EA Engineering, Science, and Technology, Inc., PBC

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THREEMILE CANYON FARMS
INLAND AREA AR LIMITED LICENSE APPLICATION

TO: Jen Woody, Oregon Water Resources Department

CC: Phil Richerson, Oregon Department of Environmental Quality

FROM: Kevin Lindsey, Phil Brown, Molly Reid, Jon Travis

DATE: 22 December 2017

Threemile Canyon Farms, LLC (TMCF) is considering use of basalt aquifer recharge (AR) to mitigate for basalt aquifer static water level declines observed in the five Inland Area irrigation wells (Figure 1). Mitigation, for the purpose of this Limited License (LL) application is defined as slowing, stopping, and/or reversing the late winter/early spring static water level declines seen in the five Inland wells in recent years. EA Engineering, Science, and Technology Inc., PBC (EA) on behalf of TMCF, is submitting a Limited License Application for this AR Project, henceforth referred to as the Inland AR Project to make continued use of the aquifer in the Inland Farms area sustainable. The proposed Limited License testing period for the Inland AR project will be for a period of 5 years from 2018 through 2023. It will focus on a year-to-year phased approach that builds on the results of previous work.

INTRODUCTION

To mitigate for the observed static water level declines, filtered surface water will be injected into one or more wells in the Inland Area at rates up to 2,500 gallons per minute (gpm). Work to be conducted under the LL will be implemented in phases. The initial phase will start with a source water treatability evaluation followed by injection testing at one Inland well in calendar year 2018 and/or 2019. In subsequent years the project will expand to include additional wells as needed based on previous results to achieve the desired outcome of slowing, stabilizing, or reversing water level declines observed in Inland Area irrigation wells. At full potential build out a maximum instantaneous injection rate of 12,500 gpm and a maximum annual volume of up to a maximum of approximately 10,000 acre-feet is possible.

Source water for the proposed Inland AR project would be diverted from the Columbia River-John Day Pool at the TMCF Willow Creek pump station. Source water will be delivered to the Inland Area project via the existing irrigation system using existing conveyance infrastructure. It is anticpated that source water will be available under a new appropriation for the periods of November 1 through April 15 in any given water year.

TMCF IRRIGATION SYSTEM

The TMCF irrigation system delivers Columbia River water to over 30,000 acres of agricultural ground (Figure 2). The withdrawal point for this water is the TMCF pump station located in Willow Creek bay at approximately Columbia River Mile 253.5. The pump station is comprised currently of two lineups of vertical turbine pumps that deliver water at two different heads (pressures). The river pump station has a current total discharge capacity of approximately 164,500 gpm. The pumps are suspended inside individual woven wire box intake screens. The screens were installed when the farm was developed in the mid 1970's. National Marine Fisheries Service standards at the time required the screens have a maximum opening of 0.125 inches. Farm managers have indicated the screens meet current fisheries standards which require a maximum opening size of 0.094 inches for square openings measured diagonally. All river water entering the irrigation system passes through the intake screens.

The river pump station discharges into two, parallel 72-inch diameter pipes that extend south approximately 13,000 feet to the RDO and Inland Area booster pump stations. The Inland booster pump station supplies water to the Inland Area where the AR project is proposed. The Inland booster pump station has a total discharge capacity of approximately 65,000 gpm and it discharges to a pipeline that extends roughly 40,000 feet east to the Inland Area. The pipeline includes some segments with a single 54-inch pipe, areas with parallel 48-inch and 30-inch pipes and some 51-inch pipe. There is very limited use of water, a total of seven irrigated circles, between the pump station and the Inland Project area. TMCF generally operates the Inland booster pump station to maintain 65 psi at an elevation of approximately 610 feet above mean sea level (amsl), where the pipeline enters the Inland Area. There is one booster pump station located in the Inland Area that boosts pressure to some of the circles. It contains four 150 horse power pumps that have a capacity of about 18,000 gpm while boosting pressure about 35 psi.

