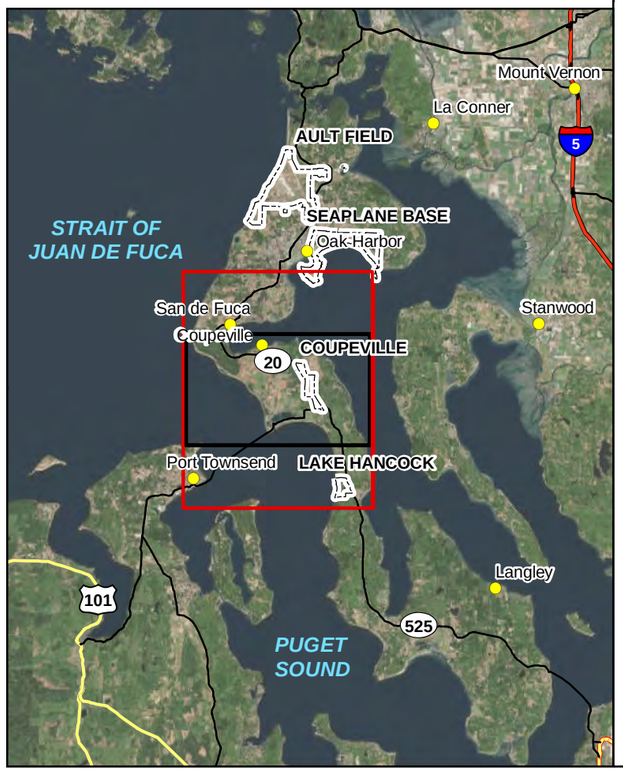

Legend

Hydraulic Conductivity (feet/day)

- <0.005
- 0.0051 - 0.01
- 0.011 - 0.05
- 0.051 - 0.1
- 0.11 - 0.5
- 0.51 - 1
- 1.1 - 5
- 5.1 - 10
- 10.1 - 50
- 50.1 - 100
- 100.1 - 500
- Base Boundary

N

0 2.5 5 Miles

1 inch = 2.5 mile

Imagery Source: Esri

Figure 4-10
Final Distribution of Horizontal Hydraulic Conductivity
Naval Air Station Whidbey Island
Coupeville, Washington

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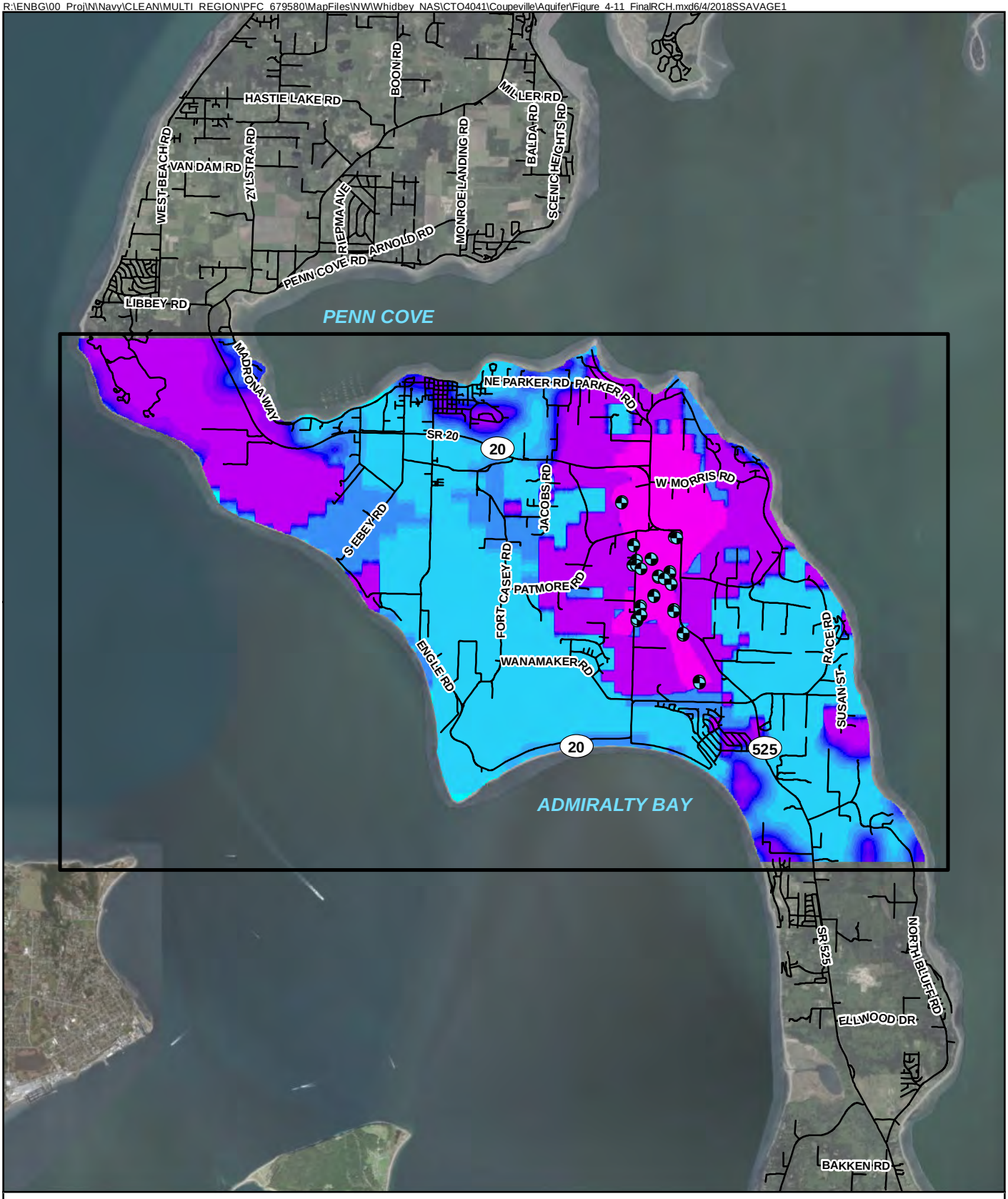

Legend

Simulated Groundwater Recharge (inches per year)

0 - 1	5.1 - 6	10.1 - 11
1.1 - 2	6.1 - 7	11.1 - 12
2.1 - 3	7.1 - 8	12.1 - 13
3.1 - 4	8.1 - 9	13.1 - 14
4.1 - 5	9.1 - 10	14.1 - 15

OLF Monitoring Wells
Road
Model Extent
Outlying Landing Field

Note: OLF = Outlying Landing Field

N

0 1 2 Miles

1 inch = 1.5 miles

Imagery Source: ©2016 ESRI

Figure 4-11
Final Distribution of Deep Percolation of Precipitation
Naval Air Station Whidbey Island
Coupeville, Washington

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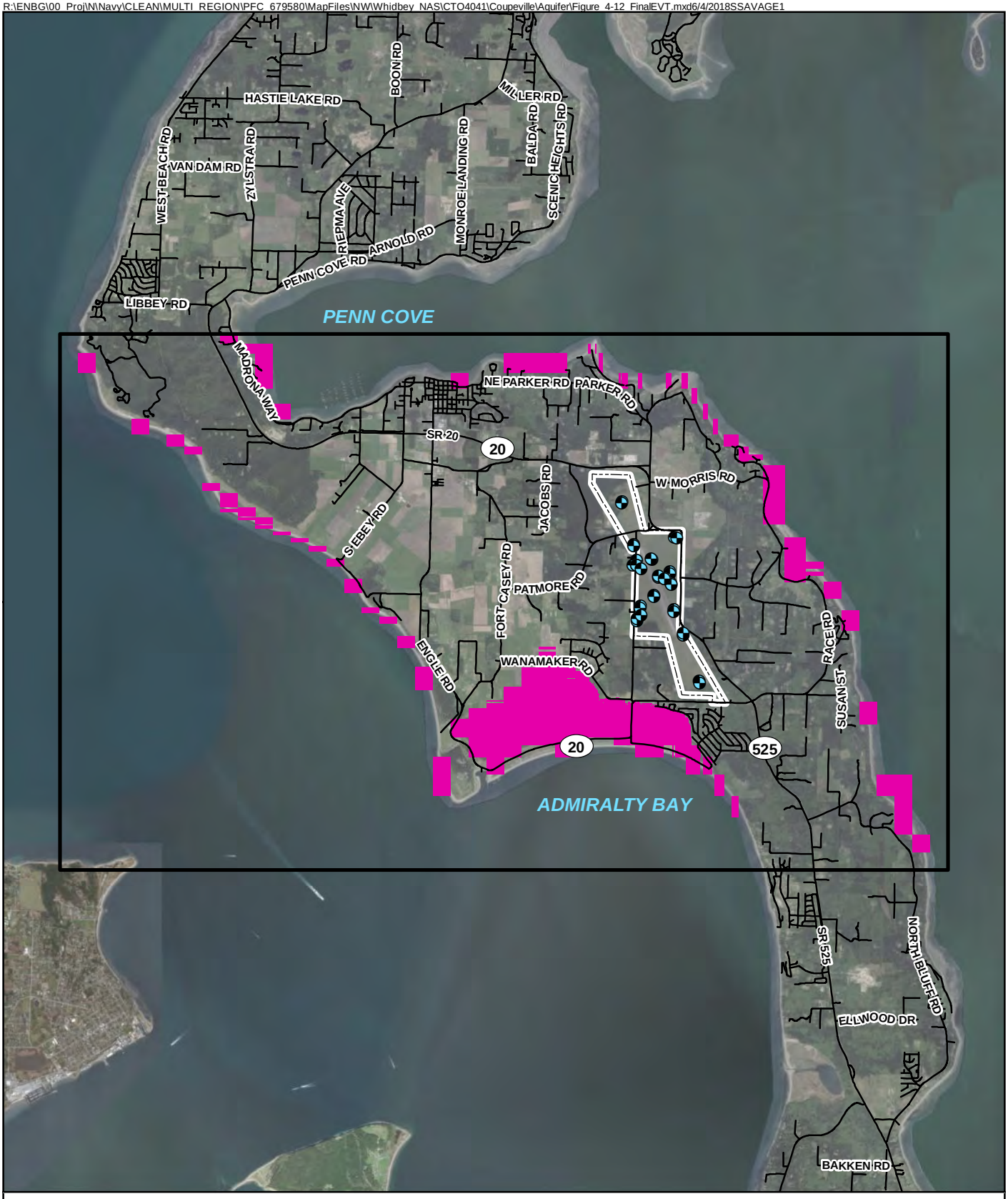

Legend

- OLF Monitoring Wells
- Road
- Model Extent
- Active Evapotranspiration Cell
- Outlying Landing Field

Note: OLF = Outlying Landing Field

N

0 1 2 Miles

1 inch = 1.5 miles

Imagery Source: ©2016 ESRI

Figure 4-12
Simulated Distribution of Active Evapotranspiration
Naval Air Station Whidbey Island
Coupeville, Washington

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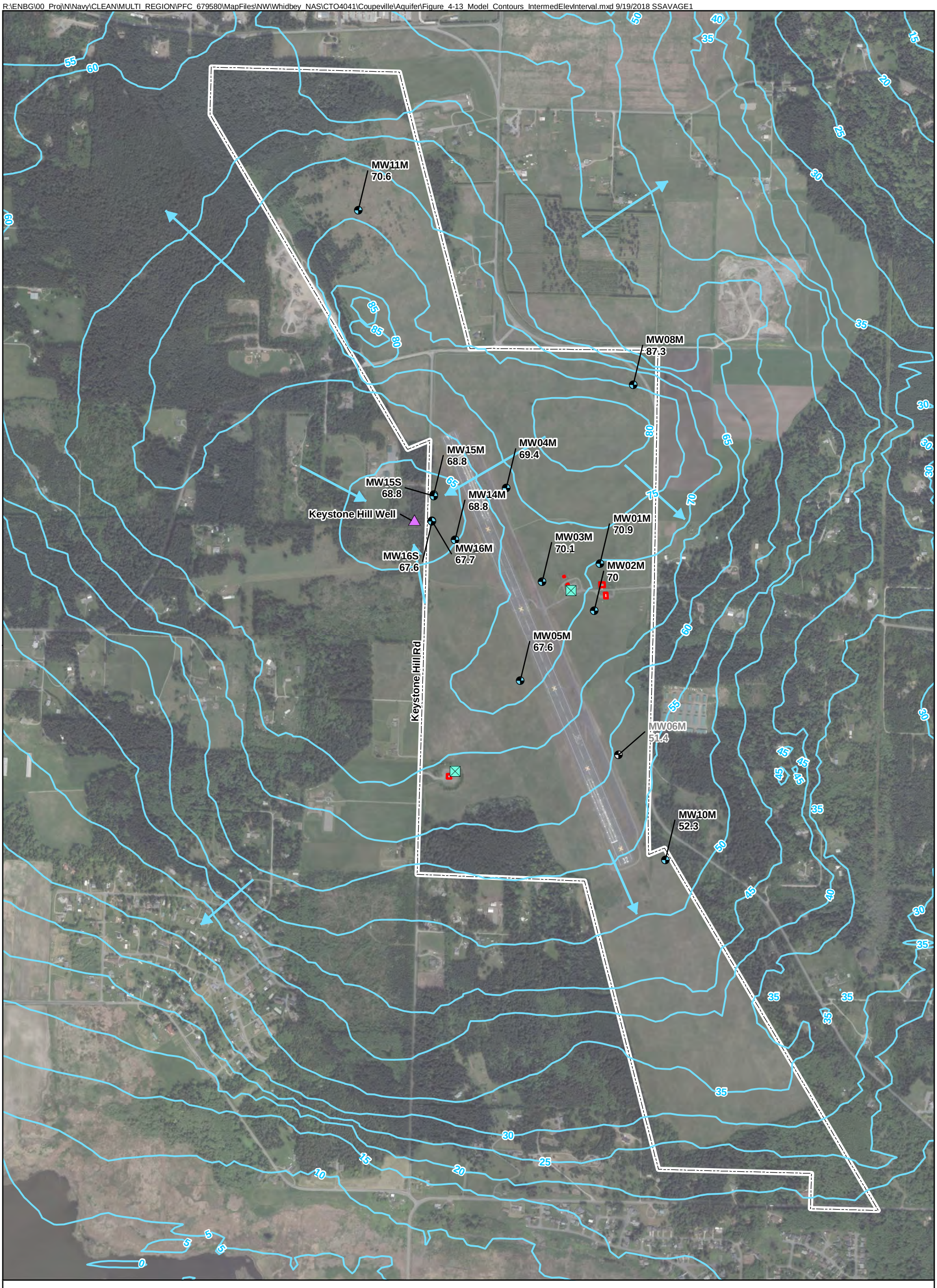

Legend

- Groundwater Well Location
- OLF Coupeville Supply Well
- Community Drinking Water Well
- Simulated Groundwater Elevation Contour (5-foot contour interval)
- Simulated Groundwater Flow Direction in Model Layer 3
- Building Location
- Base Boundary

Notes:
1. NAVD88 = North American Vertical Datum of 1988
2. Intermediate elevation interval wells are typically screened between approximately 10 and 60 feet NAVD88.
3. Groundwater elevations shown in feet NAVD88
4. Posted groundwater level measurements were collected on 1/8/2018.
5. Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation.

N

0 0.1 0.2 Miles

1 inch = 0.2 mile

Imagery Source: Esri

Figure 4-13
Simulated Groundwater Elevation Contour Map
Intermediate Elevation Interval
Naval Air Station Whidbey Island
Coupeville, Washington

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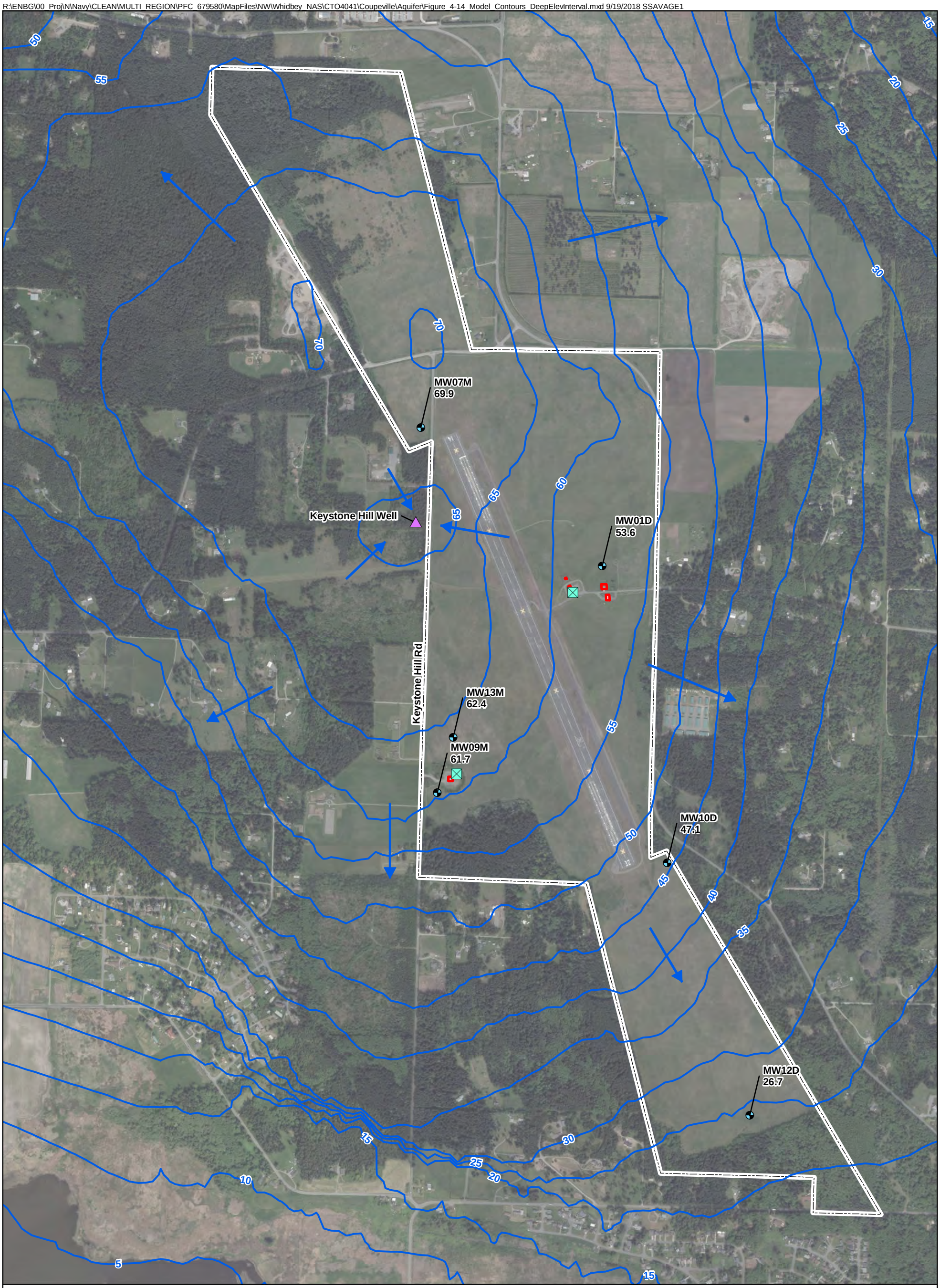

Legend

- Monitoring Well Location
- OLF Coupeville Supply Well
- Community Drinking Water Well
- Simulated Groundwater Elevation Contour (5-foot contour interval)
- Simulated Groundwater Flow Direction in Model Layer 4
- Building Location
- Base Boundary

Notes:
1. NAVD88 = North American Vertical Datum of 1988
2. Deep elevation interval wells are typically screened near or below 0 feet NAVD88.
3. Groundwater elevations shown in feet NAVD88
4. Posted groundwater level measurements were collected on 1/8/2018.
5. Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation.

N

0 0.1 0.2 Miles

1 inch = 0.2 mile

Imagery Source: Esri

Figure 4-14
Simulated Groundwater Elevation Contour Map
Deep Elevation Interval
Naval Air Station Whidbey Island
Coupeville, Washington

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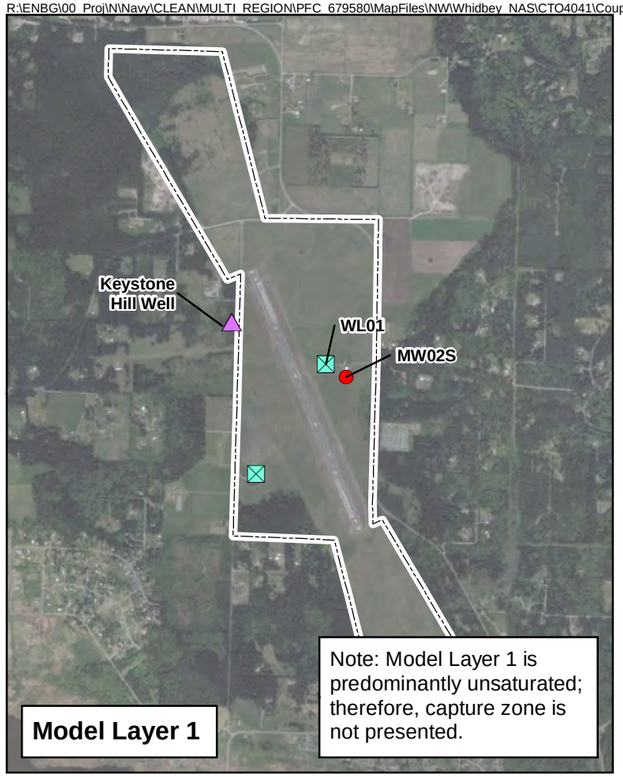

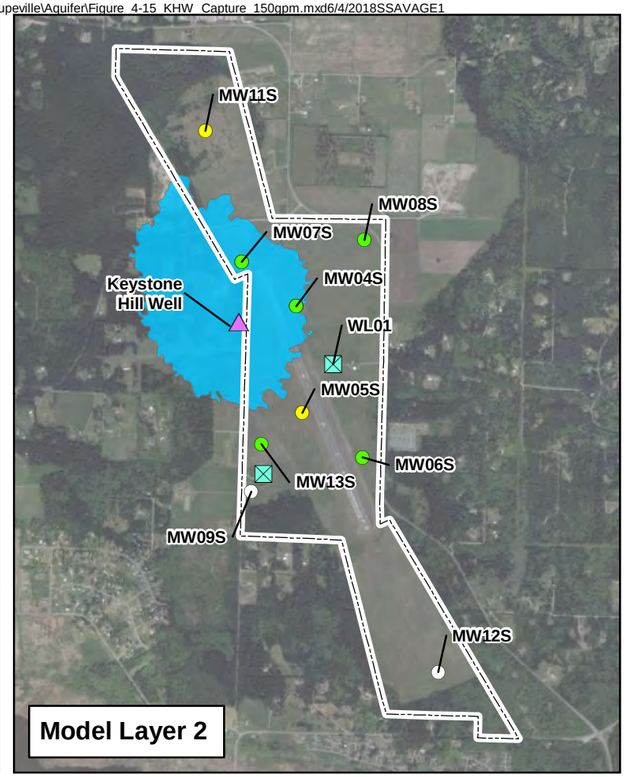

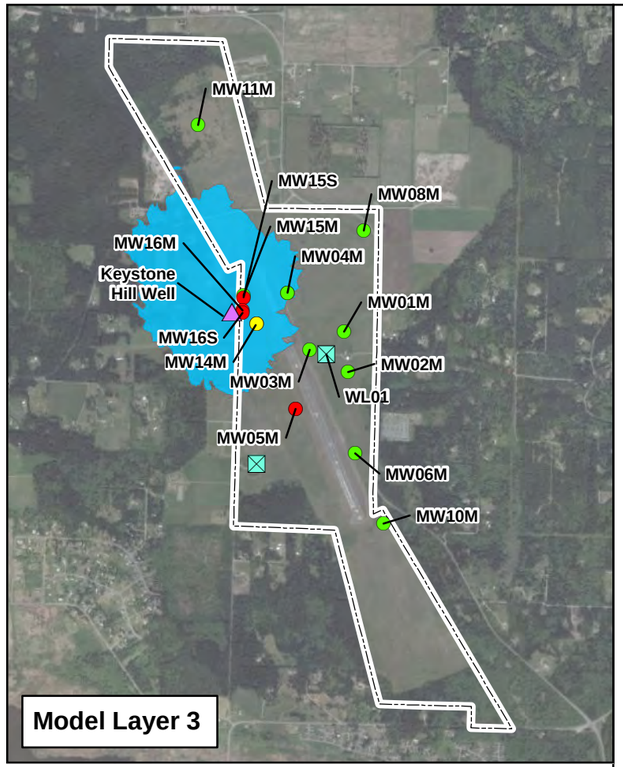

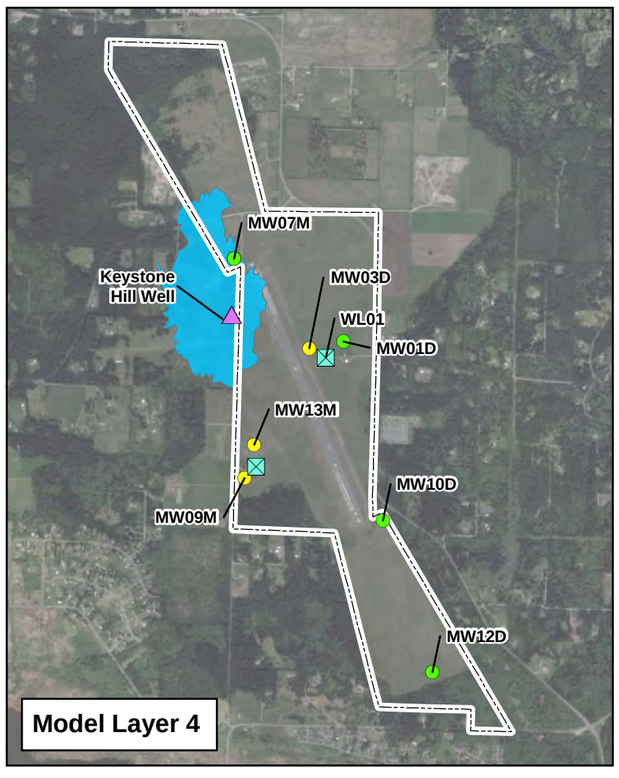

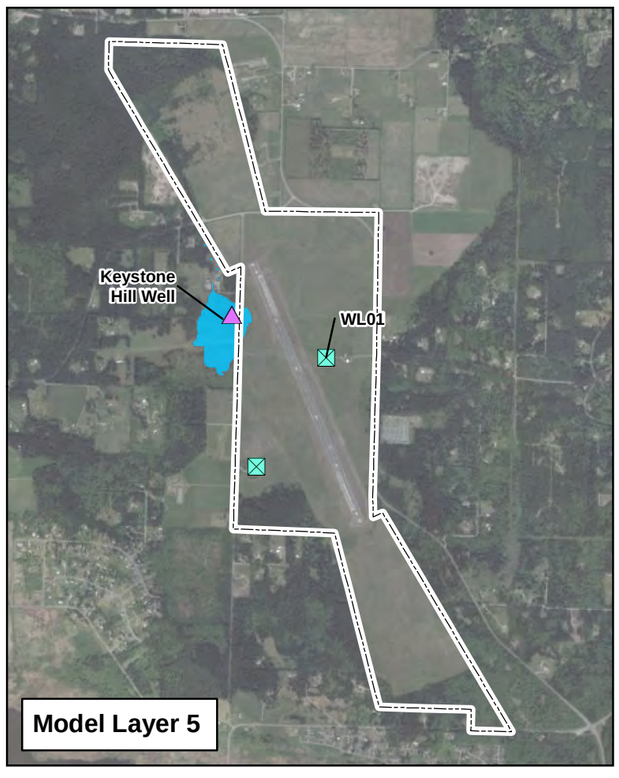

Legend

- OLF Coupeville Supply Well
- Monitoring Well with no exceedance of LHA
- Monitoring Well with LHA exceedance
- No detections of PFAS
- Not Sampled
- Community Drinking Water Well
- Simulated Keystone Hill Capture Zone
- Base Boundary