The Inland Area consists of 2 subdivisions, 71 irrigated circles on the Inland Farm and 23 irrigated circles on the Radar Range. The total water requirement for the Inland Area is approximately 82,700 gpm. The Inland booster pump station, with its maximum capacity of approximately 65,000 gpm, is sufficient to irrigate approximately 79% of the 94 combined Inland Farm and Radar Range circles simultaneously. The balance of the required irrigation water is supplied by the 5 Inland irrigation wells.

INLAND AR PROJECT

Initial work will focus on source water treatment, source water-groundwater geochemical compatibility, and antidegradation evalution done prior to injection. If the results of these evaluations are favorable to the proposed AR project the next phase of the project will foucs on injection testing at one Inland well. It is anticipated that approximately 2,500 gpm would be delivered to each Inland Area well at a pressure of about 60 psi, filtered as necessary, and injected down the AR well. As noted above, the total number of Inland wells used in the proposed project will be based on the observed water level changes in the basalt aquifer system.

Depending on the static groundwater levels in the wells, a Baski valve may be required in each AR well to hold back-pressure in the well and prevent air entrapment during source water injection. At this time, we anticipate that initial AR work will be done at Inland Well #1 (MORR 52037), with potential expansion to Inland Well #2 (MORR 52045) the following year. Use of additional Inland wells will be contingent on the results of work at Inland Wells 1 and 2. However, the actual wells to be used, and in what order thay are used, will be based on infrastructure conditions and TMCF operations. Given that, the project team will consult with OWRD and DEQ to identify specific wells to be used in the project at any given time.

The characteristics of the Inland wells are summarized below and illustrated on Figures 3 through 7:

- Of the five Inland wells, Wells 1 and 2 are closest to existing mainlines, facilitating water delivery with only minor modifications for injection.
- The hydraulic characteristics of these wells generally include pumping rates greater than 2500 gpm, with drawdown on the order of 30 to 40 feet, and spring season statics of approximately 240 to 260 feet below ground surface (bgs).
- These wells all contain 20-inch casing set and sealed to approximately 750 feet bgs. Below casing they are 19-inch open-hole completions.
- Each well is equipped with a line shaft turbine pump set somewhere between approximately 450 and 550 feet bgs.

The existing wells will require some modifications for AR including interties to main pipelines to allow delivery of water to the wells, normal pumping operations, and AR injection controls. These modifications are discussed further in the application.

ATTACHMENTS

Individual components required for the Limited License application are included as attachments to this document, and include the following:

- Attachment A - Limited License Application (OWRD form)
- Attachment B - Water Availability Statement
- Attachment C - Conceptual AR Pilot Testing Plan
- Attachment D - Preliminary Conceptual Hydrogeologic Model
- Attachment E - Water Quality Pre-Assessment
- Attachment F - Quality Assurance and Quality Control Plan

CONCLUSIONS AND CONTACTS

TMCF is looking forward to developing an AR program that will help them improve and mitigate for declining water levels in basalt aquifer wells used to supply the Inland Area. We hope you find this information sufficient to issue a conditional LL to begin AR development. TMCF will update OWRD and DEQ in a timely matter of data obtained as the project continues through its various phases.

If you have any questions, please do not hesitate to contact one or more of the following individuals:

- Greg Harris, Manager, Threemile Canyon Farms, LLC, 75906 Threemile Road, Boardman, Oregon 97818, 541-481-9274, GHarris@rdoffutt.com.
- Kevin Lindsey, Project Manager, EA Engineering, Science, and Technology, Inc., PBC, 8019 West Quinault Avenue, Suite 201, Kennewick, Washington, 99336, 509-947-5729, klindsey@eaest.com.
- Phil Brown, Principal Hydrogeologist and AR Technical Lead, EA Engineering, Science, and Technology, Inc., PBC, 205 SE Spokane Street, Suite 300, Portland, Oregon 97202, 971-202-4743, pbrown@eaest.com.

- Gary Weatherly, Irrigation Infrastructure, J-U-B Engineers, Inc., 2810 West Clearwater Avenue, Suite 201, Kennewick, Washington, 99336, 509-783-2144, gweatherly@JUB.com.
- Molly Reid, Water Rights Specialist, EA Engineering, Science, and Technology, Inc., PBC, 8019 West Quinault Avenue, Suite 201, Kennewick, Washington, 99336, 541-310-7264, mreid@eaest.com.

Figures

1	Location Map
2	TMCF Location Map Showing Basin Irrigation Infrastructure
3	Geologic and Construction Log for Inland Well #1
4	Geologic and Construction Log for Inland Well #2
5	Geologic and Construction Log for Inland Well #3
6	Geologic and Construction Log for Inland Well #4
7	Geologic and Construction Log for Inland Well #5

Attachments

A	Limited License Application (OWRD form)
B	Water Availability Statement
C	Conceptual AR Pilot Testing Program
D	Preliminary Conceptual Hydrogeologic Model
E	Water Quality Pre-Assessment
F	Quality Assurance and Quality Control Plan

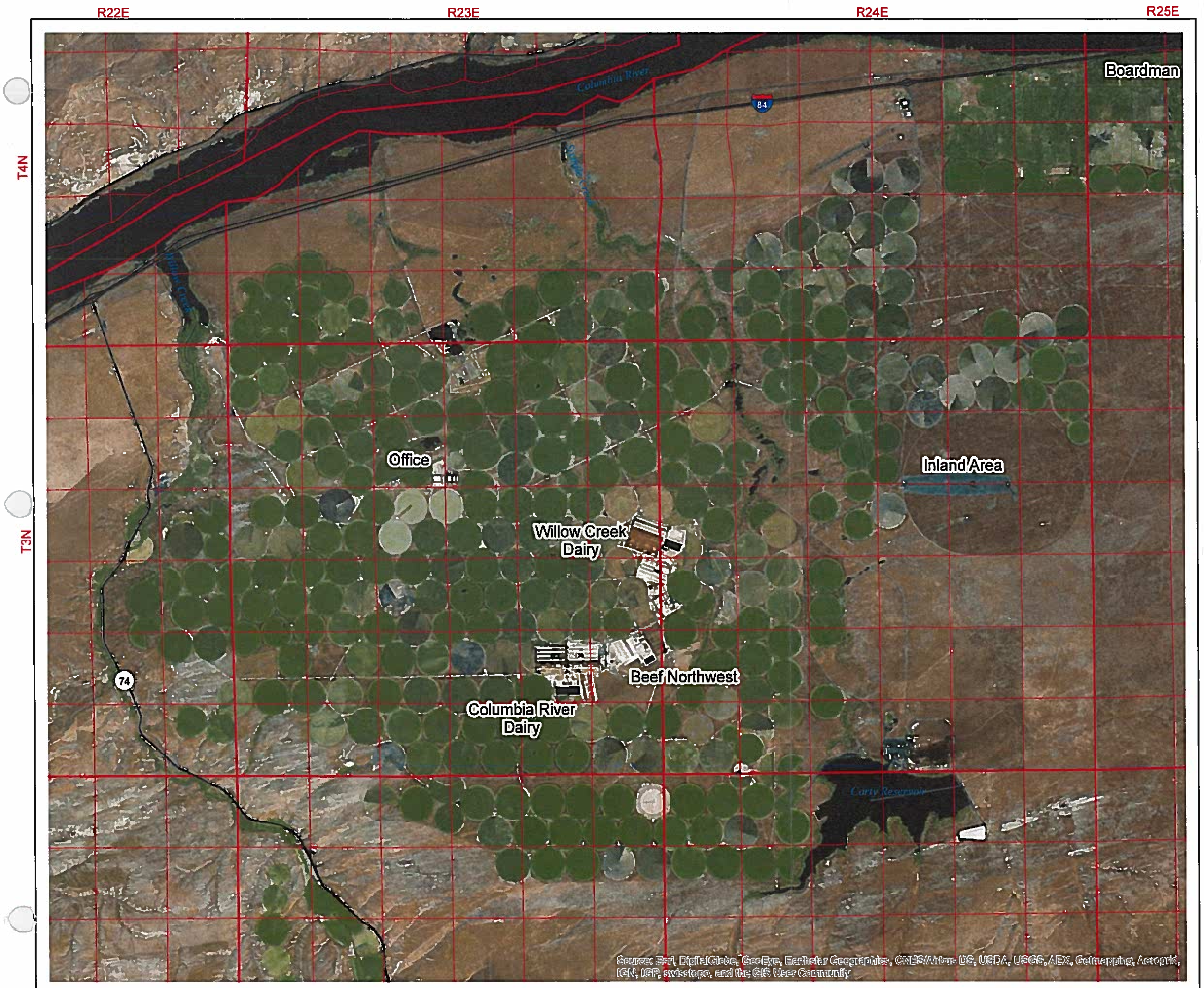

Figure 1.