N

0 0.25 0.5 Miles

1 inch = 0.55 mile

Imagery Source: Esri

Notes:

1. Particles were started at the top of the model layer encompassing the monitoring well screen and tracked forward.
2. Particle tracking assumed an effective porosity of 10%.
3. Simulated pumping at the Keystone Hill Well was 150 gallons per minute.
4. Monitoring well points presented in each data frame are those wells screened at elevations within the respective model layer.
5. Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation

Figure 4-15
Keystone Hill Well Capture Zone at Current Pumping Conditions
Naval Air Station Whidbey Island
Coupeville, Washington

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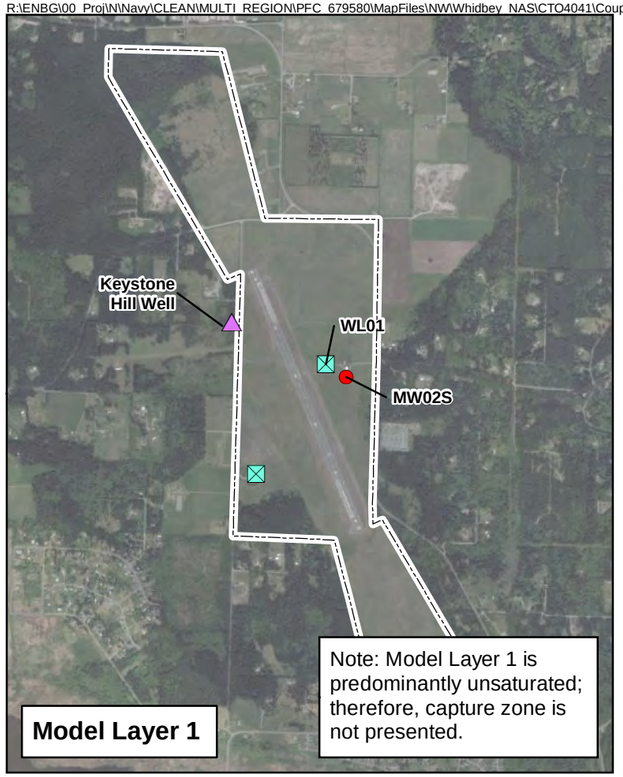

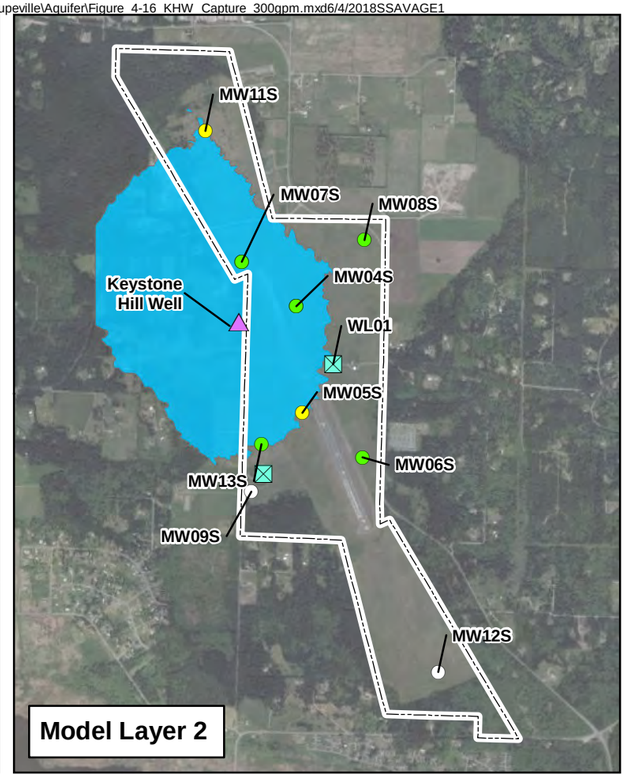

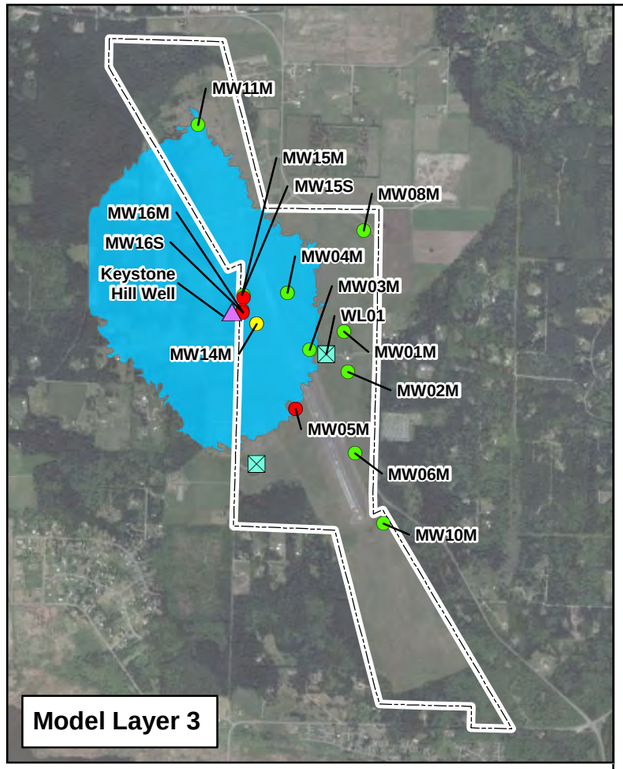

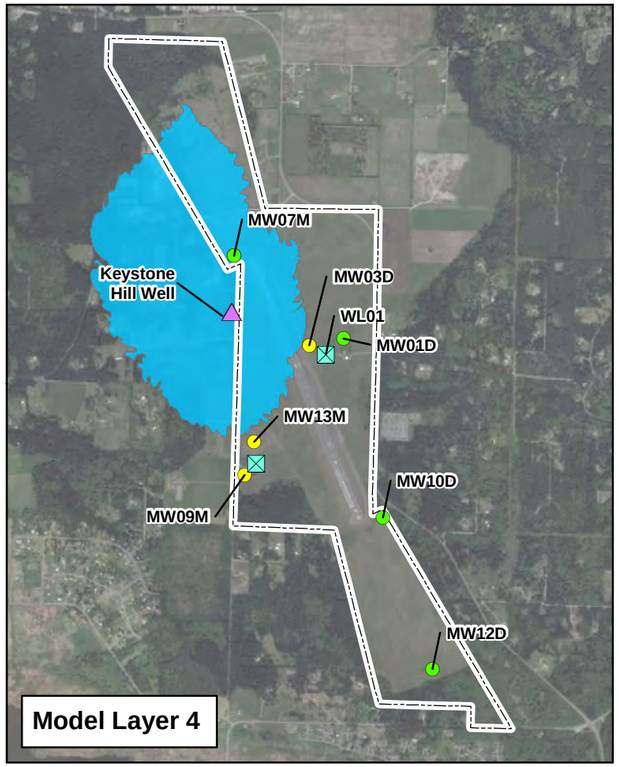

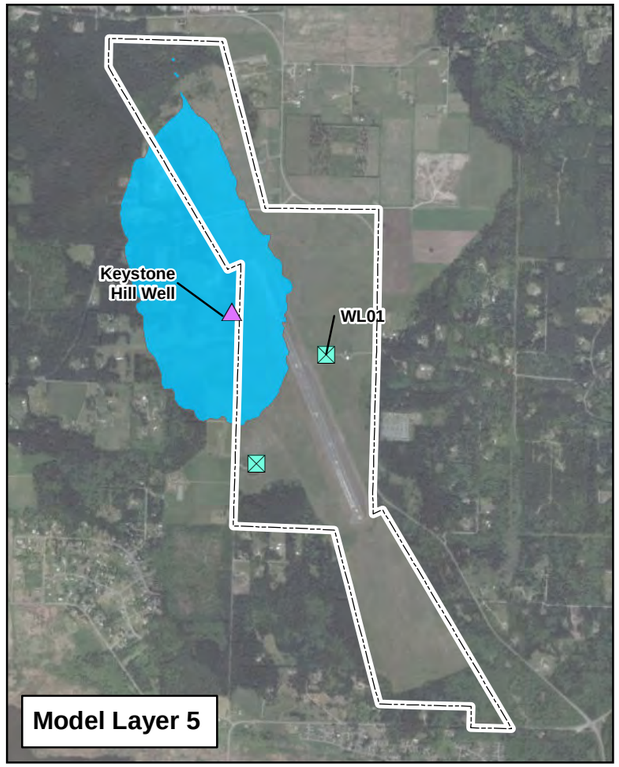

Legend

- OLF Coupeville Supply Well
- Monitoring Well with no exceedance of LHA
- Monitoring Well with LHA exceedance
- No detections of PFAS
- Not Sampled
- Community Drinking Water Well
- Simulated Keystone Hill Capture Zone
- Base Boundary

N

0 0.25 0.5 Miles

1 inch = 0.55 mile

Imagery Source: Esri

Notes:

1. Particles were started at the top of the model layer encompassing the monitoring well screen and tracked forward.
2. Particle tracking assumed an effective porosity of 10%.
3. Simulated pumping at the Keystone Hill Well was 300 gallons per minute.
4. Monitoring well points presented in each data frame are those wells screened at elevations within the respective model layer.
5. Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation

Figure 4-16
Keystone Hill Well Capture Zone
Under Increased Pumping Conditions
Naval Air Station Whidbey Island
Coupeville, Washington

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Legend

- OLF Coupeville Supply Well
- Monitoring Well with no exceedance of LHA
- Monitoring Well with LHA exceedance
- No detections of PFAS
- Not Sampled
- Community Drinking Water Well
- Groundwater Flowpath
- Particle Starting Locations
- Base Boundary
- Simulated Forward Groundwater Flowpath

Notes:
1. Particles were started at three depths in the model layer encompassing the monitoring well screen.
2. Particle tracking assumed an effective porosity of 10%.
3. Simulated pumping at the Keystone Hill Well was 150 gallons per minute.
4. Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation

N

0 0.1 0.2 0.4 Miles

1 inch = 0.38 mile

Imagery Source: Esri

Figure 4-17
Particle Tracking from Observed PFAS Exceedances at Current Pumping Conditions
Naval Air Station Whidbey Island
Coupeville, Washington

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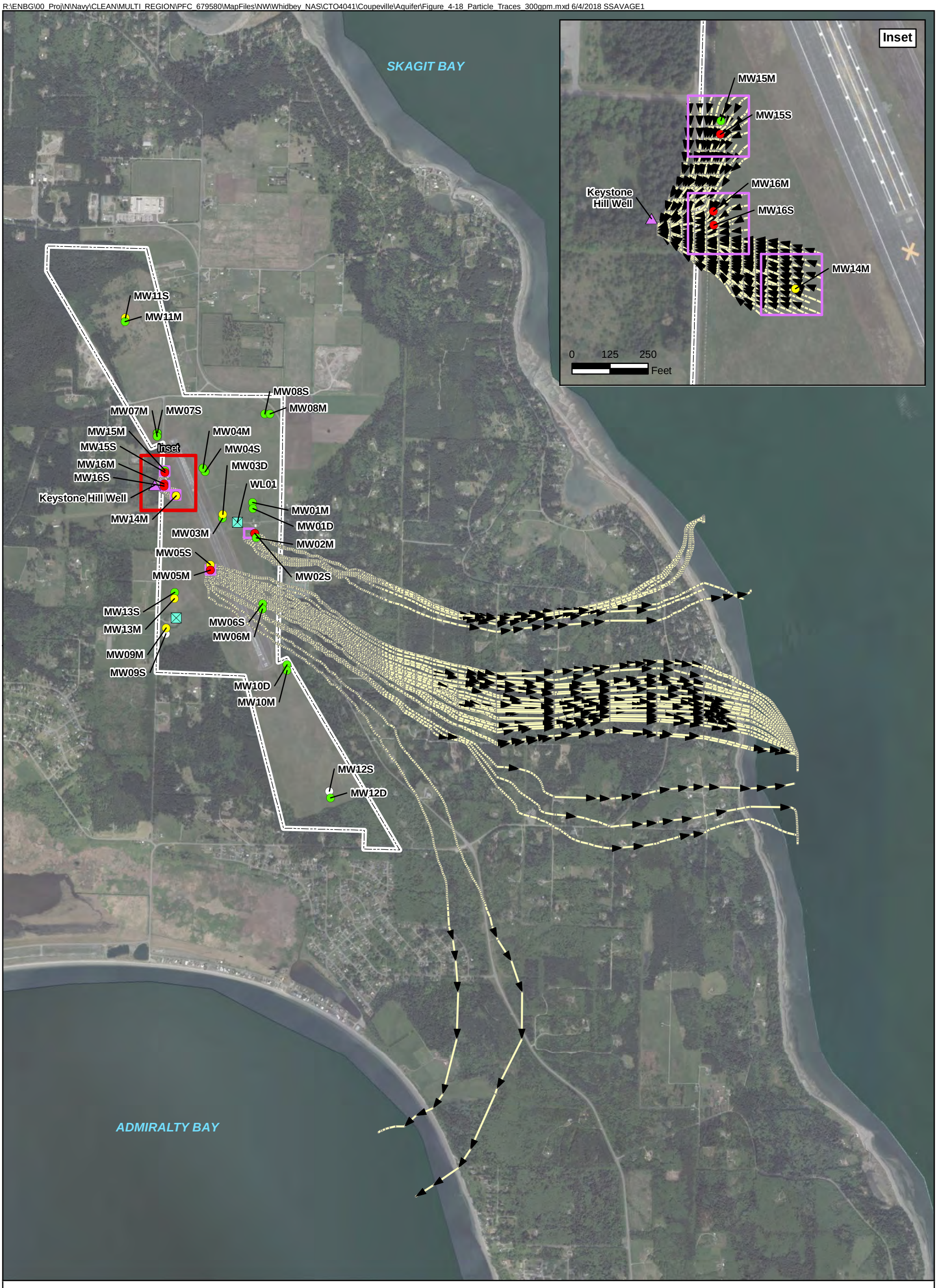

Legend

- OLF Coupeville Supply Well
- Monitoring Well with no exceedance of LHA
- Monitoring Well with LHA exceedance
- No detections of PFAS
- Not Sampled
- Community Drinking Water Well
- Groundwater Flowpath
- Particle Starting Locations
- Base Boundary
- Simulated Forward Groundwater Flowpath

Notes:
1. Particles were started at three depths in the model layer encompassing the monitoring well screen.
2. Particle tracking assumed an effective porosity of 10%.
3. Simulated pumping at the Keystone Hill Well was 300 gallons per minute.
4. Full well names include "WI-CV-" preceding the well number; however names have been abbreviated for figure presentation

N

0 0.1 0.2 0.4 Miles

1 inch = 0.38 mile

Imagery Source: Esri

Figure 4-18
Particle Tracking from Observed PFAS Exceedances at Increased Pumping Conditions
Naval Air Station Whidbey Island
Coupeville, Washington

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SECTION 5

Conclusions and Recommendations

Field investigation activities, consistent with those planned in the SAP (CH2M, 2017), at OLF Coupeville were completed between December 2017 and January 2018, and support the following conclusions:

- The four new groundwater monitoring wells (WI-CV-MW15M, WI-CV-MW15S, WI-CV-MW16M, and WI-CV-MW16S) provided additional lithologic information along the western OLF Coupeville boundary. New subsurface information, together with previous data, resulted in refinement of the CSM for the aquifer system (**Section 3.1**).
- OLF Coupeville aquifer testing provided data to enhance the understanding of pumping cycles at the KHW and resultant responses in the surrounding aquifer system. These data were used in the development and calibration of the CGFM.
- Groundwater and drinking water quality samples were collected from the KHW, newly constructed monitoring wells, and a subset of existing monitoring wells. These samples provided data to compare to previous sampling results and data in new areas of the site.
- Detections of PFAS at new sampling locations, WI-CV-MW15S, WI-CV-MW16M, and WI-CV-MW16S indicate a previously unknown area of exceedances in the vicinity of the KHW which may warrant further investigation.

A groundwater flow model of the OLF Coupeville area has been developed and calibrated to both steady-state groundwater levels as well as transient groundwater elevation data and observed pumping rates obtained from an aquifer test conducted on the nearby KHW. The model is well calibrated, with calibration statistics that meet or exceed all industry standard measures for construction and calibration of a groundwater flow model. The conclusions and recommendations developed during this effort are summarized as follows.

The primary conclusions from the model effort described herein include:

- Groundwater flow modeling indicates the presence of a groundwater mound near the north end of the OLF Coupeville runway, with groundwater flow directions moving outward in all directions heading toward the coastal areas of the island. A groundwater mound is expected in this general area as OLF Coupeville is constructed in an area of relatively higher elevation on the island, and groundwater moves outward from this area toward the island perimeters to the east, west, north, and south.
- The modeling analysis presented in **Section 3** indicates that the extent of hydraulic capture created by KHW pumping at rates of 150 gpm and 300 gpm result in full capture of the shallow and middle aquifer elevation intervals exhibiting PFAS exceedances in nearby monitoring wells WI-CV-MW15S and WI-CV-MW16S/M. There is remaining uncertainty regarding the hydraulic capture zone within the deep aquifer elevation interval due to lack of deep monitoring infrastructure in proximity to the KHW. As expected, model predictions also indicate a significantly larger capture zone when operating the well at 300 gpm, with the hydraulic capture zone extending out to encompass much of the aquifer near well WI-CV-MW05M, where recent sampling has indicated exceedances of PFAS.
- The CGFM developed under this effort can be used during future evaluations of groundwater conditions and PFAS migration behavior (such as migration pathways from source areas to drinking water wells with PFAS detections and/or exceedances) as additional data are collected at the site.
- The CGFM was constructed using a software platform (MODFLOW) that is compatible with solute transport codes; therefore, such capability can be included as part of future efforts.

SECTION 6

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Appendix A
Soil Boring Logs

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet 1 of 4
695610.04.FI.WI	WI-CV-MW16M	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic TERRASONIC 150CA

ATD WATER LEVEL : — START : 12/6/2017 10 00 END : 12/10/2017 15:35 LOGGER : G. Gardner + M. Endo

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION — SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	USCS	COMMENTS — DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
0				NA ↓	SURFACE: LOW GRASSY VEGETATION & ORGANIC TOPSOIL.		ON 12/06/17 BEGIN CLEARING BORE LOCATION WITH DITCH WITCH VAC TRUCK, 1.3' DIAM TO 7' bgs @ 10:00
2		VC			0.1'-0.5' SAND SILT DARK BROWN, DAMP, SOFT, NO ODOR, NON TO LOW PLASTIC SILT, F-M SAND, WITH ROOTS. (10YR 3/3)	ML	ON 12/06/17 @ 13:20 STOP VAC CLEARING. DEPTH = 3.2' bgs
4					0.5'-1.2' Silty Sand with Gravel Dark Yellowish Brown (10YR 3/6), Damp, No odor, Loose, Fine to coarse Sand, Non to low plastic Silt, Fine to coarse gravel (rounded), With roots	SM	DR: POOR VACUUM DUE TO SMALL DIAMETER HOSE & COBBLES CLOGGING LINE.
6					1.2'-5.4' Well Graded Sand With Silt + Gravel Dark Yellowish Brown (10YR 3/4), Moist, No odor, Med. Dense, Fine to coarse Sand, Fine to coarse rounded gravel, ~~No~~ Non-Low Plastic Silt, 3"-4" rounded cobbles @ 3' 1/2" dia tree root	SW-SM	ON 12/07/17 Resume clearing bore location @ 0834. 5.4'-7.3' could not obtain soil for classification.
8		2/2					0934 Complete Clearance
10					5.4' → 7' NO RECOVERY		ON 12/08/17 @ 1015 BEGIN DRILLING. 9" SURFACE CASING FOR MUD SEAL. 8" ISOLATION CASING, 6" INNER CASING 3 4" RODS.
12 (AC)		7/10			7' → 9' Well Graded Sand with Gravel Olive Brown (2.5Y 4/4), Damp, no odor, very loose, fine-coarse ~~Sand~~ Rounded sand, fine-coarse ~~gravel~~ rounded gravel, ~~trace Silt~~	SW	BZ: VOC = 0.7 ppm, CO = 2 ppm All else OK.
14					9' → 24.5' SAME AS ABOVE, BUT DARK GRAYISH BROWN (2.5Y 4/2) @ 16.3' WITH TRACE NON PLASTIC SILT.	SW	
16							
18							DRILLING MUD UTILIZED @ 19' bgs.
20							DR: EASIER DRILLING @ 19' bgs

VC = VACUUM CLEARED

BZ = Breathing Zone monitored with multiRAE

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet
695610.04.FI.WI	WI-CV-MW 16M	2 of 4

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic TERRASONIC 150 CC

ATD WATER LEVEL : — START : — END : — LOGGER : M. ENDE & G. GARONE

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION — SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	USCS	COMMENTS — DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
20		9/9		NA			
25					24.5'–~~33.5'~~ 34.2' (GEO) WELL GRADED SAND WITH SILT & GRAVEL. DARK GRAYISH BROWN (2.5Y 4/2), MOIST, LOOSE, NO ODOR, F-C SAND, F-C ROUNDED GRAVEL, NON PLASTIC SILT. @ 25'→27.2' 25% GRAVEL. @ 26.8'→27.2' YELLOWISH BROWN (10YR 5/8) MOTTLING. @ 31.5' gravel increase to 30%	SW-SM	B2: All clear. 70% SAND, 20% GRAVEL, 10% SILT
30		9/9					
35					34.2'–48.6' Well Graded Sand. Dark greyish Brown (2.5Y 4/2) Damp, very loose, no odor. Fine-Coarse Sand, trace fine-coarse rounded gravel	SW	
40		8/9					95% SAND, 5% GRAVEL
45							STOP DRILLING @ 13:40 CRACK IN 6"→8" DRIVER NOB FROM SITE FOR REPAIRS.
50		9/9			48.6'–49' SILTY SAND. OLIVE BROWN (2.5Y 4/3), MOIST, LOOSE, NO ODOR, 70% FINE ~~SAND~~ TO MED SAND, 30% NON-LOW PLASTIC SILT	SM	RESUME DRILLING @ 1505.
55					49'–68.5' Poorly Graded Sand. Grayish Brown (2.5Y 5/2), Moist, very loose, no odor, fine 95% fine-med. sand, 5% ~~silt~~ (GEO)	SP	
60		10/10			68.5'–69' Poorly Graded Sand with Silt. Dark Grayish Brown (2.5Y 4/2), Damp, loose, no odor, 90% fine-med sand, 10% non-low plastic silt	SP-SM	STOP DRILLING @ 1535 DEPTH = 54' bgs, 8" CASING @ 54' bgs. ON 12/09/17 @ 0850 RESUME DRILLING.
65							
70							

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet 2 (3) of 4
695610.04.FI.WI	WI-CV-MW16M	

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA
ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED: Rotosonic Terra Sonic 150 cc
ATD WATER LEVEL: — START: — END: — LOGGER: M Erdo + G. Gardner

DEPTH BELOW SURFACE (FT)	INTERVAL (FT) / RECOVERY (FT) / SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION, DRILLING ACTIONS/DRILLER COMMENTS; PID Readings: Breathing Zone: Above Hole:)
70	7/10		~~69'-72' No recovery~~ 69'-~~76'~~ 74.5' same as 49'-68.5' ~~except 74.5'-75' same as 68.5'-69'~~	SP	Maybe due to compression BZ: all clear
75			74.5'-75' same as 68.5'-69'	SP-SM	
80	7/10		75'-76' same as 69'-74.5' 76'-79' No Recovery	SP	Loose sal lost out of bottom of core barrel
85			79'-86' Poorly Graded Sand Greyish Brown (2.5Y 5/2), Moist, very loose, no odor 95% fine-med. sand, 5% fines, layers at 80' and 85' = same as 68.5'-69' 3"-5" thick	SP	
90	5/10		86'-89' No Recovery 89'-94' No Recovery		
95			94'-107.8' same as ~~74'-86'~~ 49'-68.5' but silt ~~content~~ content increases ~~toward~~ with depth ~~107.8'~~	SP	Warm Core 89'-99'
100	9/10				
105			107.8'-110.8' Silt Dark Greyish Brown (2.5Y 4/2) Moist, med-stiff, no odor, >90% low plastic silt, <10% fine sand. Mottling in horizontal lamina Strong Brown (7.5YR 5/8)	ML	
~~110~~ 110	8.5/10		110.8'-116.9' Poorly Graded Sand same as 49'-68.5' Some minor bedding of higher silt content.	SP	
115					
120					

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet 4 of 4
695610.04.FI.WI	WI-CV-MW 16M	

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA
ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED: Rotosonic Terrasonic 150 CC
ATD WATER LEVEL: — START: — END: — LOGGER: M. Ende + G. Gardner

DEPTH BELOW SURFACE (FT)	INTERVAL (FT) / RECOVERY (FT) / SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION — SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS — DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
120	10 / 9.5 / 10		116.9'–128' Poorly Graded Sand with Silt. Same as 68.5'–69'. Dark yellowish brown (10YR 4/6) mottling @ 121.4'–121.7' & 126.2'–127'. non plastic silt lense @ 127.6–127.8' grayish Brown (2.5Y 5/2)	SP-SM	BZ = All clear. DR: Slightly harder drilling than really soft @ 127'
130	8 / 10		128.8'–134.3 Lean Clay. Dark Grey (Gley 1 4/N), moist, no odor, Low plasticity, very stiff. 3"–4" cobbles @ 131.4' & 134.3'	CL	STOP DRILLING @ 15:00 [DEPTH = 139'] ON 12/10/17 @ 08:19 RESUME DRILLING.
140	9 / 10 / 10		134.3'–136.3' Poorly Graded Sand with Gravel. Grayish Brown (2.5Y 5/2), moist, very loose, no odor, 85% fine-med. sand, 15% fine-med. rounded gravel.	SP	
145			136.3'–149' Poorly Graded Sand. Grayish Brown (2.5Y 5/2), moist to 137' then wet, very loose, no odor, >95% fine-med. Sand <5% fines. @139' moist to wet. @144' wet.	SP	Driller pulling 20' of 8" casing + backfilling with medium hydrated bentonite chips. Set Isolation casing @129' bgs. @ 10:45 RESUME DRILLING w/ 6" CASING.
150	10 / 10				
155			149'–159' Poorly Graded Sand. Same as 136.3'–149' except Grey (2.5Y 5/1), wet, loose.	SP	
160	10 / 10		159'–179' POORLY GRADED SAND DARK GRAYISH BROWN (2.5Y 4/2), WET, LOOSE, NO ODOR, 95% F-M SAND, 5% FINES. @174' Change to dark gray (2.5Y 4/1)	SP	DR: EASY DRILLING, NO TORQUE PRESSURE. @ 159' bgs.
170	10 / 10		TD = 179.5' bgs		ON 12/10/17 @ 1535 COMPLETE DRILLING. 6" CASING TO TD.
180					

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet 1 of 6
695610.04.FI.WI	WI-CV-MW16S	

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA

ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED: Rotosonic Terrasonic 150cc

ATD WATER LEVEL: — START: 12/7/2017 09:38 — END: 12/13/17 15:40 — LOGGER: G.Gardner + M. Endo

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION — SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	USCS	COMMENTS — DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS
							PID Readings: Breathing Zone: Above Hole:
0		VC	NA ↓		Surface: Low grassy vegetation, organic topsoil		On 12/07/2017 begin Clearing bore location with Ditch Witch Vac truck @ 0938
					0.1'-0.6' Sandy Silt	ML	
2					Dark Brown (10YR 3/3), Damp, Soft, no odor, non to low plastic silt, Fine-med sand with roots		
					0.6'-1.7' Silty Sand with Gravel	SM	
4					Dark yellowish Brown (10YR 3/6) Damp, loose, no odor, Fine-coarse sand, non-low plastic silt, fine-coarse rounded gravel with roots		
6					1.7'-4' Well Graded Sand with Silt and Gravel	SW-SM	1012 complete Clearance couldnot obtain soil for classification for 4'-7' interval
		2/2			Dark Yellowish Brown (10YR 3/4) Moist, med dense, no odor, fine-coarse sand, fine-coarse rounded gravel, non-low plastic silt, 3"-4" rounded cobbles.		
8					4'-7' no Recovery		
10					7'-9' Well Graded Sand with Gravel	SW	12/12/2017 @ 09:15 begin drilling, 7" casing for mud seal, 6" inner casing
					Dark grayish brown to very dark grayish brown (2.5Y 4/2-2.5Y 3/2) moist, very loose, no odor, 80% fine-coarse Sand, 15% Fine-coarse rounded gravel, 5% 3"-4" rounded cobbles, trace silt		
12					9'-12' no recovery		
		7/10			12'-15' Well Graded Sand with Gravel	SW	
14					Dark Grayish Brown (2.5Y 4/2) moist, very loose, no odor, 60% Fine-coarse Sand, 35% fine-coarse angular gravel, trace silt, trace rounded cobbles (3"-4")		
16					15'-19' Well Graded Sand with Gravel	SW	
					Same as 7'-9' but Dark grayish brown (2.5Y 4/2) & moist		
18							
20							

VC = Vacuum Cleared

BZ = Breathing Zone monitored with MultiRAE

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet 2 of 6
695610.04.FI.WI	WI-CV-MW 65	

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA

ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED: Rotosonic Terra Sonic 150 CC

ATD WATER LEVEL: — START: — END: — LOGGER: (. Gardner, M. Endo

DEPTH BELOW SURFACE (FT)	INTERVAL (FT) / RECOVERY (FT) / SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION — SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS — DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
20	9/10		19'–21' No Recovery		DR: Cobble stuck in drill bit causing displacement + compression, pushed up into core barrel before reaching 29' bgs.
22 25			21'–24' Well Graded Gravel with Sand. Dark grayish brown (2.5Y 4/2), damp to moist, loose to very loose, no odor, 60% rounded fine to coarse gravel, 40% fine to coarse Sand.	GW	
24 30	8/10		24'–29' Well Graded Sand with Gravel. Olive brown (2.5Y 4/3), moist, loose, 70% fine-coarse sand, 30% fine-coarse rounded gravel		DR: LOST SOIL FROM CORE BARREL UPON RETRIEVAL. (SIV) (5) 29'→39' INTERVAL.
26 35	5/10				
28 40			29'–30.5' Well Graded Sand. Olive Brown (2.5Y 4/3), moist to wet, loose, no odor, 90% fine-coarse sand, 10% fine rounded gravel, trace fines	SW	
30 45			30.5'–33' Well Graded Sand with Gravel. Dark grayish brown (2.5Y 4/2), damp, loose, no odor, 70% fine-coarse sand, 25% fine-coarse rounded gravel, 5% fines.	SW	
32 50	8/10		33'–34.5' Poorly Graded Sand. Dark grayish brown (2.5Y 4/2), damp, loose, no odor, 95% fine-med. Sand, 5% fines.	SP	
34.55 65			34.5'–37' Well Graded Sand with Gravel. Same as 30.5'–33'.	SW	
36 60 70			37'–39' No Recovery		
38 65 75					
40 70 80					

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet
695610.04.FI.WI	WI-CV-MW 16S	3 of 6

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : — END : — LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS)
40					39'–41' ~~Well Graded Sand~~ SW No Recovery	SW	PID Readings: Breathing Zone: Above Hole:
42					41'–49' Well Graded Sand Dark grayish brown (2.5Y 4/2), moist, loose, no odor, 95% fine-coarse sand, 5% gravel, trace fines. Alternating layers of Poorly graded Sand: olive brown (2.5Y 4/3), layers are 0.3-0.5' thick.	SW	
44		8/10			49'–109' Poorly Graded Sand Olive Brown (2.5Y 4/3), moist to wet, loose, no odor, 95% fine-sand, trace fines. @54' loose to med. dense, damp	SP	
46							
48							
50		10/10			@		
52							
54					@57.5' moist		
56							
58					@54' Damp, loose to med. dense		
60							

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet
695610.04.FI.WI	WI-CV-MW 165	4 of 6

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : — END : — LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N')	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	USCS	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
60							
		10/10					
65					@69' moist		
					@71.2'-71.3' layer of silt with sand, grayish brown (2.5Y 5/2), 75% Low Plastic silt, 25% fine sand.	ML	BZ all clear
70		10/10			@72.5' very loose		
75							
80							
		10/10					
85					@88'-88.2' layer of silty sand, 75% fine-med. sand, 25% low plastic silt	SM	
90							
		10/10					
95					@98.3-98.4' layer of sand with silt, 90% fine sand 10% ~~low plastic silt~~ fines	SP-SM	
100							
105					@104'-105' med. dense, increase to ~15% fines		
110							ON 12/12/17 @ 16:00 STOP DRILLING. ON 12/13/17 @ 08:25 resume-d. drilling

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet 5 of 6
695610.04.FI.WI	WI-CV-MW165	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : — END : — LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION — SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS — DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS
							PID Readings: Breathing Zone: Above Hole:
110					109'–112' Sandy silt Grayish brown (2.5Y 5/2), moist, stiff, no odor, 60% ~~non-plastic~~ med. plastic silt, 40% fine–med. sand.	ML	BZ - All clear
112 115		10/10			112–~~127~~ 114' ~~Sand with silt~~ Poorly graded sand with silt Grayish brown (2.5Y 5/2), moist, loose, no odor, 90% fine–med. sand, 10% fines.	SP-SM	
114 ~~120~~ 115					114'–127' Poorly Graded Sand Grayish brown (2.5Y 5/2), moist, loose, no odor, 95% fine–med. sand, 5% fines. @ 119' lower fines content	SP	
116 ~~125~~ 120					@ 125'–125.7' layer of silt with sand, 70% med. plastic silt, 30% fine–med sand.	ML	
118 ~~130~~ 125		10/10			@ 127'–125' Silt with sand Grayish brown (2.5Y 5/2) moist, stiff, no odor, 70% med. plastic silt, 30% fine–med. sand. @ 127.5–127.8 layer of Poorly graded sand	ML SP	
120 ~~135~~ ~~125~~					128'–130.6' Lean Clay Gray (Gley 1 5/N), damp, very stiff, no odor, ~~45%~~ med. plastic	CL	DR - Easier drilling
122 ~~140~~ 130							
~~145~~ 124 ~~135~~ ~~140~~							
~~150~~ 126 ~~140~~ 145		10/10					
128 ~~155~~ 145							
130 ~~160~~ 150							

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet 6 of 6
695610.04.FI.WI	WI-CV-MW16S	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : — END : — LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS)
							PID Readings: Breathing Zone: Above Hole:
130					130.0'–132.3' Well Graded Sand with Clay and Gravel	SW-SC	
135		10/10			Gray (2.5Y 5/1), moist to wet, loose, no odor, 75% fine-coarse sand, 15% fine-coarse rounded gravel, 10% clay		
					132.3'–145.' Well Graded Sand	SW	
140		6/6			Dark greyish brown (2.5Y 4/2), moist to wet, very loose, no odor, 95% fine-coarse sand, 5% gravel, gravel decreasing with depth.		
145							ON 12/13/17 @ 15:40 COMPLETE DRILLING WI-CV-MW16S
					TD = 145.5' bgs		

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet 1 of 9
695610.04.FI.WI	WI-CV-MW15M	

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA

ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED: Rotosonic Terrasonic 150 CC

ATD WATER LEVEL: — START: 12/16/17 0820 — END: 12/17/17 1042 — LOGGER: D. Butler

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N')	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
0					Surface: Grass 0-0.5' Silty sand, dark brown, moist, loose, sand f to c, non-plastic silt, roots	SM	
2					0.5-2' Silty sand w/ gravel, brown, damp to moist, loose, sand f to c, gravel f to c, trace f cobble, non-plast silt	SM	
4		VC			2-4' Well graded gravel w/ sand, light brown, moist, loose, sand f to c (SA to A), gravel f to c (SR to R), trace silt	GW	
6							
8							
10					9-10' Well-graded sand, dark brown, damp, loose, fine to coarse sand, SA to A, trace fine gravel	SW	12/16/17 @0820 Begin drilling, 9" surface casing for mud seal, 8" ISO casing, 6" inner casing
12		10/10			10-13' Well graded sand w/ silt and gravel, dark brown, damp, loose, fine to coarse sand, sand SA to A, gravel predominatly SR to R (trace SA to A), gravel fine to coarse	SW-SM	
14					13-23' Well graded sand w/ gravel, dark grayish brown, damp, loose, f to C sand, sand SA to A, f to c gravel, predom. SR to R (trace SA to A), trace cobbles, trace silt	SW	
16							
18							0910 Finish setting surface casing mud seal
20							0930 BZ = normal

VC = vacuum ~~drafted~~ cleared

BZ = Breathing zone

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet 2 of 9
695610.04.FI.WI	WI-CV-MW 15M	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : 12/16/17 0820 — END : 12/17/17 1042 — LOGGER : D. Butler

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION — SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS — DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
20							
22					23 - 24.4' Same as above except more fine sand		
24		9.2 /10			24.4 - 25.4' Well graded gravel w/ silt, dark gray, loose, gravel SR to R, some sand f to c (SA to A), damp, gravel f to c	GW-GM	
26					25.4 - 29' Well graded sand w/ gravel, dark brown, damp, loose, gravel f to c (SR to R), sand f to c (SA to A), trace silt, trace cobbles, large % is gravel (~40%?)	SW	
28							
30					29 - 30.5' No recovery		
32		6.2 /10			30.5 - 37' Well graded sand w/ gravel, dark grayish brown, damp to moist, loose, sand f to c (SA to A), gravel predom. fine (trace coarse) [SR to R], lower % of gravel (~15%?)	SW	
34							
36					37-39' No recovery		
38					39 - 41.5' Same as 30.5 - 37'		DR: Lost bottom 2ft of 29-39' run
40							

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet 3 of 9
695610.04.FI.WI	WI-CV-MW 15M	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : 12/16/17 0820 — END : 12/17/17 1042 — LOGGER : D. Butler

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION — SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS — DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
40					41.5-47' Poorly graded sand, light brown, damp, loose, sand vf to f (SA to A), trace fine gravel towards top	SP	
42							
44		8.6/10					
46					47-49' Same as above with little (~10%) silt	SP SM	
48					49-51.5' No recovery		
50					51.5-57' Poorly graded sand, brown, damp, loose, sand vf to m (SA to A), coarsening downwards, trace (one small piece) ~~of~~ charcoal	SP	
52							
54		5.5/10					
56					57-60.5' No recovery		
58							DR: Lost bottom 2 ft of 49-59' run
60							

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet 4 of 9
695610.04.FI.WI	WI-CV-MW 15M	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : 12/16/17 0820 — END : 12/17/17 1042 — LOGGER : D Butler

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	USCS	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS
60					60.5-61' Same as 51.5-57', trace coarse sand from 60.5-61.5'	SP	PID Readings: Breathing Zone: Above Hole:
62							
64		6.5/10					
66					67-69' No recovery		
68							DR: Lost ~2ft of bottom of 59-69' run
70					69-79' Same as 51.5-57' except not coarsening downwards	SP	
72							
74		7.2/10					
76							
78							1145 BZ=normal
80							

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet
695610.04.FI.WI	WI-CV-MW 15 A	5 of 9

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : 12/16/17 0820 — END : 12/17/17 1042 — LOGGER : D. Butler

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
80					79-86' Same as 51.5-57' except not coarsening downwards	SP	
82							
		6.5/10					
84							
86					86-89' Poorly graded sand w/ silt, light brown, loose, damp, sand vf to f (SA to A), non-plastic silt	SP-SM	
88							1200 Drillers break for lunch
					89-107.1' Poorly graded sand, light brown, loose, damp, sand vf to f (SA to A)	SP	1245 Resume drilling
90							
92							
		7.8/10					
94							
96							
98							
100							

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet
695610.04.FI.WI	WI-CV-MW 15 M	6 of 9

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : 12/16/17 0820 — END : 12/17/17 1042 — LOGGER : D. Butler

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N')	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS)
100							PID Readings: Breathing Zone: Above Hole:
102							
104		8.8/10					
106					107.1 - 108.3' Silt, light grayish brown, damp, medium plastic, low tough, dilatancy - none, stiff	ML	
108					108.3 - 124.4' same as 89 - 107.1'	SP	
110							
112							
114		8/10					
116							
118							1435 B2 = normal
120							

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet 7 of 9
695610.04.FI.WI	WI-CV-MW 15M	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA

ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED : Rotosonic

ATD WATER LEVEL : — START : 12/16/17 0820 — END : 12/17/17 1042 — LOGGER : D. Butler

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS) PID Readings: Breathing Zone: Above Hole:
120							
122							
124		11/10			124.4-125.6' Sandy fat clay, light gray, damp, med. plastic, low tough, med. soft, sand vf to f, interbedding of sand and clay (gradational contact between above and below units)	CH	
126							
128					125.6-132.4' Fat clay, blueish gray, damp, high plastic, med. tough, hard, trace vf to f sand and silt	CH	set isolation casing at 129' bgs. No seal necessary since we are still in the clay.
130							
132		10/10			132.4-139' well graded sand w/ gravel, dark gray, moist, loose, sand f to c (SA to SR), gravel f to c (SR to R)	SW	
134							
136							
138							12/16/17 @ 1600 stop drilling for the day, DR: Used ~1000 gal of water/mud today
140							

ch2m: SU

PROJECT NUMBER	BORING NUMBER	Sheet 6 of 9
695610.04.FI.WI	WI-CV-MW 15M	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA
ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED : Rotosonic
ATD WATER LEVEL : — START : 12/16/17 0820 — END : 12/17/17 1042 — LOGGER : D. Butler

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:
140					139 - 143.5' Same as above, except % of gravel decreasing downwards	SW	On 12/17/17 @ 0803 Resume drilling from 139 ft bgs
142					143.5 - 156' Poorly graded sand, gray, moist, loose, sand is fine (trace medium), SA to A	SP	BZ = normal
144		7/10					
146							
148							
150							
152		9.4/10					
154					154' Small shell fragment		
156					156 - 156.7' Same as above with trace fine gravel	SP	
158					156.7 - 159' Same as 143.5 - 156'	SP	
160							

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet 9 of 9
695610.04.FI.WI	WI-CV-MW 15 M	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA
ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED : Rotosonic
ATD WATER LEVEL : — START : 12/16/17 0820 — END : 12/17/17 1042 — LOGGER : D. Butler

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS)
160					159-172.8' Same as 143.5-156'	SP	PID Readings: Breathing Zone: Above Hole:
162							
		9.1/10					
164							
166							
168							
							1010 BZ = normal
170							
172					172.8-173.1' Silt, dark gray, moist, trace fine sand, low plastic, low tough	ML	
		10.5/10					
174					173.1-179' Poorly graded sand, dark gray, moist, sand is very fine (SA to A)	SP	
176							No more water added to hole today.
178							
							TD @ 1042 = 179 ft will set well screen from 164-174', Sump from 174-179'.
180							

ch2m.

PROJECT NUMBER	BORING NUMBER	Sheet
695610.04.FI.WI	WI-CV-MW155	1 of 6

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA

ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED: Rotosonic TERRASONIC 150CC

ATD WATER LEVEL: — START: 12/18/17 10:45 — END: 12/19/17 1130 — LOGGER: M. ENDO, G. GARDNER

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N")	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS
							PID Readings: Breathing Zone: Above Hole:
0			NA ↓	NA ↓	SURFACE: LOW GRASSY VEGETATION		ON 12/07/17 @ 1540 BEGIN POTHOLING W/ VAC TRUCK TO 7' bgs.
0.2' → 7'					NO RECOVERY		
2		VC					ON 12/18/17 @ 1845 BEGIN DRILLING @ 7' bgs WITH 8" CONDUCTOR CASING TO 19' bgs
							• UTILIZE DRILLING MUD @ 19' bgs.
4							
6							
					7'-8' WELL GRADED SAND WITH GRAVEL	SW	BZ = All CLEAR W/ 4-GAS MONITOR.
		2/2			DARK GRAYISH BROWN (2.5Y 4/2), MOIST TO WET, LOOSE, NO ODOR. 80% F-C SAND, 20% F-M ROUNDED GRAVEL, TRACE SILT.		
8					8' - 11.2' WELL GRADED SAND	SW	
					DARK GRAYISH BROWN (2.5Y 4/2), MOIST TO WET, LOOSE, NO ODOR, 85% F-C SAND, 10% F-M ROUNDED GRAVEL, TRACE SILT.		
10							
					11.2' - 15.1' SAME AS 7'-8' BUT OLIVE BROWN (2.5Y 4/3) AND 3"-4" ROUNDED COBBLE.	SW	
12		10/10					
14					15.1' - 18.4' WELL GRADED SAND WITH SILT AND GRAVEL	SW-SM	
					OLIVE BROWN (2.5Y 4/3) TO VERY DARK GRAYISH BROWN (2.5Y 3/2), MOIST, LOOSE, NO ODOR, 70% F-C SAND, 20% F-C ROUNDED GRAVEL, 3"-4" ROUNDED COBBLE, < 10% FINES.		
16							
					18.4' - 19' POORLY GRADED SAND	SP	
18					DARK GRAYISH BROWN (2.5Y 4/2) TO OLIVE BROWN (2.5Y 4/3), DAMP, VERY LOOSE, NO ODOR, 95% F-M SAND, < 5% FINES		6" CASING, 4" RISER STICKUP, @ 19' bgs.
20							

VC = VACUUMED CLEARED

BZ = BREATHING ZONE MONITORED W/ 4-GAS METER.