Threemile Canyon Farm

Location Map

Legend

- highways
- Section
- Township

0 0.5 1 2 3 Miles

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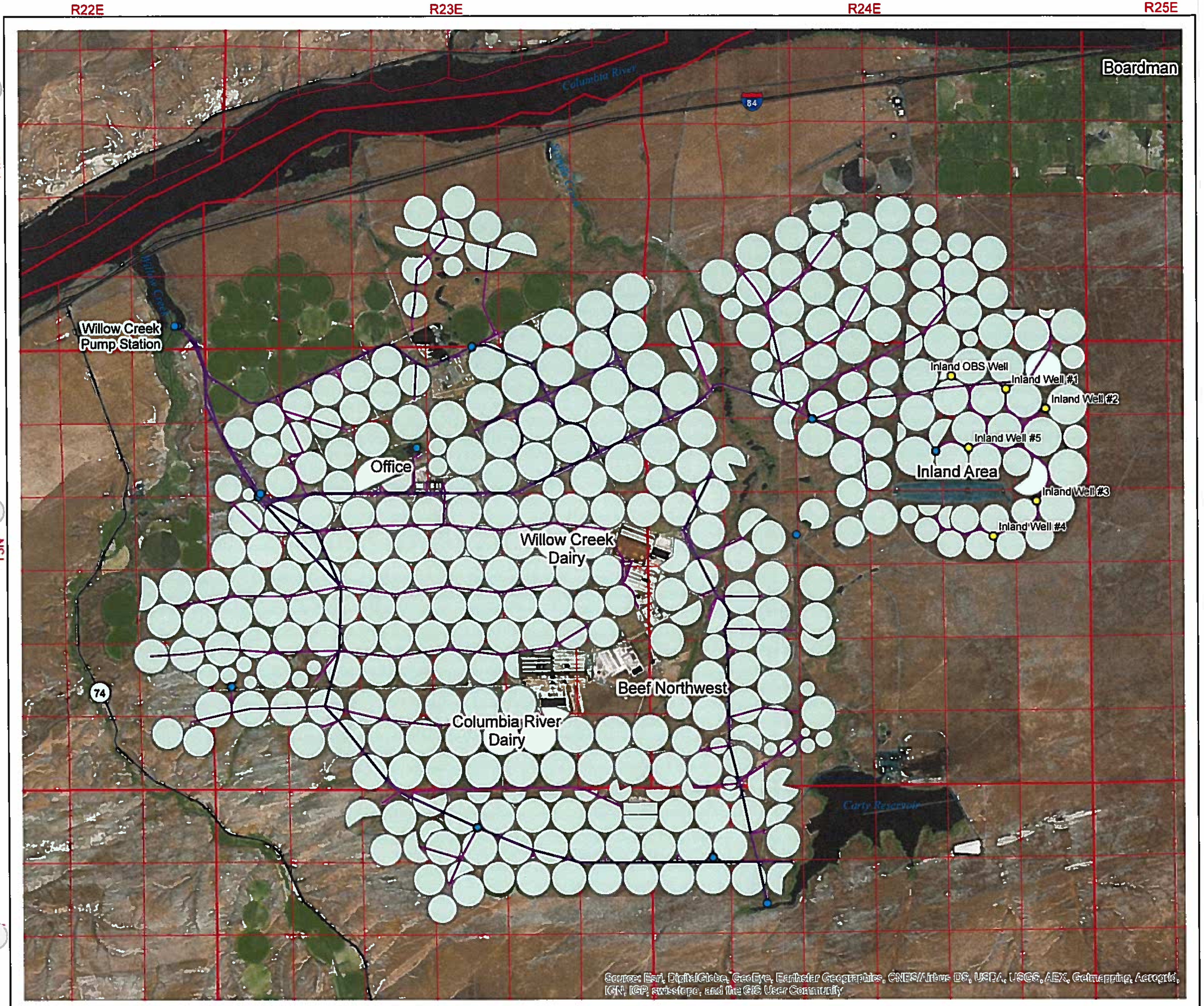

Figure 2.