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet	of
695610.04.FI.WI	WI-CV-MW155	2	6

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA

ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED: Rotosonic

ATD WATER LEVEL: — START: — END: — LOGGER:

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N')	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS)
							PID Readings: Breathing Zone: Above Hole:
20			NA ↓	NA ↓	19' - 20.1' WELL GRADED SAND OLIVE BROWN (2.5Y 4/3) TO VERY DARK GRAY (2.5Y 3/1), DAMP, VERY LOOSE, NO ODOR, 95% F-C SAND, < 5% FINES	SW	DR: COBBLE STUCK IN DRILL BIT = DISPLACEMENT / COMPRESSION IN 19'-29' INTERVAL.
22		6/10			20.1' - 21.8' WELL GRADED SAND WITH GRAVEL DARK GRAYISH BROWN (2.5Y 4/2), DAMP, LOOSE, NO ODOR, 75% F-C SAND, 25% F-C ROUNDED GRAVEL, <10% FINES	SW	
24					21.8' - 22.8' WELL GRADED GRAVEL WITH SAND DARK OLIVE GRAY (5Y 3/2) TO DARK GRAYISH GREEN (5GY 4/1), DAMP, LOOSE, NO ODOR, 70% F-C ROUNDED GRAVEL & 3" ROUNDED COBBLE, 20% F-C SAND, <10% FINES	GW	
26					22.8' - 29' POOR RECOVERY SAME AS 20.1'-21.8'	SW	POOR RECOVERY DUE TO COBBLE/GRAVEL STUCK IN BIT BEING PUSHED INTO CORE.
28					29' - 37.6' SAME AS 20.1'-21.8'	SW	
30							
32		7.3/10					
34							
36							
38					37.6' - 41' POORLY GRADED SAND GRAYISH BROWN (2.5Y 5/2), DAMP, LOOSE, NO ODOR, 90% VF-M SAND, < 10% FINES	SP	
40							

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet
695610.04.FI.WI	WI-CV-MW155	3 of 6

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA

ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket

DRILLING METHOD AND EQUIPMENT USED: Rotosonic

ATD WATER LEVEL: — START: — END: — LOGGER:

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N")	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS)
							PID Readings: Breathing Zone: Above Hole:
40			NA ↓	NA ↓			BZ = All CLEAR, CO = 0.5-> 15ppm (NOT SUSTAINED).
41					41' - 43.2' SILT WITH SAND GRAYISH BROWN (2.5Y 5/2), DAMP, MED STIFF, NO ODOR, 60% LOW PLASTIC SILT, 20% VF-M SAND	ML	
42		7/10					
43					43.2' - 44.5' POORLY GRADED SAND WITH SILT DARK GRAYISH BROWN (2.5Y 4/2), DAMP, LOOSE, NO ODOR, 90% VF-M SAND, 10% FINES	SP-SM	
44							
45					44.5' - 49' SAME AS 37.6' - 41' BUT DARK GRAYISH BROWN (2.5Y 4/2)	SP	
46							
47							
48							
49					49' - 89' SAME AS 37.6' - 41 BUT DARK GRAYISH BROWN (2.5Y 4/2) TO VERY DARK GRAYISH BROWN (2.5Y 3/2) AND ≤ 5% FINES (95% F-M SAND).	SP	DR: NO LOSS FROM CORE BARREL, COMPRESSION IN LOOSE SANDS.
50							
51							
52		7/10					
53							
54							
55							
56							
57							
58							
59							
60							

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet 4 of 6
695610.04.FI.WI	WI-CV-MW15S	

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA
ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED: Rotosonic
ATD WATER LEVEL: — START: — END: — LOGGER:

DEPTH BELOW SURFACE (FT)	INTERVAL (FT) / RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N")	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS)
60	7/10	NA ↓	NA ↓			PID Readings: Breathing Zone: Above Hole:
65						
70	8/10					
75						
80	8.5/10					
85						
90	7.4/10			89'-106.4' POORLY GRADED SAND Grayish Brown (2.5Y 5/2), Damp, Loose, No Odor, 90% VF-M Sand, <10% Fines	SP	
95						
100	8.5/10					BZ: All Clear VOC = 0.1ppm, CO = 0->5ppm (Not Sustained)
105				106.4'-107.6' SILT Gray (10YR 5/1) with Yellowish Brown Mottling (10YR 5/8), Moist, Stiff, No Odor, 90% Med Plastic Silt, <10% VF-F Sand	ML	
110						

ch2m

PROJECT NUMBER	BORING NUMBER	Sheet
695610.04.FI.WI	WI-CV-MW15S	5 of 6

SOIL BORING LOG

PROJECT: NAS Whidbey Island OLF Coupeville — LOCATION: Coupeville, WA
ELEVATION: — DRILLING CONTRACTOR: Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED: Rotosonic
ATD WATER LEVEL: — START: — END: — LOGGER:

DEPTH BELOW SURFACE (FT)	INTERVAL (FT) / RECOVERY (FT) / SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION (SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.)	USCS	COMMENTS (DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS)
					PID Readings: Breathing Zone: Above Hole:
110	NA ↓	NA ↓	107.6'-113.6' POORLY GRADED SAND DARK GRAYISH BROWN (2.5Y 4/2), DAMP, LOOSE TO VERY LOOSE, NO ODOR, 95% VF-M SAND, <5% FINES.	SP	
112	7/10		113.6'-114' SILTY SAND DARK GRAYISH BROWN (2.5Y 4/2), DAMP, LOOSE, BLOCKY, 80% VF-M SAND, 20% LOW PLASTIC SILT	SM	
114			114'-117.3' SAME AS 107.6'-113.6'	SP	
116			117.3'-119.6' SAME AS 113.6'-114	SM	
118					
120					DR: EXPANSION FROM CLAY LAYER.
122	12.5/10		122.6'-124' SANDY SILT OLIVE BROWN (2.5Y 4/3), MOIST, MED STIFF, NO ODOR, RAPID DILATANCY, 65% LOW PLASTIC SILT, 35% VF-M SAND	ML	
124			124'-126.5' POORLY GRADED SAND WITH CLAY VERY DARK GRAY (GLEY1 3/N), MOIST TO WET, LOOSE, RAPID DILATANCY, NO ODOR, 90% VF-M SAND, 10% FINES	SP-SC	
126			126.5'-130' FAT CLAY VERY DARK GRAY (GLEY1 3/N), MOIST TO WET, STIFF TO VERY STIFF, NO ODOR, 95% HIGH PLASTIC CLAY, <5% VF-F SAND	CH	
128					
130					ON 12/18/17 @ 16:05 STOP DRILLING AT DEPTH = 124' bgs

ch2m:

PROJECT NUMBER	BORING NUMBER	Sheet 6 of 6
695610.04.FI.WI	WI-CV-MW155	

SOIL BORING LOG

PROJECT : NAS Whidbey Island OLF Coupeville — LOCATION : Coupeville, WA
ELEVATION : — DRILLING CONTRACTOR : Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED : Rotosonic
ATD WATER LEVEL : — START : — END : — LOGGER : G. Gardner

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	USCS	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS
							PID Readings: Breathing Zone: Above Hole:
130					130.7'–132.3' Clayey Sand very dark gray (gley 1 3/N) moist to wet, stiff, no odor, 20% fine–med. Sand, 30% high Plastic Clay	SC	BZ = All Clear on 12/19/17 @ 0840 Begin drilling at 129' bgs.
132	135				132.3'–135.3' Well Graded Sand with Gravel Grayish brown (2.5Y 5/2), moist to wet, Very loose, no odor, 85% fine–coarse Sand, 15% fine–coarse rounded gravel	SW	
134	140	10/10					
136							
138					135.3'–139' Well Graded Sand Same as 132.3'–135.3' but <5% gravel.	SW	
					139'–149' Poorly Graded Sand	SP	
140	145				Grayish Brown (2.5Y5/2), wet, very loose, no odor 95% fine–med. Sand, 5% fines.		
142		10/10					
144							@ 1130 stop drilling at TD = 149' bgs.
146							
148							
150							

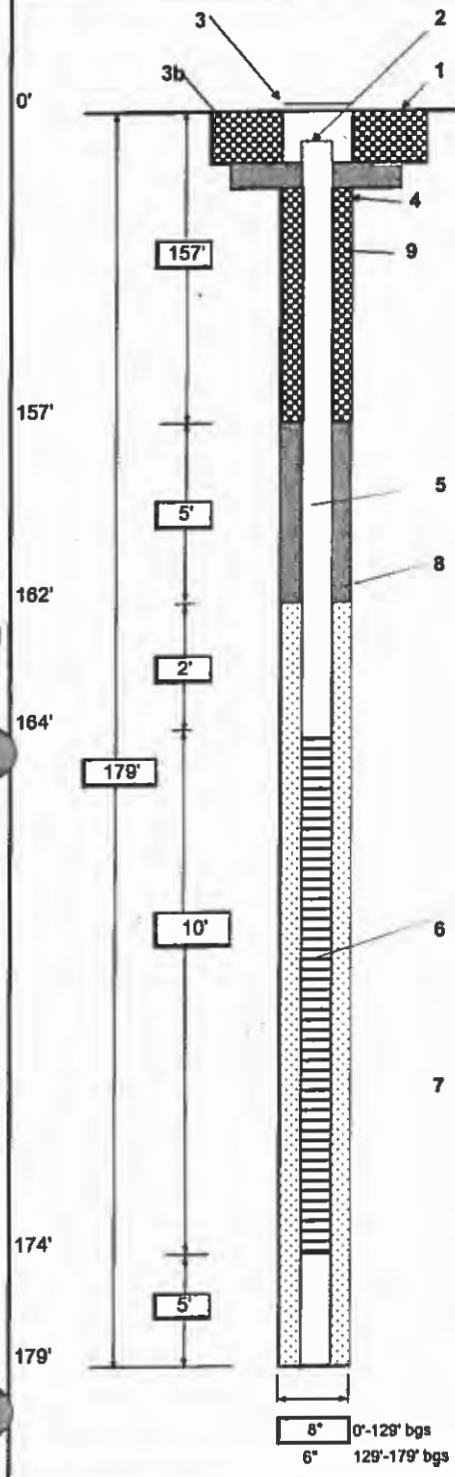
Appendix B
Well Completion Diagrams

CH2MHILL

PROJECT NUMBER	WELL NUMBER	
695610.04.FI.WI	WI-CV-MW16M	SHEET 1 OF 1

GROUND WATER MONITORING WELL COMPLETION DIAGRAM

PROJECT : NASWI OLF Monitoring Well Installation
LOCATION : Coupeville, WA
ELEVATION: TBD
DRILLING CONTRACTOR : Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED: Rotosonic (Terrasonic 150 CC)
WATER LEVELS :
START : 12/9/17 END : 12/11/17
LOGGER : M. Endo / G. Gardner



1- Ground elevation at well: TBD

2- Top of casing elevation: TBD

3- Wellhead protection cover type: Flush Mount
   a) drain tube? No
   b) concrete pad dimensions; 2' x 2'
   depth of surface concrete 1.5'

4- Dia./type surface casing: 8"

5- Dia./type of well casing: 2" Sch 80 PVC

6- Type/slot/size of screen: 0.01" PVC

7- Type screen filter: 20/40 Colorado silica sand
   quantity used: seven and 1/2 50-lb bags

8- Type of seal: 3/8" coated bentonite pellets
   quantity used: one and 1/4 5-gal. buckets

9- Grout
   a) Grout mix used: High solids 20% bentonite grout slurry
   b) Method of placement: Tremie pipe
   c) Vol.of surface casing grout
   d) Vol. of well casing grout: nine 50-lb bags

Development method

Development time

Estimated purge volume

Comments

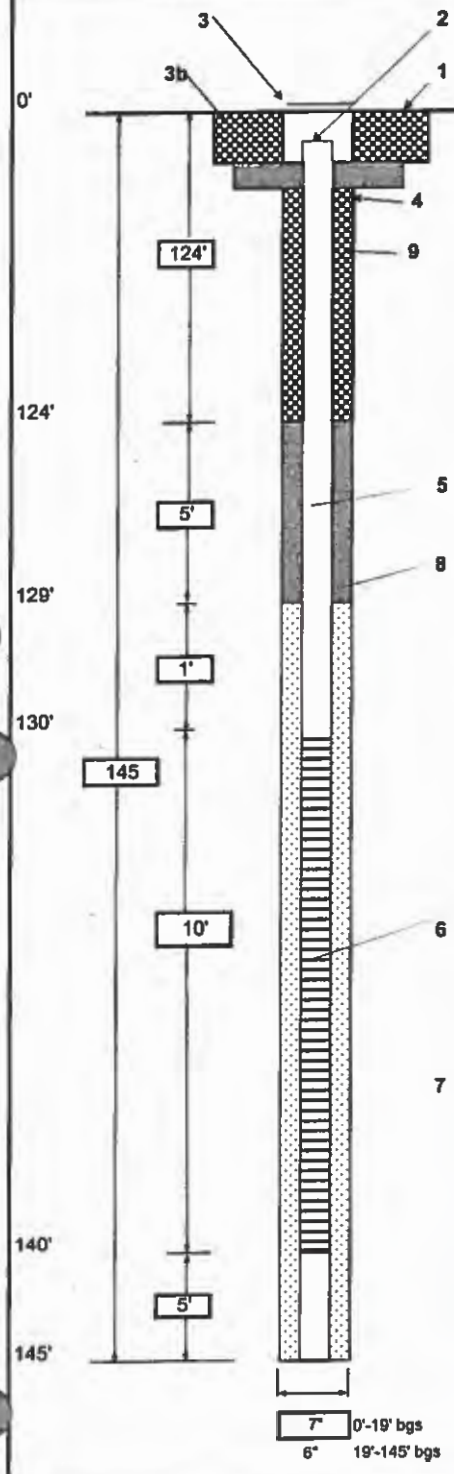
Illustration not to scale.

CH2MHILL

PROJECT NUMBER	WELL NUMBER	
695610.04.FI.WI	WI-CV-MW16S	SHEET 1 OF 1

GROUND WATER MONITORING WELL COMPLETION DIAGRAM

PROJECT : NASWI OLF Monitoring Well Installation
LOCATION : Coupeville, WA
ELEVATION: TBD
DRILLING CONTRACTOR : Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED: Rotosonic (Terrasonic 150 CC)
WATER LEVELS :
START : 12/12/17 END : 12/14/17 LOGGER : G. Gardner, M. Endo



1- Ground elevation at well TBD

2- Top of casing elevation TBD

3- Wellhead protection cover type Flush Mount
a) drain tube? No
b) concrete pad dimensions; 2' x 2'
depth of surface concrete 1.5'

4- Dia./type surface casing 8"

5- Dia./type of well casing
2" Sch 80 PVC

6- Type/slot/size of screen
0.01" PVC

7- Type screen filter 20/40 Colorado Silica Sand
quantity used

8- Type of seal 3/8" coated bentonite pellets
quantity used

9- Grout
a) Grout mix used High solids 20% bentonite grout slurry
b) Method of placement Tremie pipe
c) Vol.of surface casing grout
d) Vol. of well casing grout

Development method

Development time

Estimated purge volume

Comments

No driller daily report found for 12/14/17
needs updated sand, bintonite & grout quantities

Illustration not to scale.

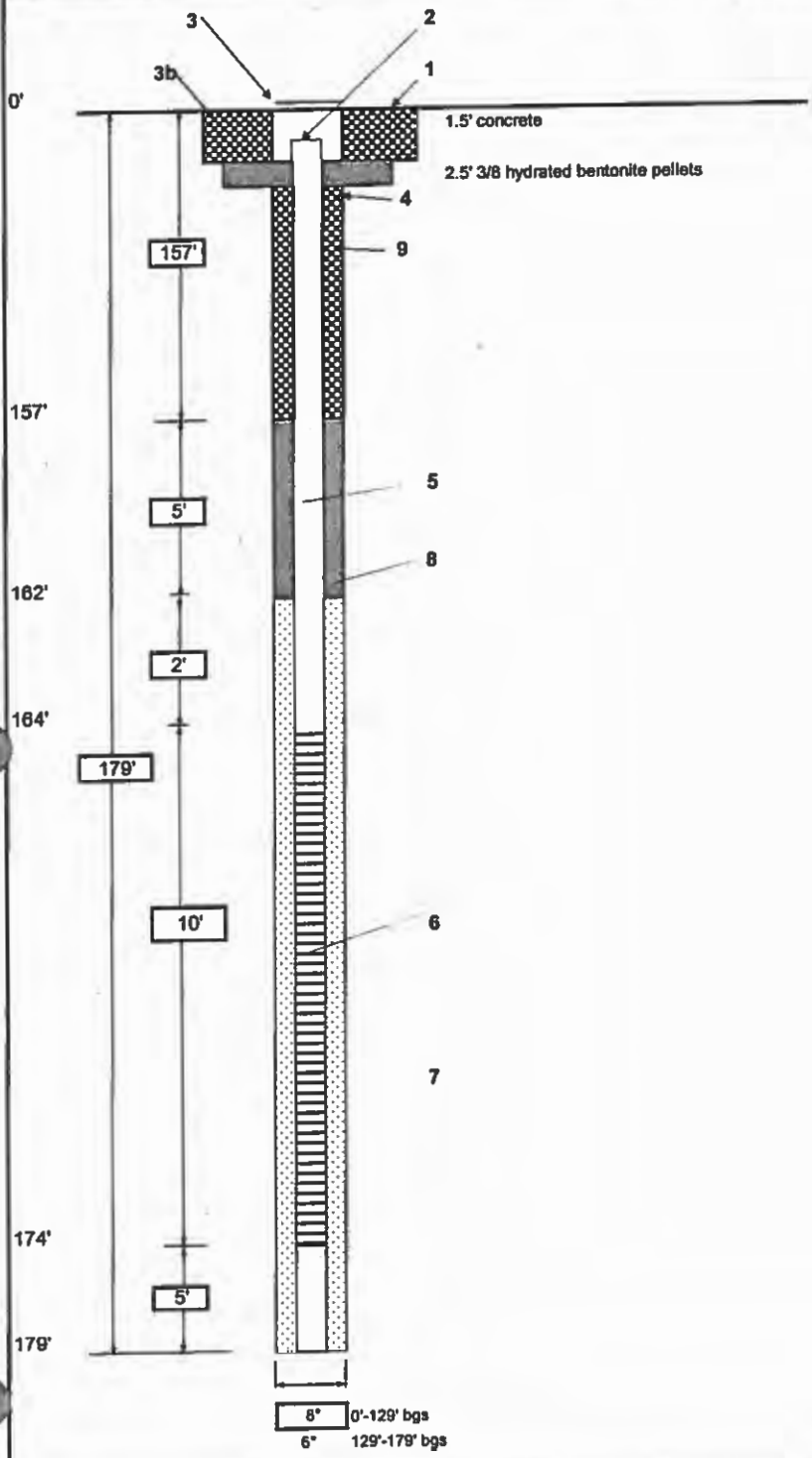
CH2MHILL

PROJECT NUMBER	WELL NUMBER	
695610.04.FI.WI	WI-CV-MW15M	SHEET 1 OF 1

GROUND WATER MONITORING WELL COMPLETION DIAGRAM

PROJECT : NASWI OLF Monitoring Well Installation
ELEVATION: TBD
DRILLING METHOD AND EQUIPMENT USED: Rotosonic (Terrasonic 150 CC)
WATER LEVELS :

LOCATION : Coupeville, WA
DRILLING CONTRACTOR : Yellow Jacket
START : 12/16/17 END : 12/17/17
LOGGER : D. Butler, E. Cutler



1- Ground elevation at well: TBD

2- Top of casing elevation: TBD

3- Wellhead protection cover type: Flush Mount
   a) drain tube? No
   b) concrete pad dimensions; 2' x 2'
   depth of surface concrete 1.5'

4- Dia./type surface casing: 8"

5- Dia./type of well casing: 2" Sch 80 PVC

6- Type/slot/size of screen: 0.01" PVC

7- Type screen filter: 20/40 Colorado silica sand
   quantity used: seven 50-lb bags

8- Type of seal: 3/8 coated bentonite pellets
   quantity used: one and 1/2 5-gal buckets

9- Grout
   a) Grout mix used: High solids 20% bentonite grout slurry
   b) Method of placement: Tremie pipe
   c) Vol.of surface casing grout
   d) Vol. of well casing grout: ten 50-lb bags

Development method

Development time

Estimated purge volume

Comments

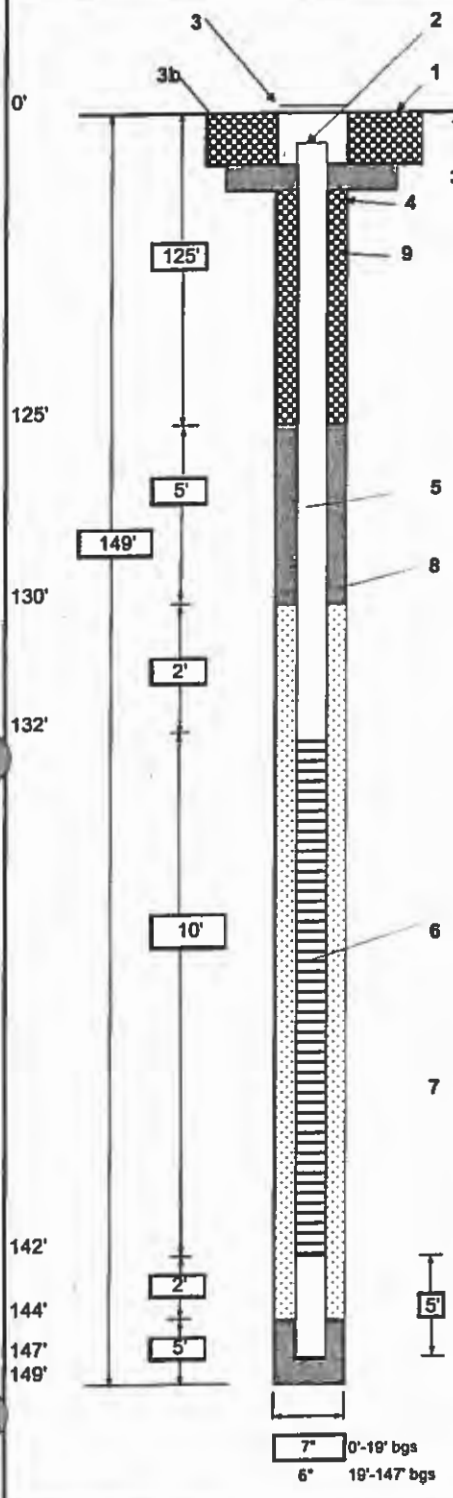
Illustration not to scale.

CH2MHILL

PROJECT NUMBER	WELL NUMBER	
695610.04.FI.WI	WI-CV-MW15S	SHEET 1 OF 1

GROUND WATER MONITORING WELL COMPLETION DIAGRAM

PROJECT : NASWI OLF Monitoring Well Installation
LOCATION : Coupeville, WA
ELEVATION: TBD
DRILLING CONTRACTOR : Yellow Jacket
DRILLING METHOD AND EQUIPMENT USED: Roto Sonic (Terrasonic 150CC)
START : 12/18/17 END : 12/19/17
LOGGER : M. Endo, D. Butler, E. Cutler, G. Gardner
WATER LEVELS :



1- Ground elevation at well: TBD

2- Top of casing elevation: TBD

3- Wellhead protection cover type: Flush Mount
- a) drain tube? No
- b) concrete pad dimensions; depth of surface concrete: 2' x 2'; 1.5'

4- Dia./type surface casing: 8"

5- Dia./type of well casing: 2" Sch 80 PVC

6- Type/slot/size of screen: 0.01" PVC

7- Type screen filter: 20/40 Colorado silica sand
quantity used: seven 50-lb bags

8- Type of seal: 3/8" coated bentonite pellets
quantity used: two 5-gal. buckets

9- Grout
- a) Grout mix used: High solids 20% bentonite grout slurry
- b) Method of placement: Tremie pipe
- c) Vol.of surface casing grout:
- d) Vol. of well casing grout: seven 50-lb bags

Development method:

Development time:

Estimated purge volume:

Comments:

Illustration not to scale.

Appendix C
Well Development Logs

ch2m

WELL DEVELOPMENT DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Well development
Date: 12/21/2017
Weather: Cloudy, Low 30's to upper 40's F, N, SE winds @ 3-10 mph

Project Number: 695610.04.FI.WI
Well ID: WI-CV-MW15M
Sample ID: NA
~~Sampling~~ Development Team: C. Gardner, M. Endo

	Before	After		
Total Depth:	* 179.1	178.90	FT.(BTOC)	* Casing not cut yet. Hard bottom
Depth to water:	* (-) 124.45	124.5'	FT.(BTOC)	
Water Column:	54.65	54.4	FT.	
	(x) 0.163	0.163	GAL/FT.	
Well Volume:	8.908	8.8672	GAL.	
Total Purge Vol.:	NA	~~50~~ 104.31 pump	GAL.	

Measuring Device: Solinst WLI #101, 201
Date and Time: 12/21/17 @ 2245 → 12/22/17 @ 0900

Purge Device: Manual lift ~~pump~~, 449 brass check valve w/ Teflon seal.

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DTW ft btoc	Color / Odor / Comments
Stabilizaton Criteria		constant	± 3%	± 10%	± 0.1	± 10 mV	<10		
0820	7.4	NA						124.45	Turbid, brown,
0839	39.9115	NA						123.90'	← WL rising.
0900	>50.0	NA						124.5'	Slightly cloudy very light brown
	(104.31)								

Observations/Notes: Purge Start Time: NA Purge Rate: NA

@0835 BZ = All clear, HS = all clear (12/21/2017)
~~0850~~ 0846 Begin surge with surge block, 10' sweep of entire screen. Small T-4 (#18) development rig
0916 Stop surge. TD = 179' semi-soft bottom
0926 Start bailing w/ 5' SS (~0.25 gal) bailer. 1st bailer was very turbid w/ mod settling solids.
0950 Surge 10' screen for 5 min. TD = 179.1' btoc hard bottom

Signature(s): Mark Endo / CH2M

1000 Resume bailing
1010 Finish bailing ~~5~~ 7.4 gal purged with bailers.

ON 12/22/2017

Begin (0820) over pumping w/ manual lift pump (449 brass ✓ valve - Dean Bennet). Initial DTW = 124.45' btoc
0900 Stop pumping. DTW = 124.5' btoc (final elevation). ~ 57 gal total. > 10 well volumes purged. For 2nd pump off

ch2m

WELL DEVELOPMENT DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Well development
Date: 12/21/2017
Weather: Mostly Sunny, Mid 30's to Low 40's F, E, NE winds 5-10 mph

Project Number: 695610.04.FI.WI
Well ID: WI-CV-MW15S
Sample ID: NA
Sampling Team: M. Endo, G. Gardner

	Before	After		
Total Depth:	*149.4	@148.17'	FT.(BTOC)	*Casing not cut yet Hard bottom & Final Riser Elevation
Depth to water:	*(-)114.79	@124.9	FT.(BTOC)	
Water Column:	29.61	23.27	FT.	
	(x) 0.163	0.163	GAL/FT.	
Well Volume:	4.826	3.793	GAL.	
Total Purge Vol.:	NA	48.65	GAL.	

Measuring Device: NA
Date and Time: 12/21/2017 1045 → 12/22/17 1015

Purge Device: Manual lift pump, 4" SS check valve & leather seal

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DTW (FT BTOC)	Color / Odor / Comments
Stabilizaton Criteria		constant	± 3%	± 10%	± 0.1	± 10 mV	<10		
0948	3.17	NA						123.72	Cloudy, turbid, brownish gray, no odor
1006	45.48							122.78'	Cloudy, very light brown
1015	—	NA						124.9'	—

Observations/Notes: Purge Start Time: NA Purge Rate: NA

0835 B2 + HS = all clear (12/21/2017)
1047 Begin surge with surge block, 10' sweeps of entire screen. smear ET-4 (#18) development
1110 Stop surging 149.4' btoc. Hard bottom.
1115 Start bailing

Signature(s): Mark End Mark Endo/CH2M

1120 finish bailing. 3.17 gal. bailed.
ON 12/22/17
0948 BEGIN OVER PUMPING W/ MANUAL LIFT PUMP.
INITIAL DTW = 123.72' BTOC (FINAL ELEVATION CUT)
1006 PUMPED 42.3176 GAL. STOP DEVELOPMENT, > 10 WELL VOLUMES PURGED. DTW = 122.78' BTOC & RISING.
1015 FINAL DTW = 124.9' BTOC, TD = 148.17' BTOC (HARD BOTTOM)

ch2m

WELL DEVELOPMENT DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Well development
Date: 12/20/2017
Weather: SUNNY, MID 40'S°F, N WINDS @ 13-16 mph

Project Number: 695610.04.FI.WI
Well ID: WI-CV-MW6S
Sample ID: NA
Sampling Team: M. ENDO, G. GARDNER
AARON ADAMS / YELLOW JACKET

	Before	After	
Total Depth:	* α 145.05	Φ 144.9'	FT.(BTOC)
Depth to water:	(-) 124.37	~~124.50~~ 124.48'	FT.(BTOC)
Water Column:	20.68	20.42	FT.
	(x) 0.163	0.163	GAL/FT.
Well Volume:	3.3708	3.3285	GAL.
Total Purge Vol.:	NA	44.4277	GAL.

* CASING NOT FINAL ELEVATION, NOT CUT. α HARD BOTTOM
Φ FINAL RISER ELEVATION HARD BOTTOM

Measuring Device: NA
Date and Time: 12/20/17 12:00 → 12/22/17 11:15

Purge Device: MANUAL LIFT PUMP, 449 BRASS CHECK VALVE & LEATHER SEAL

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DTW (FTbTOC)	Color / Odor / Comments
Stabilizaton Criteria		constant	± 3%	± 10%	± 0.1	± 10 mV	<10		
1050	2.12	NA						124.4'	NA
1115	~~42.3077~~ (20) 44.4277	NA						124.48'	CLOUDY, SLIGHT BROWN COLOR, NO ODOR

Observations/Notes: Purge Start Time: NA Purge Rate: NA

1155 MEASURE TD & DTW.
1200 BEGIN SURGE WITH SS ROD & SURGE BLOCK. 10' SURGE ON 10' SCREEN INTERVAL (130'-140' bgs).
1215 PAUSE SURGE TO BAIL W/ 5' SS BAILER. BAILED TWO FULL BAILERS, MINIMAL SOLIDS RETURN TO SUMP. @ ~~1025~~ 1225
1240 STOP SURGE. TD = 145.05', HARD BOTTOM.
1245 BEGIN BAILING. 5' SS BAILER (~0.25 GAL). 1258 STOP BAILING, LITTLE TO NO SEDIMENT SETTLING (~~40~~ ~2.1153 GAL PU

Signature(s): MARK ENDO/CH2M

1258 SET-UP TO BEGIN PUMPING, UTILIZE MANUAL LIFT PUMP. = BRASS CHECK-VALVE TOO LARGE.
ON 12/22/17
1050 DTW INITIAL = 124.4' bTOC (FINAL RISER ELEVATION), BEGIN OVER PUMP W/ MANUAL LIFT PUMP
1115 STOP PURGING. PURGED 42.3077 GALLONS. PURGED >10 WELL VOLUMES.
FINAL DTW: 124.48' bTOC

ch2m

WELL DEVELOPMENT DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Well development
Date: 12/20/17
Weather: SUNNY, UPPER 30'S TO LOW 40'S °F, N WINDS @ 13-18 mph

Project Number: 695610.04.FI.WI
Well ID: WI-CV-MW16M
Sample ID: NA
Sampling Team: M. ENDO, G. GARDNER, D. ADAMS / YELLOW JACKET

	Before	After	
Total Depth:	*ϕ 179.2' btoc	ϕ 179.42'	FT.(BTOC)
Depth to water:	^ (-) 125.06'	ϕ 124.63'	FT.(BTOC)
Water Column:	54.14	55.29	FT.
	(x) 0.163	0.163	GAL/FT.
Well Volume:	8.8248	9.0122	GAL.
Total Purge Vol.:		100.48	GAL.

*CASING NOT CUT YET @ HARD BOTTOM
ϕ AT FINAL RISER ELEVATION HARD BOTTOM

Measuring Device: NA
Date and Time: 12/20/2017 09:35 → 12/22/17 12:25

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

Purge Device: MANUAL LIFT BAILER, 449 BRASS VALVE (BALL VALVE) & LEATHER SEAL.

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DTW (FTBTOC)	Color / Odor / Comments
Stabilizaton Criteria		constant	± 3%	± 10%	± 0.1	± 10 mV	<10		
1140	4.23	NA						124.67	CLOUDY, TURBID, BROWN (COLOR: AK CAMO)
1200	53.9415	NA						NA	MOSTLY CLOUDY, SLIGHT TURBID, LIGHT BROWN, NO
1225	100.48	NA						124.63'	NA

Observations/Notes: Purge Start Time: NA Purge Rate: NA

@ 09:35 BZ (4-GAS MONITOR) = CO = 6 ppm, ALL ELSE CLEAR, HS = ALL CLEAR.
09:35 ← NOT SUSTAINED.
~~09:36~~ BEGIN SURGE WITH SURGE BLOCK, 10' SWEEP OF ENTIRE SCREEN. SMEAL T-4 (#118) DEVELOPMENT RIG
10:07 STOP SURGE. TD = 179.2' BTOC, HARD BOTTOM. BEGIN BAILING @ 10:18 - SS, 5' BAILER (~0.25 GAL)
10:35 STOP BAILING, ~~(0.2364 GAL PURGED)~~ (4.23 GAL PURGED)
10:55 - SUBMERSIBLE MONSOON PUMP SET @ 2' ABOVE SCREEN

Signature(s): Mark Endo MARK ENDO/CH2M

1102 Begin Pumping
1118 Monsoon pump unable to remove water, Stop pumping
1238 2nd MONSOON PUMP NOT ABLE TO LIFT H_2O TO SURFACE. ON 12/22/2017

1140 INITIAL DTW = 124.67' BTOC (FINAL RISER ELEVATION)
1145 BEGIN OVER PUMP W/ MANUAL LIFT PUMP
1225 STOP PUMPING. PURGED = 96.2 GAL. FINAL DTW: 124.63'. >10 WELL VOLUMES PURGED

Appendix D
Well Survey Report

Set Monitoring Wells
Whidbey Island Naval Air Station - Outlying Landing Field
Coupeville, WA

Survey Date: February 2018

Point Id	Northing	Easting	Top of Metal Case Elev	Top of PVC Casing Elev	
KEYSTONE WELL	440098.088	1200294.122	197.371	194.744	*Elevations are to top of flange and top of box
MW15M	440404.383	1200504.865	193.660	193.351	
MW15S	440393.080	1200505.471	193.184	192.921	
MW16M	440104.821	1200484.089	192.575	192.274	
MW16S	440094.699	1200484.483	192.538	192.162	

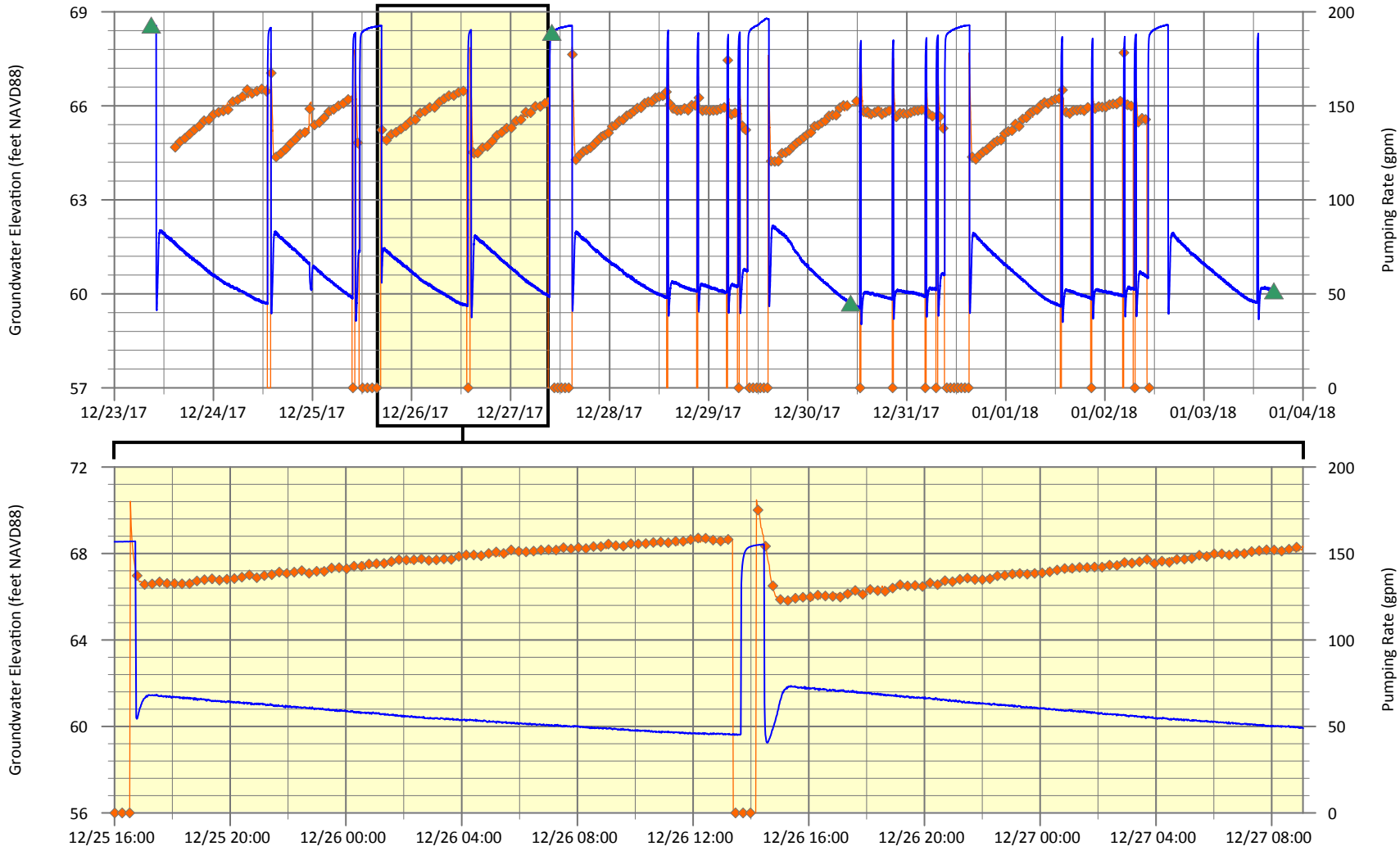
Notes:

1. HORIZONTAL DATUM: NAD83/11, WASHINGTON STATE PLANE COORDINATE SYSTEM, NORTH ZONE NAD83/11
WSDOT MONUMENT USED FOR THIS PROJECT
COUPEVILLE 3" BRASS DISK W/PUNCH IN CONC "USC&GS COUPEVILLE 1954"
J 328 3" BRASS DISK W/PUNCH IN CONC 0.40 ABOVE SURFACE "USC&GS J328 1952"

2. VERTICAL DATUM: NAVD88
BENCHMARK USED COUPEVILLE ELEV 199.347

3. EQUIPMENT USED: LEICA MS50 TOTAL STATION, LEICA DNA10 DIGITAL LEVEL

Appendix E
Aquifer Test Hydrographs



LEGEND

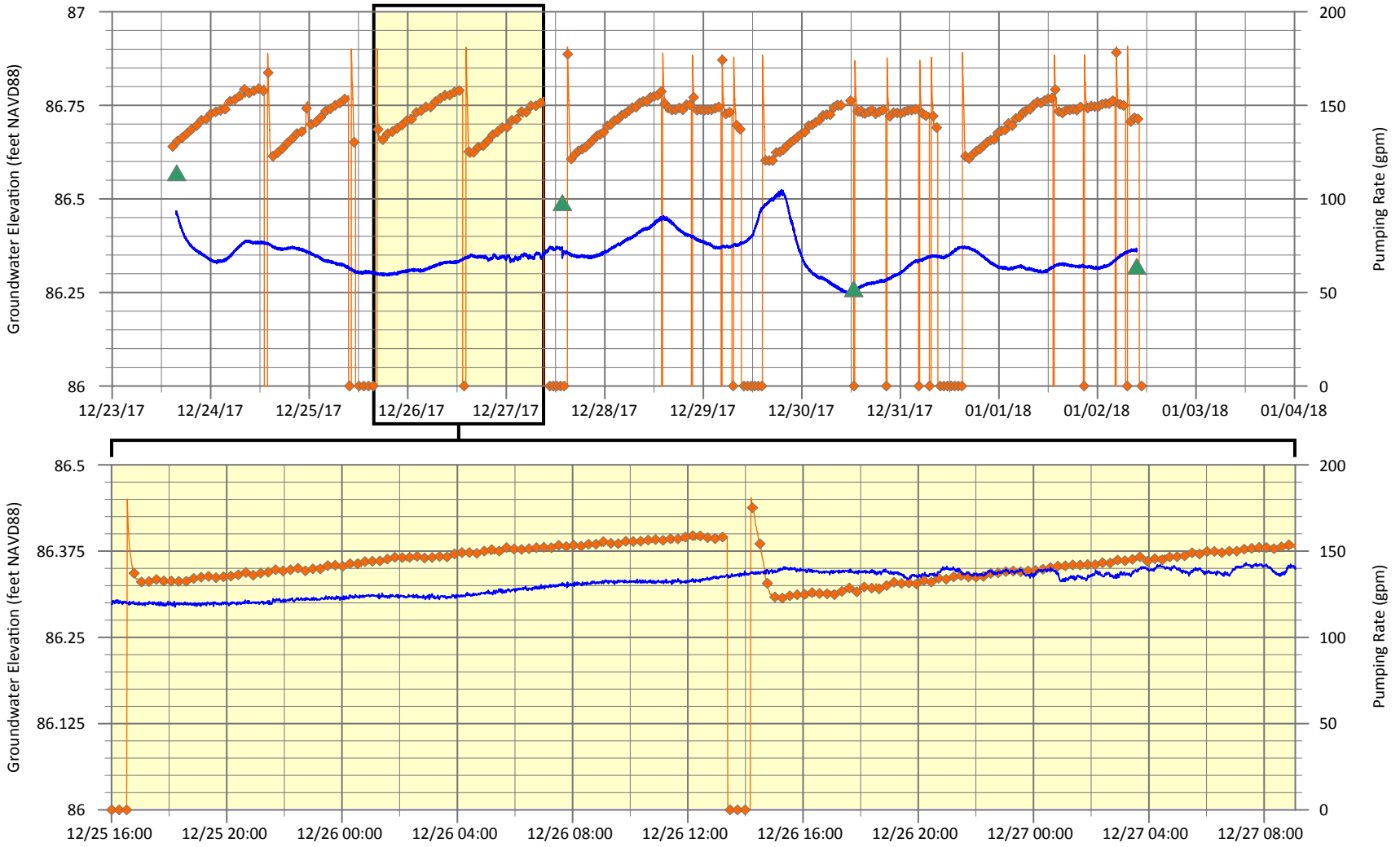
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-1.
Hydrograph of Groundwater Elevation and Pumping versus Time – Keystone Hill Well
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

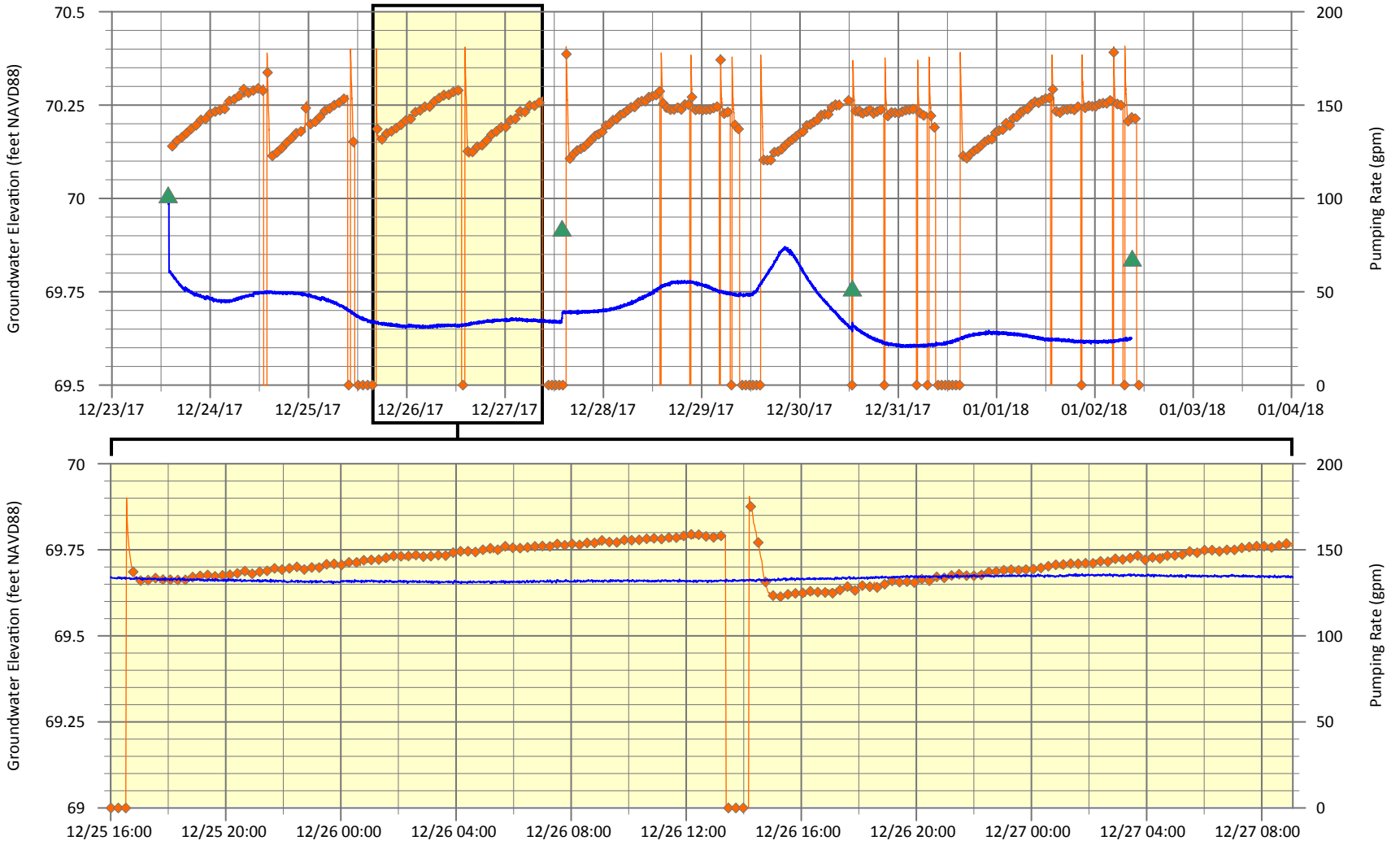
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-2.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW04S
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

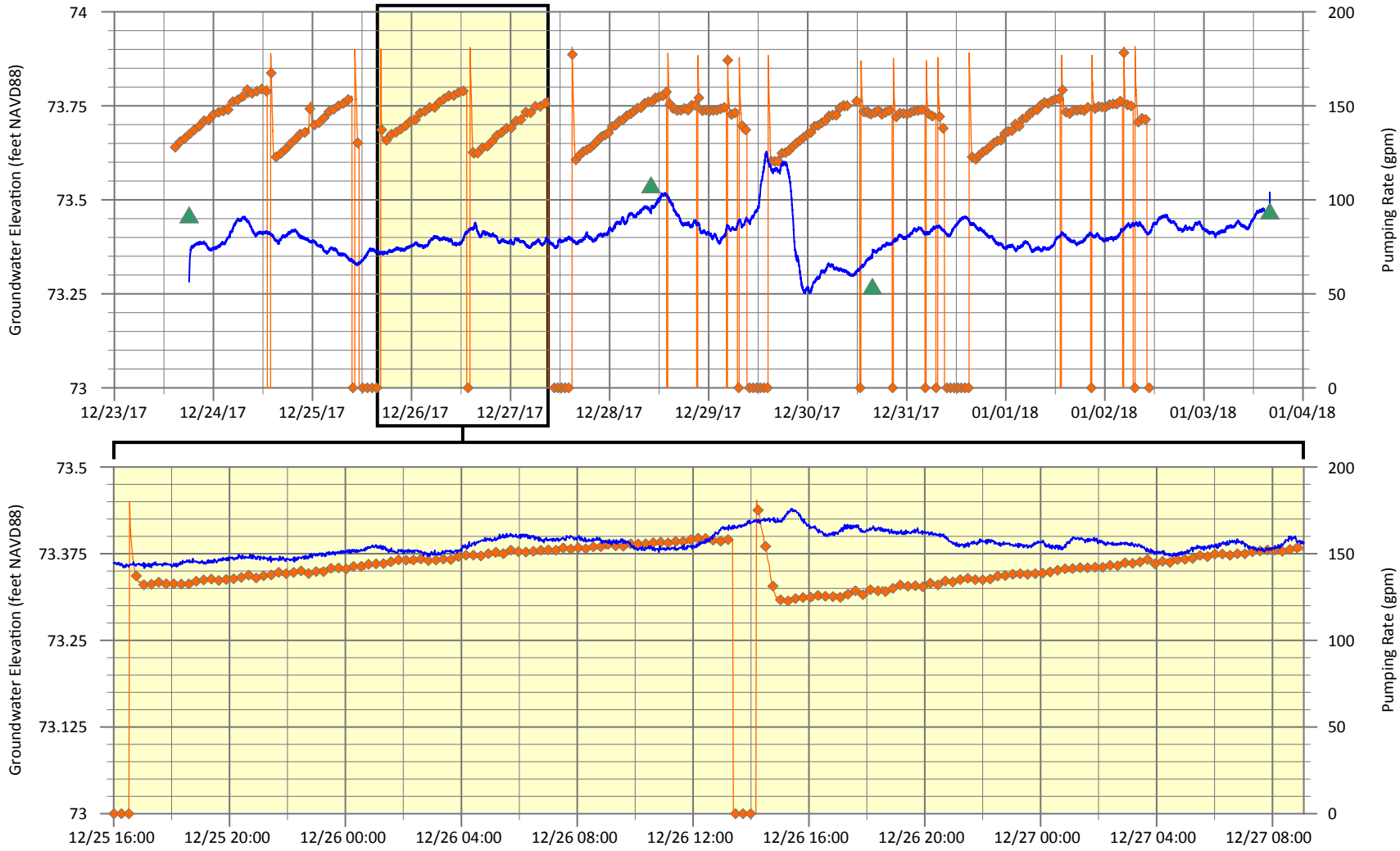
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-3.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW04M
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

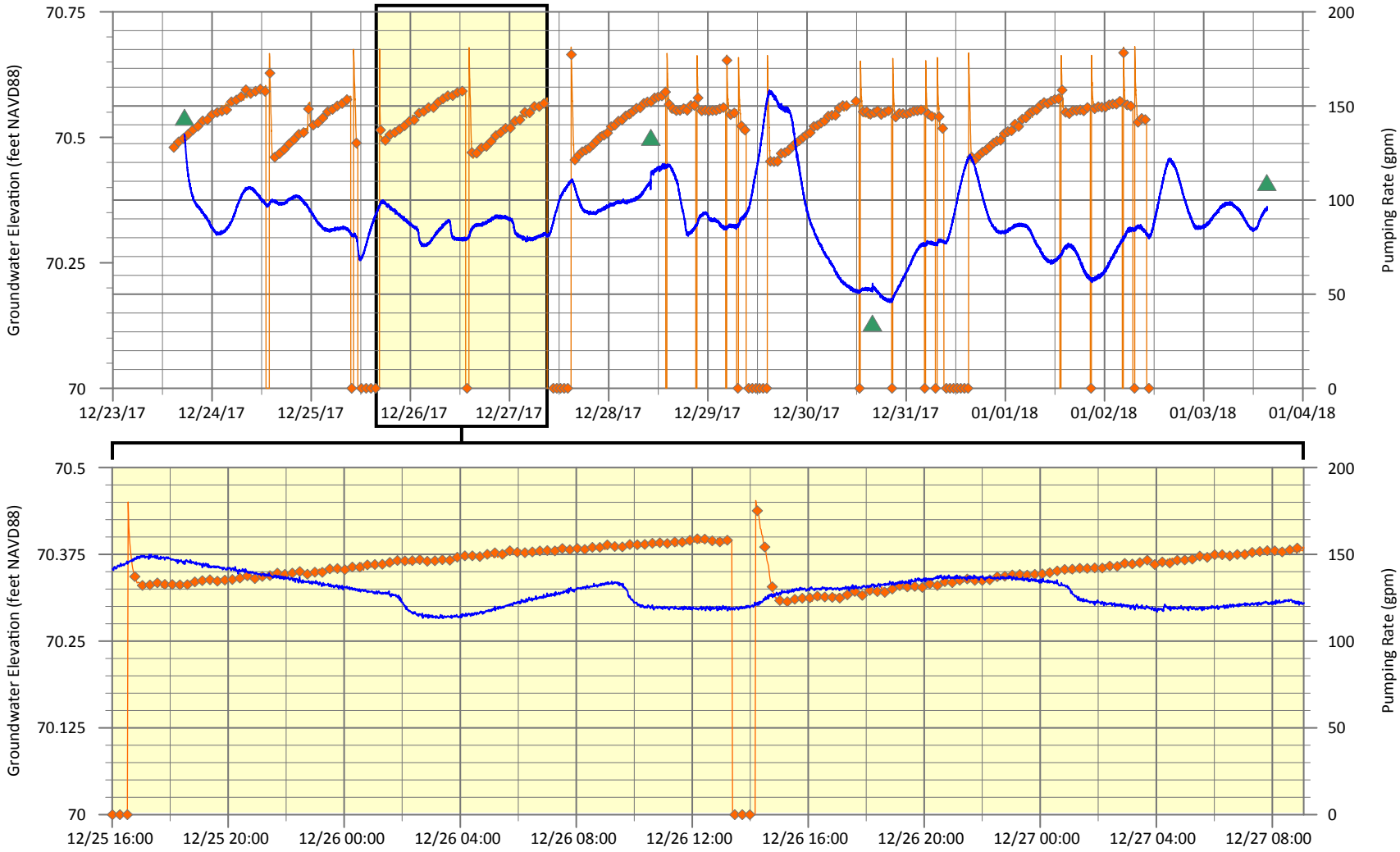
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-4.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW07S
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