Threemile Canyon Farm

TMCF location map showing basic irrigation infrastructure

Legend

- Inland Wells
- TMCF Pumps
- TMCF Submain lines
- TMCF Main lines
- highways
- TMCF Circles
- Section
- Township

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OWRD

0 0.5 1 2 3 Miles

N

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Figures

Figure 3. Geologic and Construction Log for Inland Well #1

Geologic Log of: Inland Well #1

Project: TMCF Inland Wells | **State Well ID: MORR 52037**

Logged By: Jon Travis R.G. | **Borehole Diameter: 24", 19", 10"**

Location: NE, SE, sec. 2, T3N, R24E

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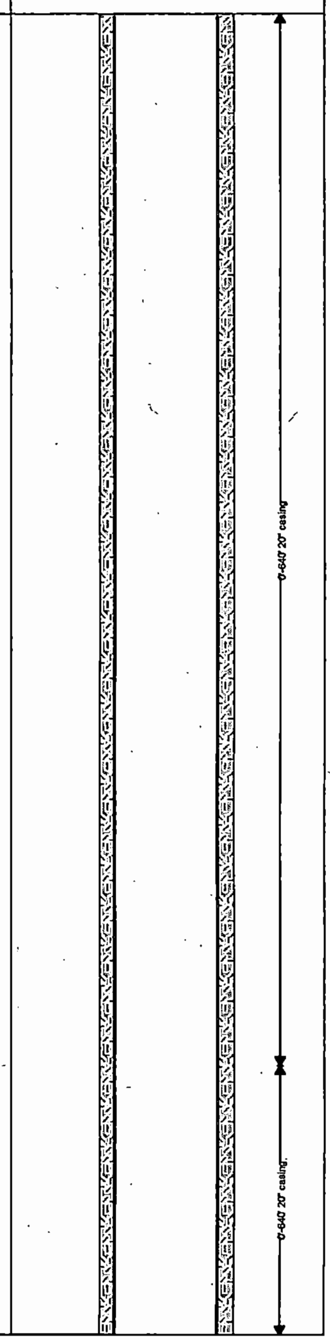
Depth (ft. bgs)	Lithologic Description	Elevation (ft. amsl)	Geochemistry Sample
0	Ground Surface	608 / 0	
0–20	**Flood Deposit** fine sand		
20–45	silty fine sand	588 / 20	
45–100	**Alkali Canyon Formation** tan clay	563 / 45	
100–110	gray clay	508 / 100	
110–166	**Elephant Mountain Member - Saddle Mountains Basalt** red weathered flow top; dense interior	498 / 110	
166–185	**Rattlesnake Ridge Member - Ellensburg Formation** gray clay	442 / 166	
185–228	gray clay with invasive basalt lobes	423 / 185	
228–345	**Pomona Member - Saddle Mountains Basalt** red weathered flow top; dense interior	380 / 228	
345–398	**Selah Member - Ellensburg Formation** green claystone	263 / 345	
398–500	**Umatilla Member - Saddle Mountains Basalt** flow top; dense interior	210 / 398	

Well Construction



Drilled By: Person Pump and Drilling
Drilling Method: mud/air rotary
Date Completed: 1/23/2013