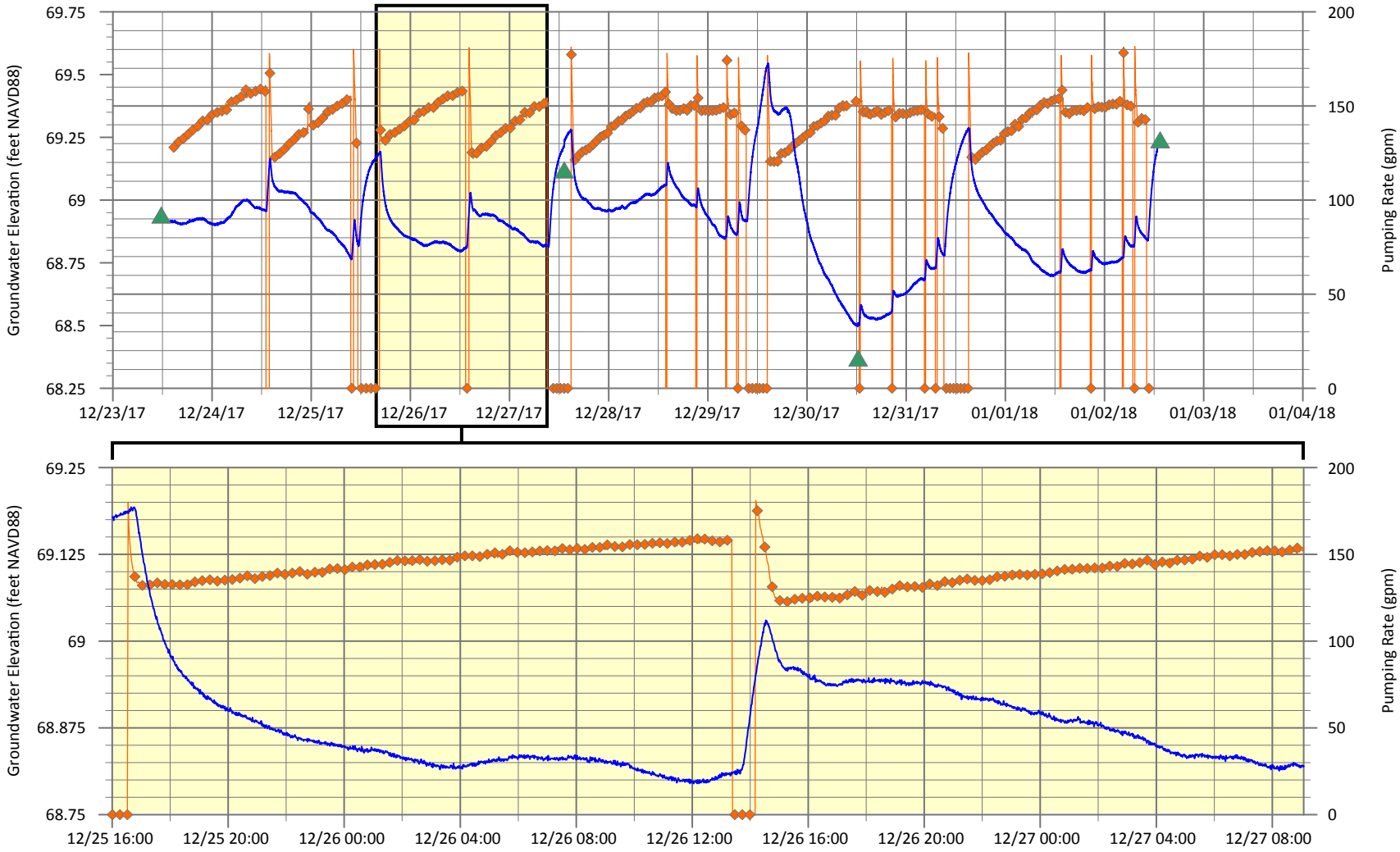
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-5.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW07M
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

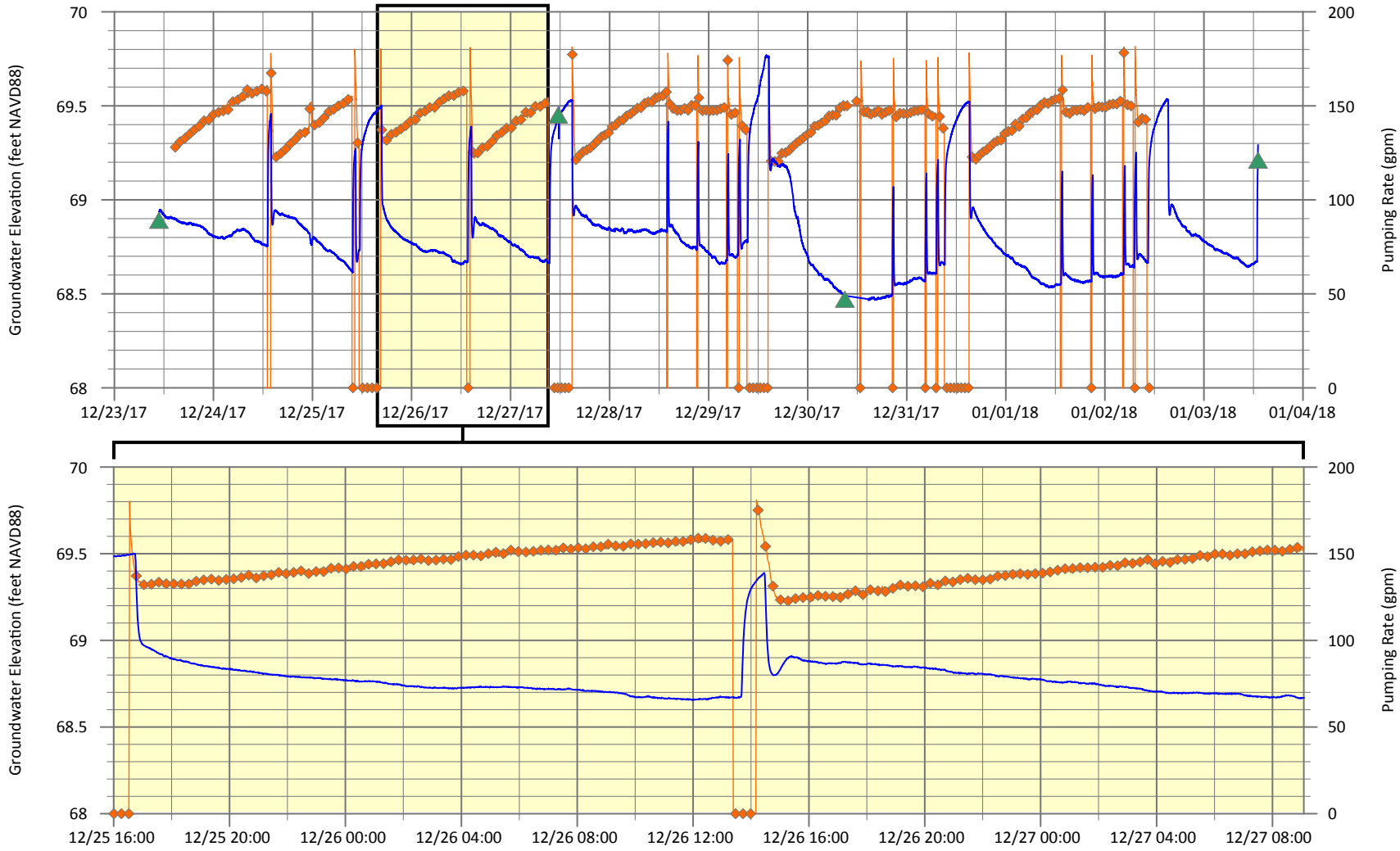
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-6.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW14M
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

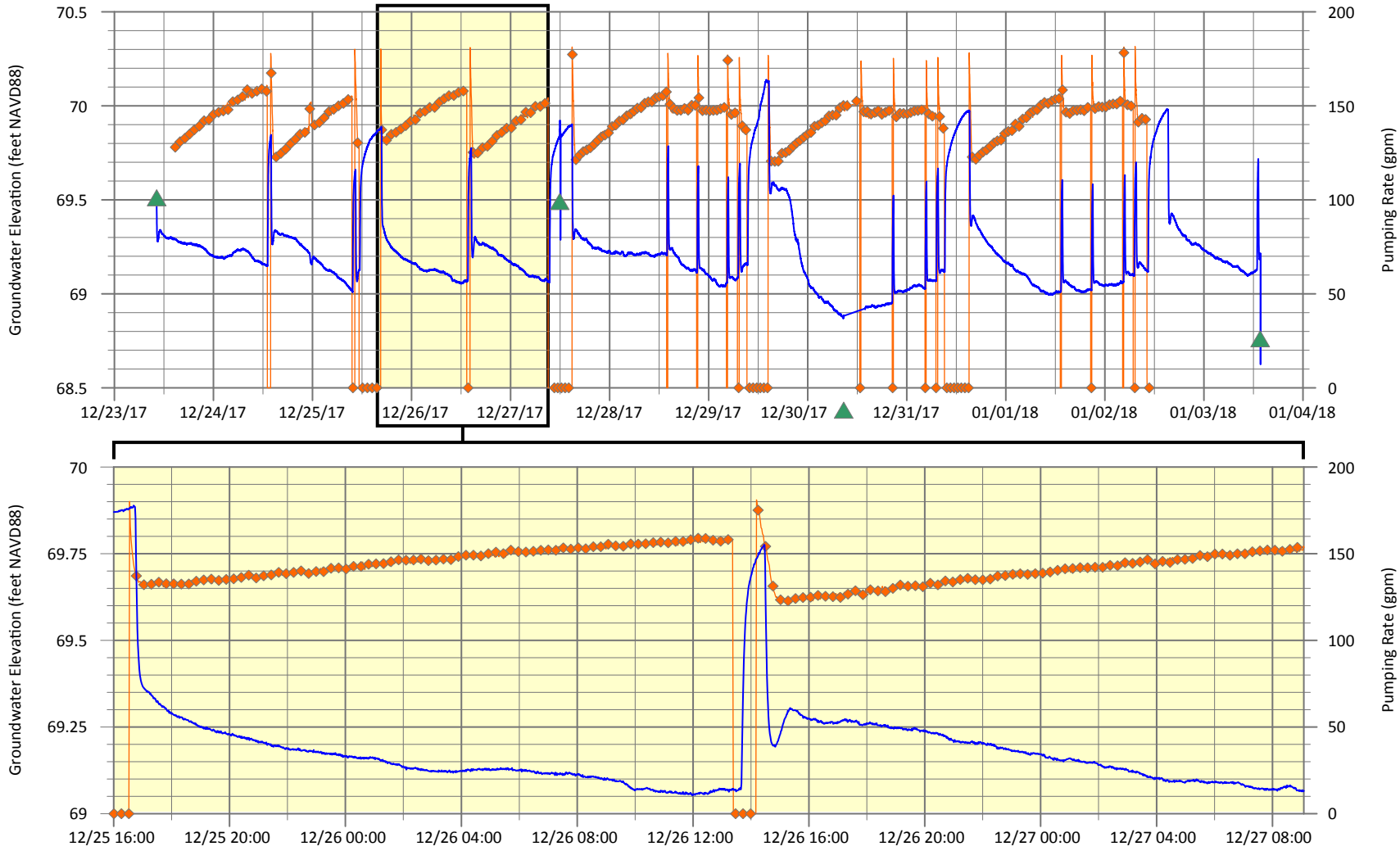
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-7.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW15S
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

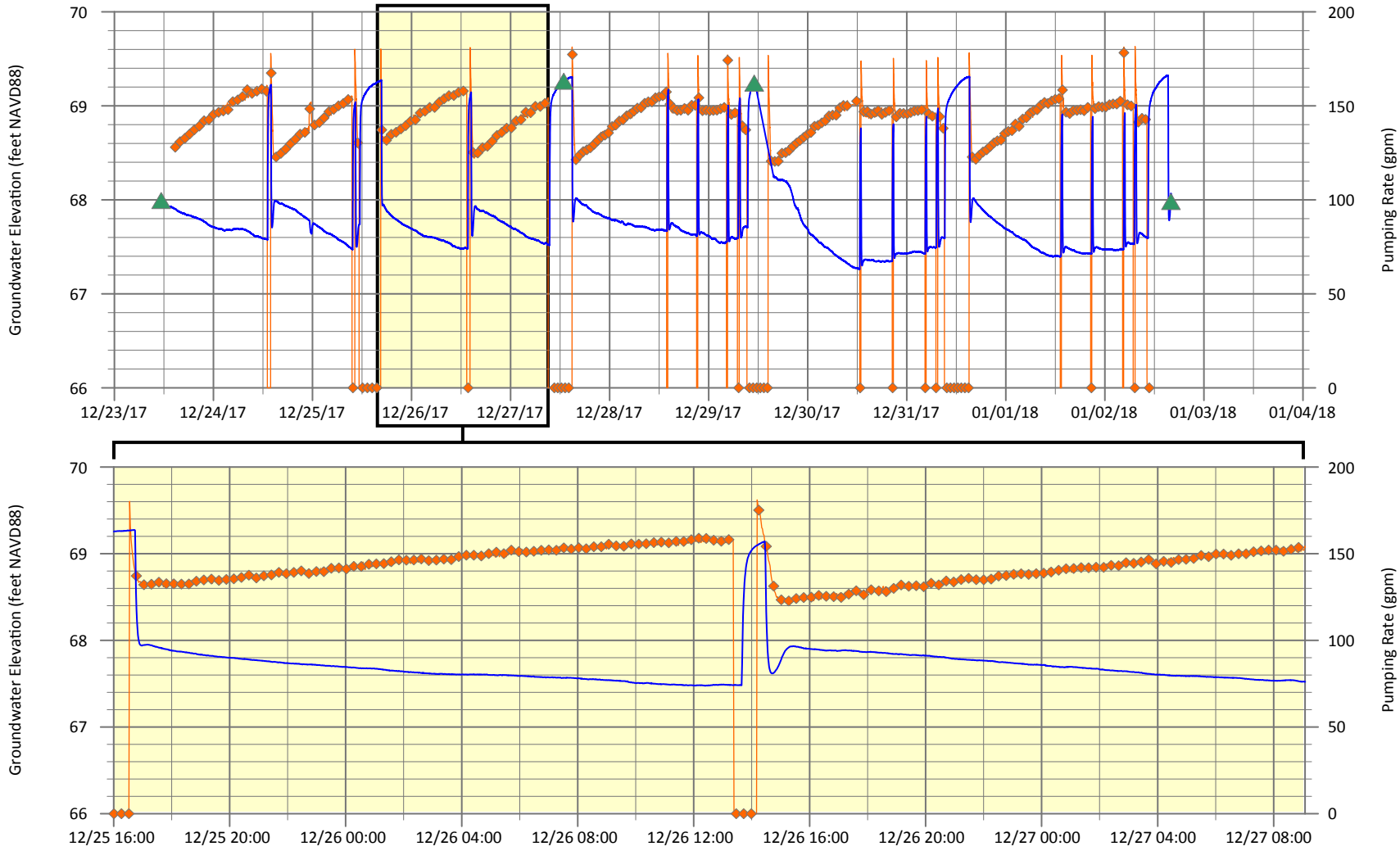
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-8.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW15M
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

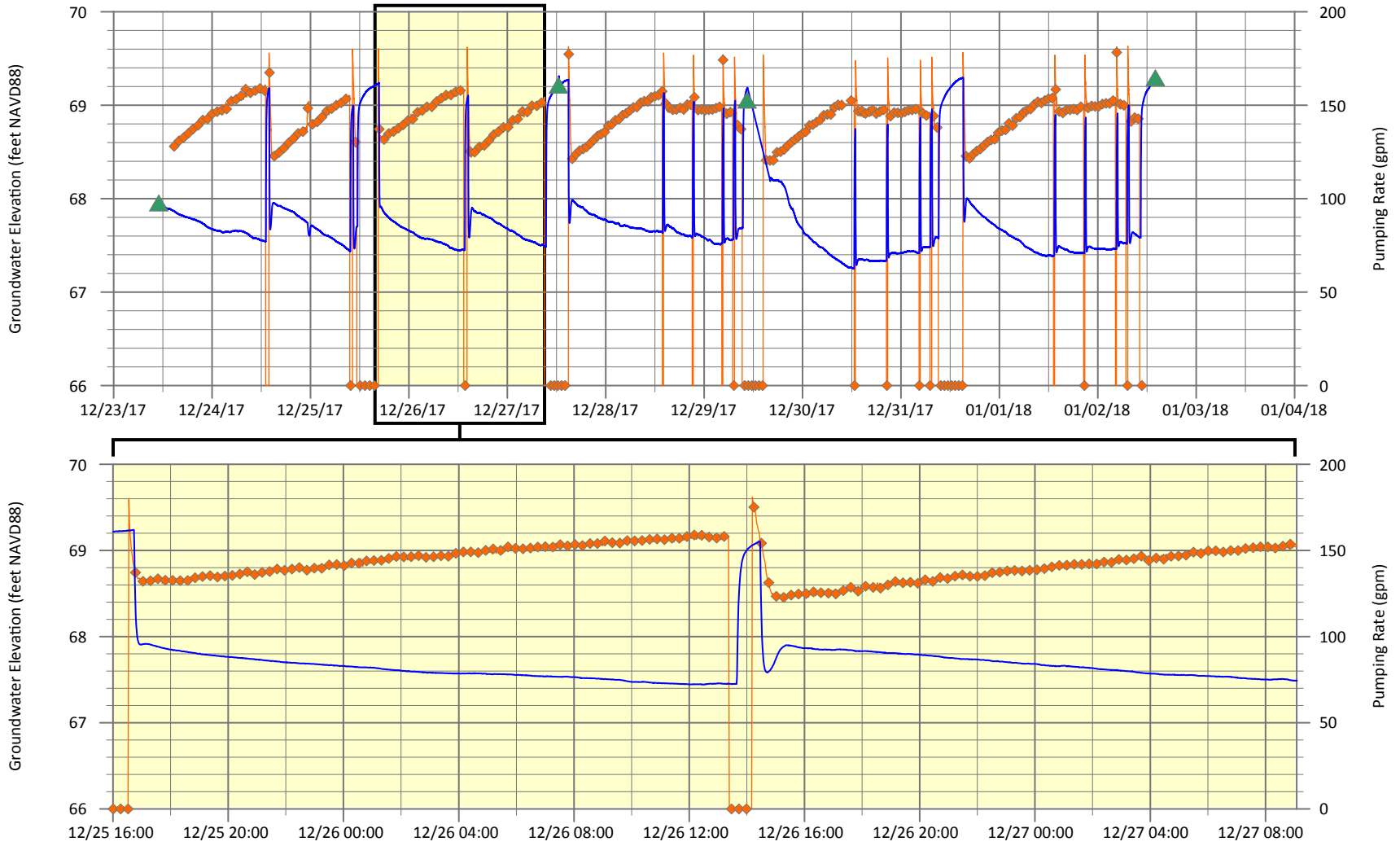
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-9.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW16S
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

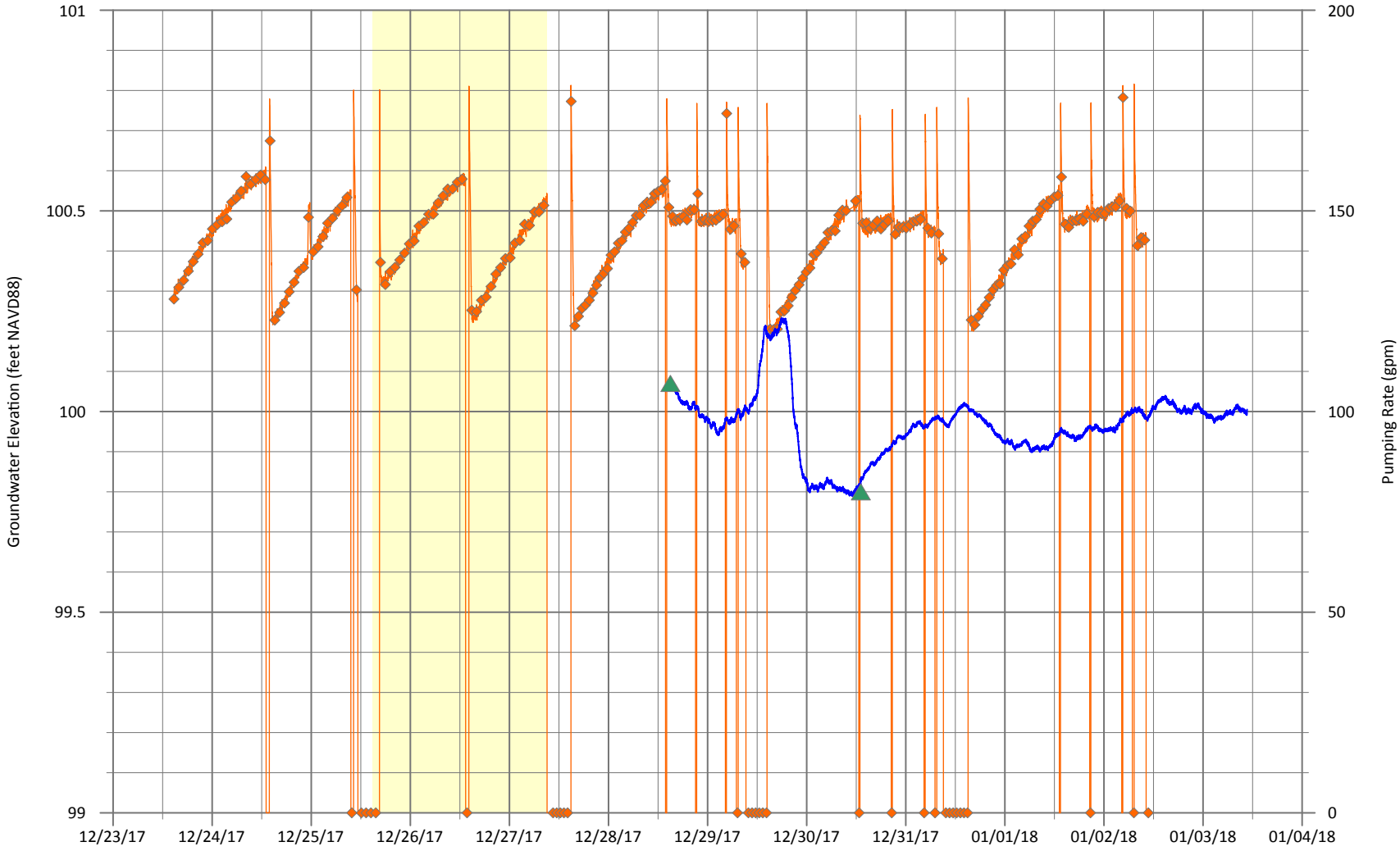
- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Figure E-10.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW16M
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

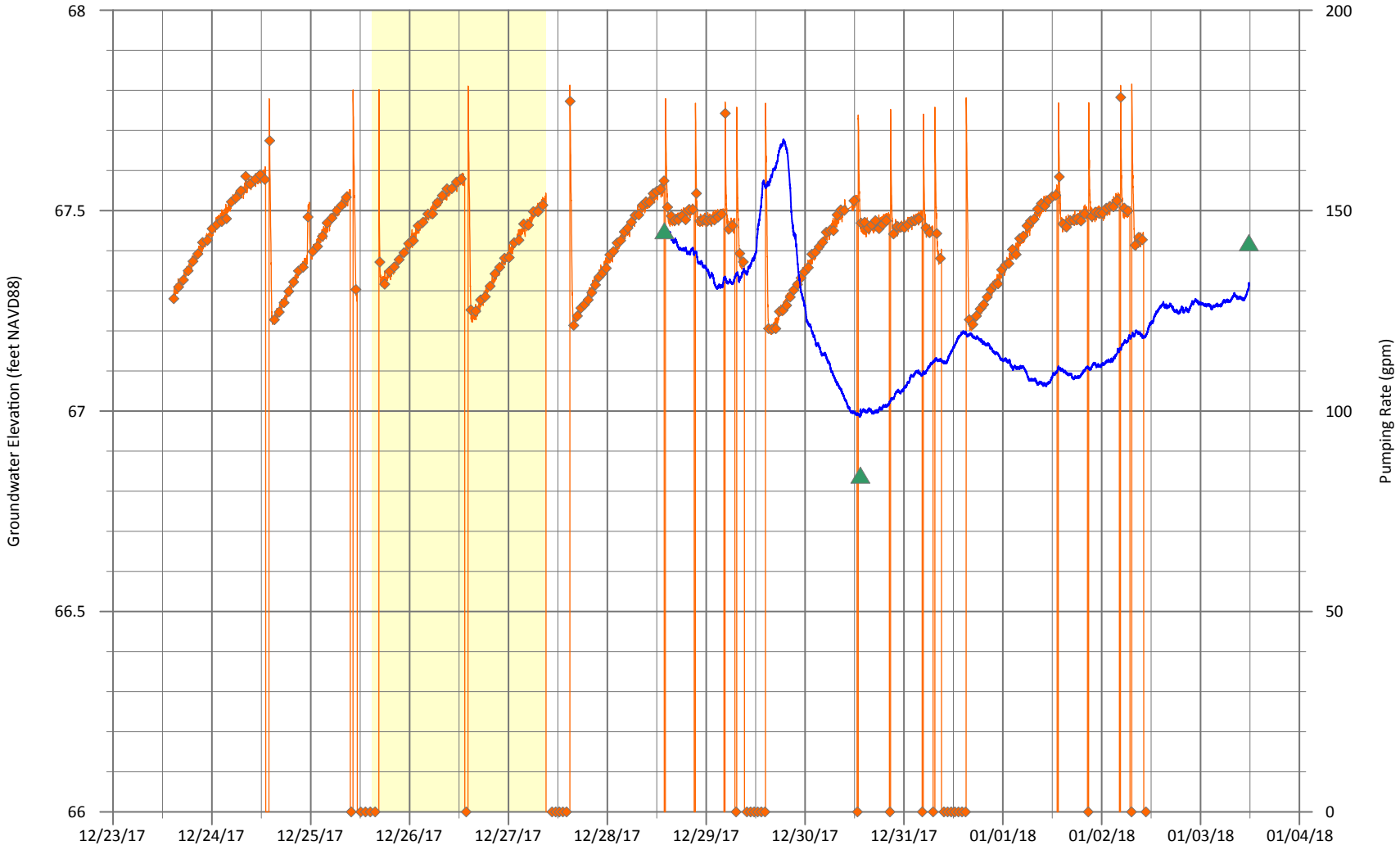
Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Data not used for groundwater flow model calibration.

Figure E-11.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW02S
Naval Air Station Whidbey Island
Coupeville, Washington



LEGEND

- Keystone Hill Well Pumping Rate
- Groundwater Elevation
- Manual WL
- 41-hour Calibration Period

Notes:

gpm = gallons per minute

NAVD88 = North American Vertical Datum of 1988

Data not used for groundwater flow model calibration.

Figure E-12.
Hydrograph of Groundwater Elevation and Pumping versus Time – MW05M
Naval Air Station Whidbey Island
Coupeville, Washington

Appendix F
Selected Photographs

Ultrasonic flow meter installed on vertical pipe segment at Keystone Hill well pumphouse—12/21/2017

WI-CV-MW15M completed well pad—12/21/2017

WI-CV-MW15S completed well pad—12/21/2017

WI-CV-MW16M completed well pad—12/21/2017

WI-CV-MW16S completed well pad—12/21/2017

Transducer installation at WI-CV-MW14M—12/21/2017

Transducer installed at Keystone Hill well—12/21/2017

Appendix G
Groundwater Sampling Data Sheets

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 01/05/2018
Weather: CLOUDY, RAIN, UPPER 30's °F, S WINDS @ 10-18mph

Project Number: 695610.04.FI.FS
Well ID: WI-CV-MW05M
Sample ID: WI-CV-GW05M-0118
Sampling Team: G. GARDNER, M. ENDE, M. LOPEZ

Page: 1 of

Total Depth: 178.91 FT.(BTOC)
Depth to water: ~~(-) 122.28~~ FT.(BTOC) 123.28
Water Column: 55.63 FT.
(x) 0.163 GAL/FT.
Well Volume: 9.07 GAL.
Total Purge Vol.: 2.19 GAL.

Measuring Device: SOLINST WLI #101, MULTIRAE HORIBA U-52

Purge Device: GEOTECH BFC BLADDER PUMP

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
0940	initial (0.5)	8.22	0.355	10.04	7.70	245	11.1	123.31	Clear, no odor
0944	0.44	8.35	0.358	8.99	7.71	246	9.5	123.32	"
0948	0.58	8.46	0.358	8.41	7.77	243	8.7	123.32	"
0952	0.72	8.60	0.356	8.96	7.86	238	8.8	123.32	"
0956	0.86	8.62	0.356	8.17	7.85	239	8.3	123.30	"
1000	1.0	8.65	0.355	7.81	7.85	239	8.2	123.30	"
1004	1.14	8.66	0.355	7.63	7.89	236	7.7	123.30	"
1008	1.28	8.73	0.354	8.77	7.82	238	7.2	123.30	"
1012	1.42	8.73	0.354	7.85	7.92	233	7.7	123.30	"
1016	1.56	8.77	0.354	8.72	7.92	232	6.9	123.30	"
1020	1.70	8.79	0.354	7.83	7.88	234	5.6	123.30	"

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes: DROP PUMP @ 0850 TO SUCTION DEPTH = 165' BTOC (MID SCREEN). TOP OF PUMP @ 163.4' BTOC. TARGET PRESSURE = (163.4 ÷ 2) + 10 = 92 psi.

Air Monitoring:
VOC (ppm)= 0.0
H2S (ppm) = 0.0
LEL (%)= 0
CO (ppm)= 0.0
O2 (%)= 20.9

Pump Start Time: 0914
Initial Fill Time(FT; sec): 16
Initial Discharge Time(DT; sec): 43

Final Fill Time:
Final Discharge Time:

Pump Depth: 165' BTOC

Purge Rate: 130 mL/min @ 0944

Sample /Time:

MS/MSD | Duplicate ID:

Signature(s):

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 1/5/2018
Weather:

Project Number: 695610.04.FI.FS
Page: 2 of
Well ID: WI-CV-MW05M
Sample ID: WI-CV-GW05M-D118
Sampling Team:

Total Depth: ____ FT.(BTOC)
Depth to water: (-) ____ FT.(BTOC)
Water Column: ____ FT.
(x) ____ GAL/FT.
Well Volume: ____ GAL.
Total Purge Vol.: ____ GAL.

Measuring Device:

Purge Device:

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
1024	1.84	8.80	0.353	8.25	7.89	233	5.5	123.30	Clear, no odor
1028	1.98	8.82	0.354	8.09	7.94	224	5.0	123.30	"
1033	2.12	8.84	0.354	8.2	7.95	228	3.8	123.30	"

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes:

Air Monitoring:
VOC (ppm)=
H2S (ppm)
LEL (%)=
CO (ppm)=
O2 (%)=

Pump Start Time:
Initial Fill Time(FT; sec):
Initial Discharge Time(DT; sec):

Final Fill Time:
Final Discharge Time:

Pump Depth:

Purge Rate:

Sample /Time: 1040

MS/MSD

Duplicate ID:

Signature(s):

ch2m.

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 01/05/2018
Weather: UPPER 40'S, RAIN AT TIMES, WINDS from S

Project Number: 695610.04.FI.FS
Page: 1 of 1
Well ID: WI-CV-MW14M
Sample ID: WI-CV-GWFM-0118
Sampling Team: M ENDO, M LOPEZ

Total Depth: 175.05 FT.(BTOC)
Depth to water: (-) 122.68 FT.(BTOC)
Water Column: 52.37 FT.
(x) 0.163 GAL/FT.
Well Volume: 8.54 GAL.
Total Purge Vol.: 1.15 GAL.

Measuring Device: SOLINST RENTAL #901859
PINE
MULTIPAR

Purge Device: GEOPROBE 2" BLADDER PUMP & CONTROL BOX

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
1117	0.15	9.28	0.334	2.29	7.96	-72	6.35	122.80	CLEAR, ODORLESS
1125	0.25	9.35	0.331	4.57	8.04	-74	6.41	122.88	CLOUDY WHITE
1130	0.35	9.35	0.332	2.33	8.76	37	6.40	122.92	" CLOUDY WHITE
1135	0.45	9.48	0.334	1.15	8.50	-13	6.55	122.93	DARK GRAY
1140	0.55	9.71	0.333	0.53	8.20	-14	6.50	122.97	" "
1145	0.65	9.70	0.333	0.38	8.20	-24	6.59	122.97	" "
1150	0.85	9.82	0.334	0.00	8.15	-63	10.2	122.49	" CLOUDY
1155	0.95	9.92	0.334	0.00	8.17	-88	10.9	123.05	CLEARING
1200	1.00	10.00	0.334	0.00	8.17	-92	11.8	123.15	CLEARING
1205	1.10	10.19	0.334	0.00	8.19	-113	11.2	123.12	CLEARING
1210	1.15	10.17	0.334	0.00	8.18	-123	12.0	123.10	CLEAR

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers
MOD METHOD 537	N/A	125mL POLY	2

Observations/Notes: TOTAL DEPTH: 175.05' BTOC (SOFT BOTTOM), SCREEN
AT 1150 SWITCHED POWER SOURCE FROM BATTERY TO VEHICLE

Air Monitoring:
VOC (ppm)= 0.0
H2S (ppm) 0.0
LEL (%)= 0.0
CO (ppm)= 0.0
O2 (%)= 20.9

Pump Start Time: 10:45
Initial Fill Time(FT; sec): 16 sec
Initial Discharge Time(DT; sec): 43 sec
Final Fill Time: 14 SEC
Final Discharge Time: 55 SEC

Pump Depth: 166' BTOC
Purge Rate: 89ml/18SEC

Sample /Time: 1210

MS/MSD
Duplicate ID:
Signature(s):

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 1/4/2018
Weather:

Project Number: 695610.04.FI.FS Page: 1 of
Well ID: WI-CV-MW~~01S~~-07M
Sample ID: WI-CV-GW07M
Sampling Team: G Gardner, M Endo, E. Cutler

Total Depth: 193.04 FT.(BTOC)
Depth to water: (-) 127.35 FT.(BTOC)
Water Column: 65.69 FT.
(x) 0.163 GAL/FT.
Well Volume: 10.7 GAL.
Total Purge Vol.: 0.53 GAL.

Measuring Device: Solinst W.L.I #101
Horiba U-53

Purge Device: GeoTech PFE-free Bladder

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. ~~(gals)~~ mL	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
~~1048~~	~~N/A~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~129.10~~	~~NA~~
1134	~~0~~ 0	7.02	0.377	1.26	8.29	-63	~~NA~~ 4.27	134~~3.80~~	NA
1145	~~426~~ 426	8.32	0.383	0.20	8.32	-111	4.53	134.28	NA
1151	702	8.24	0.386	0.00	8.35	-121	4.88	134.30	NA
1156	977	8.62	0.382	0.00	8.35	-130	4.98	134.35	Clear
1201	1,242	8.53	0.383	0.00	8.38	-133	5.03	134.38	Clear
1206	1,513	8.57	0.382	0.00	8.39	-137	5.10	131.42	Clear
1210	1,723	8.60	0.381	0.00	8.39	-136	5.19	131.43	Clear / No Odor
1215	1,948	8.59	0.381	0.00	8.40	-136	5.21	131.44	Clear

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes: PUMP SUCTION DEPTH = 186' btoc, 10' STINGER, TOP OF PUMP = 176.5' btoc @1010 DTW = 129.55' btoc

Air Monitoring:
VOC (ppm)= 0.0
H2S (ppm) = 0.0
LEL (%)= 0
CO (ppm)= 0.0
O2 (%)= 20.9

Pump Start Time: 0955
Initial Fill Time(FT; sec): 18
Initial Discharge Time(DT; sec): 47
target pressure - 98 psi
Pump Depth: 176.4

Final Fill Time: 50
Final Discharge Time: 50

Purge Rate: 54 mL/min

Sample /Time: 1225

MS/MSD
Duplicate ID:
Signature(s):

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 01/03/2018
Weather: Sunny, upper 30's°F, NE winds @ 4mph

Project Number: 695610.04.FI.FS
Page: 1 of 2
Well ID: WI-CV-MW04S
Sample ID: WI-CV-
Sampling Team: M. Endo, G. Gardner

Total Depth: 126.5 FT.(BTOC)
Depth to water: (-) 105.82 FT.(BTOC)
Water Column: 20.68 FT.
(x) 0.163 GAL/FT.
Well Volume: 3.37 GAL.
Total Purge Vol.: _____ GAL.

Measuring Device: Solinst WL1 #1011
Horiba U-53
MULTIRAE

Purge Device: GeoTech PFE-Free Bladder

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
0941	Initial	6.1	0.548	5.73	6.75	277	2.93	108.10	Clear, NO ODOR

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes: @ 1407 DTW BELOW TOP OF PUMP, MEASURED SUCTION DEPTH IS 123' BTOC. WELL PURGED DRY. 1419 STOP PUMP & ALLOW TO RECHARGE

Air Monitoring:
VOC (ppm)= 0
H2S (ppm)= 0
LEL (%)= 0
CO (ppm)= 0
O2 (%)= 20.9

Pump Start Time: @ 0940
Initial Fill Time(FT; sec): 12 25sec Final Fill Time: 26 sec
Initial Discharge Time(DT; sec): 31 23sec Final Discharge Time: 26 sec

Purge Rate: NA, SLOW

Suction
Pump Depth: 116.6' BTOC (TOP OF PUMP @ 115' BTOC)

Sample /Time:
MSD
Duplicate ID:
Signature(s):

0942 - GETTING SIGNIFICANT DRAWDOWN, STOP PUMP & MEASURE RECHARGE RATE IN WELL. 0.1'/11 MIN (RECHARGE RATE)
1002 Recharge rate very slow, will purge well dry Target DTW = 120' btoc Allow well to recharge 80% within 24 hrs, then sample
1222 DTW = 117.35' BTOC

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 01/04/2018
Weather:

Project Number: 695610.04.FI.FS
Page: 2 of 2
Well ID: WI-CV-MW04S
Sample ID: WI-CV-GW04S-0118
Sampling Team: M. Endo, G. Gardner, E. Cutler

Total Depth: ____ FT.(BTOC)
Depth to water: (-) 106.98 FT.(BTOC)
Water Column: ____ FT.
(x) ____ GAL/FT.
Well Volume: ____ GAL.
Total Purge Vol.: ____ GAL.

Measuring Device:

Purge Device:

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
1424	NA	NA						106.07	CLEAR, NO ODOR
1433	NA	NA						107.39	"
1442	0.5GAL	NA						106.40	"
1445	0.55	8.39	0.268	6.99	7.89	151	7.02	108.57	"

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes: DROP PUMP TO 128.38' btoc @ 1415. INITIAL DTW (NO PUMP) = 106.98' btoc (RECOVERY). 1432 WATER @ SURFACE.

Air Monitoring:
VOC (ppm)= 0.0
H2S (ppm) 0.0
LEL (%)= 0
CO (ppm)= 0.0
O2 (%)= 20.9

Pump Start Time: 1423
Initial Fill Time(FT; sec): 26sec
Initial Discharge Time(DT; sec): 26sec

Final Fill Time: 28sec
Final Discharge Time: 24sec.

Pump Depth:

Purge Rate:

Sample /Time: 1440 ON 01/04/18

MS/MSD

Duplicate ID:

Signature(s):

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 1/4/2018
Weather: Cloudy, hi 30s

Project Number: 695610.04.FI.FS Page: 1 of
Well ID: WI-CV-MW075
Sample ID: WI-CV-GW075-0118
Sampling Team: G Gardner, M. Endo, E. Cutler

Total Depth: ~~120.48~~ 144.67 FT.(BTOC)
Depth to water: (-) 126.40 FT.(BTOC)
Water Column: 18.27 FT.
(x) 0.163 GAL/FT.
Well Volume: 2.97 GAL.
Total Purge Vol.: 2.07 GAL.

Measuring Device: Solinst WLI #101
Horiba U-53

Purge Device: GeoTech PFC-free Bladder

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
1146	~1gal	7.29	0.713	1.65	7.69	114	1.3	127.8	clear, no odor
1156	1.2	7.57	0.698	0.57	7.78	47	0.2	127.75	"
1201	1.3	7.69	0.697	0.44	7.79	40	0.2	127.75	"
1206	1.4	7.84	0.694	0.26	7.81	29	0.1	127.75	"
1211	1.5	7.97	0.689	0.06	7.81	19	0.0	127.75	"
1216	1.6	8.05	0.687	0.00	7.82	14	0.0	127.75	"
1221	1.7	8.06	0.686	0.00	7.82	10	0.0	127.75	"
1226	1.8	8.04	0.685	0.00	7.82	9	0.0	127.70	"
1231	1.9	8.01	0.684	0.00	7.83	7	0.0	127.70	"
1236	2.0	8.02	0.684	0.00	7.83	6	0.0	127.70	"

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes: TARGET SUCTION DEPTH = ~~132.4 btoc~~ 134.5' btoc
TOP OF PUMP @ ~133' btoc. @1118 FLOWCELL LEAKING, CHECK O-RINGS & RESTART.

Air Monitoring:
VOC (ppm)= 0.0
H2S (ppm) = 0.0
LEL (%)= 0
CO (ppm)= 4.0 (NOT SUSTAINED)
O2 (%)= 20.9

Pump Start Time: 1049
Initial Fill Time(FT; sec): 15s
Initial Discharge Time(DT; sec): 35
TARGET P= 76.5psi
Final Fill Time: 17s
Final Discharge Time: 33s
Pump Depth: 134.5' btoc suction depth
Purge Rate: ~~70~~ mL/min @ 1150

Sample /Time: 1245

MS/MSD
Duplicate ID:
Signature(s):

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 1/3/2018
Weather: Sunny, 43°F

Project Number: 695610.04.FI.FS
Page: 1 of 2
Well ID: WI-CV-MW-025 GW
Sample ID: WI-CV-~~MW~~-025-0118
Sampling Team: M. Endo
B. Prentice

Measuring Device: Solinst WL #038629
Horiba U-53
Multirae

Total Depth:	116	FT.(BTOC)
Depth to water:	(-) 93.19	FT.(BTOC)
Water Column:	22.81	FT.
	(x) 0.163	GAL/FT.
Well Volume:	3.71	GAL.
Total Purge Vol.:	4.0	GAL.

Purge Device: Geotech PFC-Free Bladder

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
1400	.5	11.46	.424	4.31	8.16	201	18.0	93.1	Slightly cloudy, no odor
1404	.8	11.34	.423	3.55	8.18	198	116.8	93.4	"
1407	1.0	11.18	.424	3.67	8.18	198	17.1	93.4	"
1410	1.2	11.14	.430	3.12	8.18	196	18.3	93.5	"
1413	1.4	11.15	.434	2.80	8.19	195	18.3	93.6	"
1416	1.6	10.85	.443	2.57	8.18	195	17.9	93.7	"
1419	1.8	11.07	.450	2.00	8.21	193	15.6	93.7	"
1422	2.0	10.93	.466	1.15	8.22	191	9.7	93.7	"
1425	2.2	10.92	.471	0.79	8.24	189	8.38	93.7	"
1428	2.6	10.87	.475	0.68	8.26	185	7.59	93.7	"
1431	2.8	10.92	.477	0.52	8.27	181	5.09	93.7	"

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers
Modified 537-537	None	~~3~~ 2 x 125ml poly	2

Observations/Notes: 58.15 target pressure (psi)

Pump Start Time: 1340
Initial Fill Time(FT; sec): 14
Initial Discharge Time(DT; sec): 26

Final Fill Time:
Final Discharge Time:

Purge Rate: 100ml/min

Air Monitoring:
VOC (ppm)= 0.0
H2S (ppm) = 0.0
LEL (%)= 0
CO (ppm)= 0.0
O2 (%)= 20.9

Pump Depth: 97.7' btoc

Sample /Time: WI-CV-~~MW~~-GW-025-0118 @ 1450

FIELD REAGENT BLANK (WI-CV-FBEI-010318) TAKEN @ 1455

MSD

Duplicate ID:

Signature(s):

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 1/3/2017
Weather:

Project Number: 695610.04.FI.FS
Well ID: WI-CV-MW-025
Sample ID: WI-CV-[redacted]025-0117
Sampling Team: B. Phenix
M. Endo

Total Depth: _____ FT.(BTOC)
Depth to water: (-) _____ FT.(BTOC)
Water Column: _____ FT.
(x) _____ GAL/FT.
Well Volume: _____ GAL.
Total Purge Vol.: _____ GAL.

Purge Device: _____

Measuring Device: _____
Date and Time: _____

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

SAMPLE DATA

Date: / Time: / Method:	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: _____	Color / Odor / Comments

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DIW	Color / Odor / Comments
1433	3.0	10.86	.479	0.25	8.28	176	4.01	43.7	
1436	3.2	10.88	.479	0.19	8.28	173	3.98	93.7	
1439	3.4	10.87	.479	0.23	8.27	170	3.70	93.7	
1442	3.5	10.88	.480	0.18	8.28	169	3.86	93.7	

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers
Modified SW-537	None	125ml poly	2

Observations/Notes: See pg. 1

Pump Start Time: VOC Reading:

Pump Depth:

Sample /Time:

MS/MSD Duplicate ID No.:

Signature(s):

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 1/2/2018
Weather: Cloudy, mid 30s

Project Number: 695610.04.FI.FS Page: 1 of 2
Well ID: WI-CV-MW04M
Sample ID: WI-CV-GW04M-0118
Sampling Team: G. Garcinez, M. Endo

Total Depth: 158.60 FT.(BTOC)
Depth to water: (-) 121.70 FT.(BTOC)
Water Column: 36.9 FT.
(x) 0.163 GAL/FT.
Well Volume: 6.01 GAL.
Total Purge Vol.: ~6 GAL GAL.

Measuring Device: Solinst WL1 500 model 101 Horiba U-53

Purge Device: GeoTech PFC-free Bladder Pump

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
1145	Initial	9.69	0.295	0.00	8.34	-138	96.4	125.93	CLOUDY, SLIGHT SULFUR ODOR
1146	~~375 mL~~ 2nd	8.96	0.295	0.00	8.43	-139	96.4	125.73	"
1154	NA	8.53	0.295	0.00	8.51	-140	155	125.0	"
1200	NA	8.46			8.54				increase in turbidity
1213	NA							125.28	
1238	NA	9.59	0.283	0.00	8.84	-144	172	125.55	SLIGHTLY CLOUDY, SLIGHT SULFUR ODOR
1242	NA	9.49	0.295	0.00	8.82	-175	201	125.52	"
1246	~3	9.64	0.284	0.00	8.81	-186	168	125.80	"
1252		9.61	0.284	0.00	8.80	-188	107	125.80	"
~~1257~~		9.63	0.284	0.00	8.84	-191	104	125.8	"
1304		9.63	0.284	0.00	8.90	-194	311	125.75	"

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes:

Air Monitoring:
VOC (ppm)= 0
H2S (ppm) 0
LEL (%)= 0
CO (ppm)= 0
O2 (%)= 20.9

Pump Start Time: 1110
Initial Fill Time(FT; sec): 14
Initial Discharge Time(DT; sec): 38

Final Fill Time: 20 sec
Final Discharge Time: 40 sec

Purge Rate: 125 mL/min @1145
131 mL/min @ 1252

Pump Depth: 142' btoc with 10' Stinger tube (secured at 20') suction depth = 153.7' btoc

Sample /Time:
MSD
Duplicate ID:
Signature(s):

1200 Significant increase in turbidity. Remove water quality sensor & discharge directly into bucket. No significant change in purge rate.
1225 Water cleared up. DTW = 125.79' btoc. Re-attach Horiba flow cell.
1304 Disconnect horiba to clean turbidity sensor.

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 1/2/2018
Weather:

Project Number: 695610.04.FI.FS Page: 2 of 2
Well ID: WI-CV-MW04M
Sample ID: WI-CV-GW04M-0118
Sampling Team:

Total Depth: FT.(BTOC)
Depth to water: (-) FT.(BTOC)
Water Column: FT.
(x) GAL/FT.
Well Volume: GAL.
Total Purge Vol.: GAL.

Measuring Device:

Purge Device:

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
1317		9.71	0.284	0.00	8.91	-156	141	125.75	slightly cloudy, slight sulfur odor
1322		9.70	0.283	0.00	8.9	-166	79	125.75	"
1326		9.4	0.284	0.00	8.89	-196	59.8	125.75	"
1330		9.85	0.255	0.00	8.89	-196	46.3	125.75	"
1334		9.8	0.285	0.00	8.88	-197	38.5	125.75	"
1338		9.78	0.285	0.00	8.88	-198	40.3	125.78	"
1342		9.84	0.286	0.00	8.88	-199	32.9	125.75	"
1346		9.85	0.285	0.00	8.88	-199	23.1	125.75	"
1350		9.85	0.285	0.00	8.88	-199	28.6	125.75	"
1354	~5	9.90	0.285	0.00	8.88	-200	27.5	125.77	mostly clear, no odor
1358		9.85	0.285	0.00	8.9	-201	24.2	125.78	"

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers
MOD METHOD 537	None, 4°C	2 x 125mL POLY	4

Observations/Notes:

Air Monitoring:
VOC (ppm)=
H2S (ppm)
LEL (%)=
CO (ppm)=
O2 (%)=

Pump Start Time:
Initial Fill Time(FT; sec):
Initial Discharge Time(DT; sec):

Final Fill Time:
Final Discharge Time:

Purge Rate: ~130 mL/min @ 1322

Pump Depth:

FRB: WI-CV-FB01-010218 @ 1412

Sample /Time: 1404

MS/MSD

Duplicate ID: WI-CV-GW04MP-0118 @ 1408

Signature(s):

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 12/30/2017
Weather: Partly Cloudy, low 40s

Project Number: 695610.04.FI.FS
Page: 1 of 2
Well ID: WI-CV-MW15M
Sample ID: WI-CV-GW15M-1217
Sampling Team: M Ende, C Gardner, D. Butler

Total Depth: ~179 FT.(BTOC)
Depth to water: (-) 124.97 FT.(BTOC)
Water Column: 54.03 FT.
(x) 0.163 GAL/FT.
Well Volume: 8 8 GAL.
Total Purge Vol.: 5250 GAL. mL

Measuring Device: Solinst W-I #101 (038029) Hydrant

Purge Device: Geotech PFE Free Bladder pump
Geotech Control Pro (C-103058)

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. ~~(gals)~~ mL	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
~~1000~~ 958	Initial	8.86	0.404	7.96	6.98	237	5.94	124.97	clear, no odor
1003	475	8.92	0.413	5.95	7.32	143	19.7	125.00	" "
1008	950	9.22	0.433	2.76	8.02	-8	27.5	125.00	" "
1013	1425	9.51	0.452	0.39	8.37	-104	26.3	125.00	" "
1018	1900	9.56	0.454	0.16	8.39	-124	22.9	125.01	" "
1023	2375	9.68	0.454	0.00	8.40	-179	19.9	125.01	" "
1028	2850	9.67	0.453	0.00	8.43	-188	18.9	125.01	" "
1033	3325	9.64	0.452	0.00	8.45	-210	18.9	125.01	" "
1038	3800	9.63	0.450	0.00	8.46	-222	17.9	125.01	" "
1043	4275	9.65	0.447	0.00	8.46	-234	16.1	125.01	" "
1048	4750	9.65	0.446	0.00	8.45	-235	14.4	125.01	" "

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers
PFAS	none 4-6°C	125 mL poly	2

Observations/Notes:

Air Monitoring:
VOC (ppm)= 0
H2S (ppm) 0
LEL (%)= 0
CO (ppm)= 0
O2 (%)= 20.9

Pump Start Time: 09:42
Initial Fill Time(FT; sec): 17
Initial Discharge Time(DT; sec): 45
Pump off @ 1106

Final Fill Time: 16 17
Final Discharge Time: 50

Purge Rate: 95 mL/min

Pump Depth: 160' btoc

Sample /Time: 1105 Collected Field Reagent Blank WI-CV-FB01-123017 @ 1100

MSD —
Duplicate ID: —

Signature(s): Dennit Mandron

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 12/30/2017
Weather: Clouds, low 40s

Project Number: 695610.04.FI.FS
Page: 2 of 2
Well ID: WI-CV-MW15M
Sample ID: WI-CV-GW15M-1217
Sampling Team:

Total Depth: _____ FT.(BTOC)
Depth to water: (-) _____ FT.(BTOC)
Water Column: _____ FT.
(x) _____ GAL/FT.
Well Volume: _____ GAL.
Total Purge Vol.: _____ GAL.

Measuring Device:

Purge Device:

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. ~~(gals)~~ mL	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
1053		4.65	0.444	0.00	8.48	-240	13.6	135.01	clear, no odor

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes:

Air Monitoring:
VOC (ppm)=
H2S (ppm)
LEL (%)=
CO (ppm)=
O2 (%)=

Pump Start Time:
Initial Fill Time(FT; sec):
Initial Discharge Time(DT; sec):

Final Fill Time:
Final Discharge Time:

Purge Rate:

Pump Depth:

Sample /Time:

MS/MSD

Duplicate ID:

Signature(s):

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 12/30/2017
Weather: Clouds, Low 40s

Project Number: 695610.04.FI.FS Page: 1 of 2
Well ID: WI-CV-MW15S
Sample ID: WI-CV-GW15S
Sampling Team: D. Butler, G Gardner

Total Depth: 147 FT.(BTOC)
Depth to water: (-) 124.49 FT.(BTOC)
Water Column: 22.51 FT.
(x) 0.163 GAL/FT.
Well Volume: 3.67 GAL.
Total Purge Vol.: 3.6 GAL.

Measuring Device: Solinst WLI #101
MultiRAE
Horiba U-53
Pine # 10672

Purge Device: GeoTech PFC-Free Bladder
GeoTech Control Pro (C-102721)

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
~~1211~~ 1156	initial	~~7.73~~	0.405	0.00	8.25	147	19.5	124.48	Clear, no odor
1216	800	8.44	0.405	0.60	8.19	145	22.8	124.48	"
1221	1600	9.64	0.406	0.45	8.31	135	29.7	124.50	"
1226	2400	9.79	0.406	0.31	8.31	124	33.5	124.50	"
1231	3200	9.81	0.406	0.26	8.33	116	30.2	124.50	"
1236	4000	9.87	0.405	0.14	8.35	90	30.3	124.50	"
1241	4800	9.90	0.405	0.08	8.37	74	33.7	124.15	"
1246	5600	9.86	0.406	0.06	8.38	67	34.8	123.96	"
1251	6400	9.90	0.405	0.06	8.38	65	28.8	123.91	"
1256	7200	9.95	0.403	0.24	8.41	60	28.3	124.06	"
1301	8000	10.01	0.402	0.25	8.41	49	30.7	124.33	"

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers
Method 537 Mod	4°C	2 x 125 mL amber poly	2

Observations/Notes: Had issues with Horiba, which delayed start of parameter record.

Air Monitoring:
VOC (ppm)= 0
H2S (ppm)= 0
LEL (%)= 0
CO (ppm)= 0
O2 (%)= 20.9

Pump Start Time: 1130
Initial Fill Time(FT; sec): ~~17~~ 10, 15
Initial Discharge Time(DT; sec): ~~50~~ 50, 30
Final Fill Time: 15
Final Discharge Time: 30

Pump End Time: 1344

Purge Rate: @ 1211 = 160 mL/min
@ 1240 = 160 mL/min

Pump Depth: 137' btoc

Sample /Time: 1340

MSD —
Duplicate ID: —

Signature(s): Dave Butler

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 12/30/2017
Weather: Rain, hi 30s

Project Number: 695610.04.FI.FS
Page: 2 of 2
Well ID: WI-CV-MW155
Sample ID: WI-CV- GW155-1217
Sampling Team:

Total Depth: ____ FT.(BTOC)
Depth to water: (-) ____ FT.(BTOC)
Water Column: ____ FT.
(x) ____ GAL/FT.
Well Volume: ____ GAL.
Total Purge Vol.: ____ GAL.

Purge Device:

Measuring Device:

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

PARAMETER STABILIZATION CRITERIA

Parameter	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	
Criteria	±0.1	±0.01 (if <1) ±0.02 (if >1)	±0.05 (if <1) ±0.2 (if >1)	±0.1	±10	±10 % ≤ 10 NTU	±0.3 (low flow)	

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	DTW ft BTOC	Color / Odor / Comments
1306	5800	10.10	0.402	0.57	8.41	42	33.4	124.40	Clear, No odor
1311	9600	10.06	0.403	0.50	8.41	39	39.5	124.45	"
1316	10400	10.05	0.404	0.49	8.41	33	36.8	124.50	"
1321	11200	10.06	0.404	0.61	8.42	27	37.5	124.46	"
1326	12000	10.08	0.402	0.86	8.42	20	31.1	124.45	"
1331	12800	10.10	0.402	0.87	8.41	20	24.8	124.50	"
1336	13600	10.08	0.401	0.87	8.40	19	27.9	124.50	"
	All params. stable, proceed to sample								

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes:

Air Monitoring:
VOC (ppm)=
H2S (ppm)
LEL (%)=
CO (ppm)=
O2 (%)=

Pump Start Time:
Initial Fill Time(FT; sec):
Initial Discharge Time(DT; sec):

Final Fill Time:
Final Discharge Time:

Purge Rate:

Pump Depth:

Sample /Time: 1346

MSD —

Duplicate ID:

Signature(s): David Bill

ch2m:

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 12/29/2017
Weather: Rain, upper 30s°F, SE winds 6-12mph

Project Number: 695610.04.FI.FS
Well ID: WI-CV-MW165
Sample ID: ~~WI-CV-MW165-1217~~ WI-CV-GW165-1217
Sampling Team: M Endo, G Gardner, M Lopez, J Hauser

Total Depth: 145. FT.(BTOC)
Depth to water: (-) 122.64 FT.(BTOC)
Water Column: 22.36 FT.
(x) 0.163 GAL/FT.
Well Volume: 3.64 GAL.
Total Purge Vol.: ~1.14 GAL.

Purge Device: GeoTech PFC-Free Bladder Pump

Measuring Device: Horiba U-53 R126634
Date and Time: 12/29/2017

SOLINST WLI 101

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

~~SAMPLE DATA~~ Stabilization Criteria								
Date: 12/29/2017 Time:	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DTW ft	Color / Odor / Comments
Method: Bladder	±0.1	±0.01	±0.05	±0.1	±10	± 10% / ≤ 10 NTU	±0.3 ft	

Low Flow

FIELD PARAMETERS

Time	Purge Vol. ~~(gals)~~ mL	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DTW ft btoc	Color / Odor / Comments
1406	initial	7.61	0.396	0.00	6.82	148	123	122.64	mostly clear, no odor
1412	~~360~~ 630	7.93	0.390	0.00	7.08	114	68.5	122.64	mostly clear, no odor
1417	~~671~~ 1155	8.48	0.374	0.00	7.55	52	48.0	122.64	" "
1423	1680	8.43	0.369	0.00	7.68	43	36.5	122.64	" "
1428	2205	8.18	0.367	0.00	7.81	37	26	122.64	clear, no odor
1433	2730	8.30	0.367	0.00	7.85	32	22.6	122.64	" "
1437	3255	8.33	0.366	0.00	7.88	33	21.8	123.00	" "
1442	3780	8.31	0.365	0.00	7.89	34	27.7	124.00	" "
~~1447~~	~~4080~~								

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers
PFAS	None 4-6°C	2x 125 mL Poly	2

Observations/Notes:

Pump Start Time: 1354 FT=15 Sec DT=30 Sec. 4-gas ~~VOC~~ Reading: VOC= 0.0 ppm CO=0 ppm H_2S=0 ppm CH_4=0 %LEL O_2=20.9% vol

Pump Depth: 135' btoc

Sample /Time: 1449 FIELD DUPLICATE (WI-CV-GW165P-1217) TAKEN @ 14:59

MS/MSD

Duplicate ID No.: ~~WI-CV-MW165P-1217~~ @1459 WI-CV-GW165P-1217

Signature(s): Brett Gardner

Final DTW = 124.00' btoc

Flow rate at 1406 = ~~60~~ 105 mL/min
at 1437 = 60 mL/min

WL drop due to Keystone Hill well cycling on.

ch2m

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 12/29/2017
Weather: CLOUDY, RAIN, UPPER 30's °F, SE WIND, @ 6-12mph

Project Number: 695610.04.FI.FS
Well ID: WI-CV-MW16M
Sample ID: WI-CV-GW16M-1217, WI-CV-GW16M-1217-MS, WI-CV-GW16M-1217-MSD
Sampling Team: M. ENG, G. GALANIS, M. LOPEZ, T. HUGHES, D. BUTNER

Total Depth: 179.92 FT.(BTOC)
Depth to water: (-) 122.89 FT.(BTOC)
Water Column: 57.03 FT.
(x) 0.163 GAL/FT.
Well Volume: 9.296 GAL.
Total Purge Vol.: 2.5 GAL.

Measuring Device: Solinst WLI PINE RENTAL 2814 18
Date and Time: 12/29/17

HORIBA U-53

Purge Device: Geoprobe Bladder Pump (PFC FREE) (1.66" x 18")

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

SAMPLE DATA

Date: 12/29 Time: 1430 Method: BLADDER PUMP/LOW FLOW	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DTW FT BTOC	Color / Odor / Comments
	9.50	0.403	4.67	8.20	0.403	7.92	122.88	Clear, odorless

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DTW FT BTOC	Color / Odor / Comments
1336	0.75	8.17	0.407	8.06	8.19	216	39.3	122.89	Cloudy
1342	0.90	8.50	0.404	7.70	8.18	216	31.7	122.88	Slightly turbid
1345	1.00	8.43	0.404	7.56	8.20	214	30.0	122.87	" "
1348	1.10	8.38	0.404	7.24	8.21	213	25.4	122.88	" "
1351	1.25	8.45	0.404	6.85	8.21	211	24.2	122.87	" "
1355	~~1.00~~ 1.25	8.39	0.404	6.53	8.22	210	22.5	122.88	" "
1358	1.35	8.42	0.404	6.31	8.22	209	21.3	122.86	" "
1401	1.45	8.53	0.405	6.24	8.21	209	19.6	122.87	" "
1404	1.55	8.68	0.406	6.14	8.21	208	19.5	122.88	" "
1407	1.65	9.01	0.405	5.84	8.21	207	17.5	122.87	" "
1410	1.75	9.19	0.404	5.68	8.21	206	15.3	122.88	" " SEE PG # 2

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers
MOD METHOD 537 (PANEL)	NONE, 4-6°C	125 mL POLY	2
" (FOR MS)	"	"	2
" (FOR MSD)	"	"	2

Observations/Notes: 1237 - WATER AT SURFACE, 1239 - SET FT = 13 SEC, DT = 46 SEC, DTW = 123.6' BTOC, 1256 - HORIBA FLOWCELL FULL

Pump Start Time: 1215 FT = 16 SEC, DT = 43 SEC

VOC Reading: VOC = 0.0 ppm, CO = 0.0 ppm, LEL = 0%, H_2S = 0.0 ppm, O_2 = 20.9% (4 min)

Pump Depth: 168' BTOC, SUCTION DEPTH = 170' BGS (STINGER TUBE, INTAKE BELOW PUMP, LENGTH = 10')

Sample /Time:

FT = FILL TIME, DT = DISCHARGE TIME

MS/MSD | Duplicate ID No.:

Signature(s):

Stabilization criteria: ~~±10%~~ (DO)
±0.1°C
±0.1 pH
[±0.01 mS/cm < 1 mS/cm
±0.02 mS/cm > 1 mS/cm]
±10 mV (ORP)
[±0.05 mg/L < 1 mg/L
±0.2 mg/L > 1 mg/L]
±10% turb/ ≤ 10 NTU

GROUNDWATER SAMPLING DATA SHEET

Client: NAVFAC
Location: OLF Coupeville
Event: Winter 2017 Groundwater Sampling
Date: 12/29/2017
Weather: CLOUDY, RAIN AT TIMES

Project Number: 695610.04.FI.FS
Well ID: WI-CV-MW-16M
Sample ID: WI-CV-MW-16M
Sampling Team: MENDO. G. GARNER, M LOPEZ, D. BUTTLER

Total Depth: _____ FT.(BTOC)
Depth to water: (-) _____ FT.(BTOC)
Water Column: _____ FT.
(x) _____ GAL/FT.
Well Volume: _____ GAL.
Total Purge Vol.: 2.5 GAL.

Measuring Device: _____
Date and Time: _____

Purge Device: GEOPROBE BLADDER PUMP

Well Dia. (inches)	Volume (gallons/foot)
1	0.041
1.25	0.064
2	0.163
4	0.653

See 1st Page

SAMPLE DATA

Date: 12/29/2017 Time: ~~1430~~ 1425	Temp. °C	Cond. mS/cm	DO mg/L	pH SU	ORP mV	Turbidity NTU	Other: DTW	Color / Odor / Comments
Method: LOW FLOW	~~9.36~~	~~0.405~~	~~4.89~~	~~8.22~~	~~199~~	~~9.23~~	~~122.87~~	~~NO ODOR~~
	0.1	±0.10	0.05/0.1					

FIELD PARAMETERS

Time	Purge Vol. (gals)	Temp. °C	Cond. mS/cm	DO mg/L	pH 0.1 SU	ORP 10 mV	Turbidity NTU	Other: DTW	Color / Odor / Comments
1413	1.85	9.30	~~0.405~~ 0.405	5.46	8.20	205	14.5	122.87	Clearing
1416	1.95	9.35	0.403	5.14	8.22	202	11.9	122.87	Clear
1419	2.05	9.30	0.405	5.05	8.21	201	11.7	122.87	Clear, odorless
1422	2.15	9.38	0.404	4.95	8.21	200	10.6	122.87	" "
1425	2.25	9.36	0.405	4.89	8.22	199	9.23	122.87	
1428	2.35	9.38	0.405	4.79	8.22	198	7.92	122.88	" "

Sample information: method, container number, size, and type, preservative used.

Analysis	Preservative	Container requirements	No. of containers

Observations/Notes: WI-CV-GW16M-1217 @ 1425. MS/MSD WI-CV-GW16M-1217-MS, WI-CV-GW16M-1217-MSD @ 1425. FIELD BLANK WI-CV-FB01-~~1217~~ 122917 @ 1438.

Pump Start Time:

VOC Reading:

Pump Depth:

Sample /Time: SAMPLE TIME: 1425

MS/MSD: YES

Duplicate ID No.: NO

Signature(s): [signature]

FLOW RATE 112.5 ml/min

FINAL DTW: 124.37 → WATER DROPPED DUE TO PUMPING AT KEYSTONE WELL OPERATION

END OF SAMPLING @ 1445

FINAL FT = 12 SEC, FINAL DT = 56 SEC

Appendix H
Sampling Results Raw Data Tables

Sample ID Sample Date	USEPA Lifetime Health Advisory (May 2016)	USEPA Tapwater RSL HQ = 1.0 (November 2017)	WI-CV-1RW23-1217 12/30/17
Chemical Name			
Semivolatile Organic Compounds (NG/L)			
N-Ethylperfluoro-1-octanesulfonamidoacetic acid (EtFOSAA)	--	--	4.7 U
N-Methylperfluoro-1-octanesulfonamidoacetic acid (MeFOSAA)	--	--	4.7 U
Perfluorobutanesulfonic acid (PFBS)	--	400,000	12.5
Perfluoroheptanoic acid (PFHpA)	--	--	8.5 J
Perfluorohexanesulfonic acid (PFHxS)	--	--	59.2 J
Perfluorononanoic acid (PFNA)	--	--	4.7 U
Perfluorooctane Sulfonate (PFOS)	70	--	4.7 U
Perfluorooctanoic acid (PFOA)	70	--	54.1 J
Perfluorodecanoic Acid (PFDA)	--	--	4.7 U
Perfluorododecanoic Acid (PFDoA)	--	--	4.7 U
Perfluorohexanoic Acid (PFHxA)	--	--	27
Perfluorotridecanoic Acid (PFTeDA)	--	--	4.7 UJ
Perfluorotridecanoic Acid (PFTrDA)	--	--	4.7 U
Perfluoroundecanoic Acid (PFUnA)	--	--	4.7 U
PFOA+PFOS	70	--	54

https://delivery.ch2m.com/projects/695610/Field Work/OLF Coupeville/Aquifer Test/Report/Appendices/[Coupeville_PFAS_validated_RDE_table_Rev1.xlsx], Tiffany Hill, 03/12/2018

Notes:

J - Analyte present. Value may or may not be accurate or precise

NG/L - Nanograms per liter

NS - Not sampled

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

Shading indicates detection

Bolded indicates USEPA LHA exceedance

Underlined indicates USEPA Tapwater RSL HQ = 1.0 exceedance

Sample ID	WI-CV-1RW23P-1217	WI-CV-GW02S-0118	WI-CV-GW04M-0118	WI-CV-GW04MP-0118
Sample Date	12/30/17	1/3/18	1/2/18	1/2/18
Chemical Name				
Semivolatile Organic Compounds (NG/L)				
N-Ethylperfluoro-1-octanesulfonamidoacetic acid (EtFOSAA)	4.68 U	5.48 U	5.34 U	5.3 U
N-Methylperfluoro-1-octanesulfonamidoacetic acid (MeFOSAA)	4.68 U	5.48 U	5.34 U	5.3 U
Perfluorobutanesulfonic acid (PFBS)	12.9	390	5.34 U	5.3 U
Perfluoroheptanoic acid (PFHpA)	8.5 J	234	5.34 U	5.3 U
Perfluorohexanesulfonic acid (PFHxS)	65.3	7,700	5.34 U	5.3 U
Perfluorononanoic acid (PFNA)	4.68 U	5.48 U	5.34 U	5.3 U
Perfluorooctane Sulfonate (PFOS)	4.68 U	**87.8**	1.25 J	5.3 U
Perfluorooctanoic acid (PFOA)	53.2	**1,010**	5.34 U	5.3 U
Perfluorodecanoic Acid (PFDA)	4.68 UJ	5.48 UJ	5.34 U	5.3 U
Perfluorododecanoic Acid (PFDoA)	4.68 U	5.48 U	5.34 U	5.3 U
Perfluorohexanoic Acid (PFHxA)	28.5	1,010	5.34 U	5.3 U
Perfluorotridecanoic Acid (PFTeDA)	4.68 U	5.48 U	5.34 U	5.3 U
Perfluorotridecanoic Acid (PFTrDA)	4.68 U	5.48 U	5.34 U	5.3 U
Perfluoroundecanoic Acid (PFUnA)	4.68 U	5.48 U	5.34 U	5.3 U
PFOA+PFOS	53	**1,098**	1.25	ND

https://delivery.ch2m.com/projects/695610/Field Work/OLF Coupeville/Aquifer Test/Report/Appendices/[Coupe

Notes:

J - Analyte present. Value may or may not be accurate or precise

NG/L - Nanograms per liter

NS - Not sampled

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

Shading indicates detection

Bolded indicates USEPA LHA exceedance

Underlined indicates USEPA Tapwater RSL HQ = 1.0 exceedance

Sample ID	WI-CV-GW04S-0118	WI-CV-GW05M-0118	WI-CV-GW07M-0118	WI-CV-GW07S-0118
Sample Date	1/4/18	1/5/18	1/4/18	1/4/18
Chemical Name				
Semivolatile Organic Compounds (NG/L)				
N-Ethylperfluoro-1-octanesulfonamidoacetic acid (EtFOSAA)	5.3 U	5.34 U	5.34 U	5.17 U
N-Methylperfluoro-1-octanesulfonamidoacetic acid (MeFOSAA)	5.3 U	5.34 U	5.34 U	5.17 U
Perfluorobutanesulfonic acid (PFBS)	5.3 U	533	5.34 U	5.17 U
Perfluoroheptanoic acid (PFHpA)	5.3 U	263	5.34 U	5.17 U
Perfluorohexanesulfonic acid (PFHxS)	5.3 U	1,070	5.34 U	5.17 U
Perfluorononanoic acid (PFNA)	5.3 U	5.34 U	5.34 U	5.17 U
Perfluorooctane Sulfonate (PFOS)	5.3 U	2.84 J	5.34 U	5.17 U
Perfluorooctanoic acid (PFOA)	5.3 U	**1,220**	5.34 U	5.17 U
Perfluorodecanoic Acid (PFDA)	5.3 UJ	5.34 UJ	5.34 UJ	5.17 UJ
Perfluorododecanoic Acid (PFDoA)	5.3 U	5.34 U	5.34 U	5.17 U
Perfluorohexanoic Acid (PFHxA)	5.3 U	1,240	5.34 U	5.17 U
Perfluorotridecanoic Acid (PFTeDA)	5.3 U	5.34 U	5.34 U	5.17 U
Perfluorotridecanoic Acid (PFTrDA)	5.3 U	5.34 U	5.34 U	5.17 U
Perfluoroundecanoic Acid (PFUnA)	5.3 U	5.34 U	5.34 U	5.17 U
PFOA+PFOS	ND	**1,223**	ND	ND

Notes:

J - Analyte present. Value may or may not be accurate or precise

NG/L - Nanograms per liter

NS - Not sampled

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

Shading indicates detection

Bolded indicates USEPA LHA exceedance

Underlined indicates USEPA Tapwater RSL HQ = 1.0 exceedance

Sample ID	WI-CV-GW14M-0118	WI-CV-GW15M-1217	WI-CV-GW15S-1217	WI-CV-GW16M-1217
Sample Date	1/5/18	12/30/17	12/30/17	12/29/17
Chemical Name				
Semivolatile Organic Compounds (NG/L)				
N-Ethylperfluoro-1-octanesulfonamidoacetic acid (EtFOSAA)	5.43 U	5.25 U	5.21 U	5.17 U
N-Methylperfluoro-1-octanesulfonamidoacetic acid (MeFOSAA)	5.43 U	5.25 U	5.21 U	5.17 U
Perfluorobutanesulfonic acid (PFBS)	10	5.25 U	15.8	34.8
Perfluoroheptanoic acid (PFHpA)	3.19 J	5.25 U	3.32 J	30.9
Perfluorohexanesulfonic acid (PFHxS)	11.1	5.25 U	363	149 J
Perfluorononanoic acid (PFNA)	5.43 U	5.25 U	5.21 U	5.17 U
Perfluorooctane Sulfonate (PFOS)	1.24 J	5.25 U	5.21 U	2.63 J
Perfluorooctanoic acid (PFOA)	8.86	5.25 U	**253**	**373**
Perfluorodecanoic Acid (PFDA)	5.43 UJ	5.25 U	5.21 U	5.17 U
Perfluorododecanoic Acid (PFDoA)	5.43 U	5.25 U	5.21 U	5.17 U
Perfluorohexanoic Acid (PFHxA)	18.9	5.25 U	52.9	104 J
Perfluorotridecanoic Acid (PFTeDA)	5.43 U	5.25 U	5.21 U	5.17 U
Perfluorotridecanoic Acid (PFTrDA)	5.43 U	5.25 U	5.21 U	5.17 U
Perfluoroundecanoic Acid (PFUnA)	5.43 U	5.25 U	5.21 U	5.17 U
PFOA+PFOS	10.1	ND	**253**	**376**

https://delivery.ch2m.com/projects/695610/Field Work/OLF Coupeville/Aquifer Test/Report/Appendices/[Coupe

Notes:

J - Analyte present. Value may or may not be accurate or precise

NG/L - Nanograms per liter

NS - Not sampled

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

Shading indicates detection

Bolded indicates USEPA LHA exceedance

Underlined indicates USEPA Tapwater RSL HQ = 1.0 exceedance

Sample ID	WI-CV-GW16S-1217	WI-CV-GW16SP-1217
Sample Date	12/29/17	12/29/17
Chemical Name		
Semivolatile Organic Compounds (NG/L)		
N-Ethylperfluoro-1-octanesulfonamidoacetic acid (EtFOSAA)	5.3 U	5.25 U
N-Methylperfluoro-1-octanesulfonamidoacetic acid (MeFOSAA)	5.3 U	5.25 U
Perfluorobutanesulfonic acid (PFBS)	36.6	36.1
Perfluoroheptanoic acid (PFHpA)	34.8	28.5
Perfluorohexanesulfonic acid (PFHxS)	216	174
Perfluorononanoic acid (PFNA)	5.3 U	5.25 U
Perfluorooctane Sulfonate (PFOS)	3.47 J	2.76 J
Perfluorooctanoic acid (PFOA)	**277**	**297**
Perfluorodecanoic Acid (PFDA)	5.3 U	5.25 U
Perfluorododecanoic Acid (PFDoA)	5.3 U	5.25 U
Perfluorohexanoic Acid (PFHxA)	106	108
Perfluorotridecanoic Acid (PFTeDA)	5.3 U	5.25 U
Perfluorotridecanoic Acid (PFTrDA)	5.3 U	5.25 U
Perfluoroundecanoic Acid (PFUnA)	5.3 U	5.25 U
PFOA+PFOS	**280**	**300**

https://delivery.ch2m.com/projects/695610/Field Work/OLF Coupeville/Aquifer Test/Report/Appendices/[Coupe

Notes:

J - Analyte present. Value may or may not be accurate or precise

NG/L - Nanograms per liter

NS - Not sampled

U - The material was analyzed for, but not detected

UJ - Analyte not detected, quantitation limit may be inaccurate

Shading indicates detection

Bolded indicates USEPA LHA exceedance

Underlined indicates USEPA Tapwater RSL HQ = 1.0 exceedance

Appendix I
Data Validation Report

Data Validation Report will be provided upon request.