Total Depth: 1450 ft.
Static Water Level: 190.97 ft bgs (1-29

Figure 3. Geologic and Construction Log for Inland Well #1

Geologic Log of: Inland Well #1

Project: TMCF Inland Wells — **State Well ID: MORR 52037**

Logged By: Jon Travis R.G. — **Borehole Diameter: 24", 19", 10"**

Location: NE, SE, sec. 2, T3N, R24E

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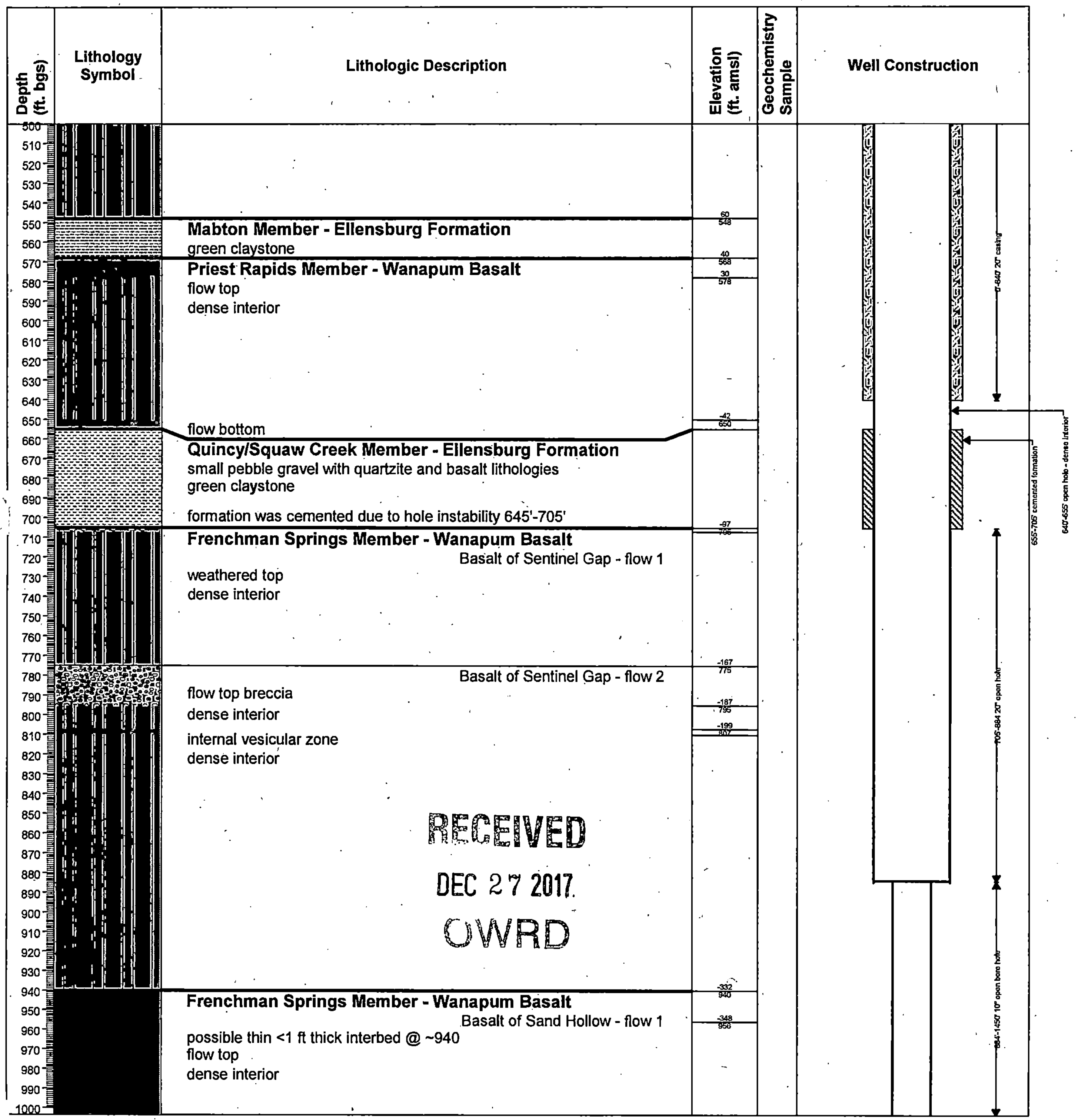

Drilled By: Person Pump and Drilling — **Total Depth: 1450 ft.**

Drilling Method: mud/air rotary — **Static Water Level: 190.97 ft bgs (1-29**

Date Completed: 1/23/2013

Figure 3. Geologic and Construction Log for Inland Well #1

Geologic Log of: Inland Well #1

Project: TMCF Inland Wells | **State Well ID: MORR 52037**

Logged By: Jon Travis R.G. | **Borehole Diameter: 24", 19", 10"**

Location: NE, SE, sec. 2, T3N, R24E

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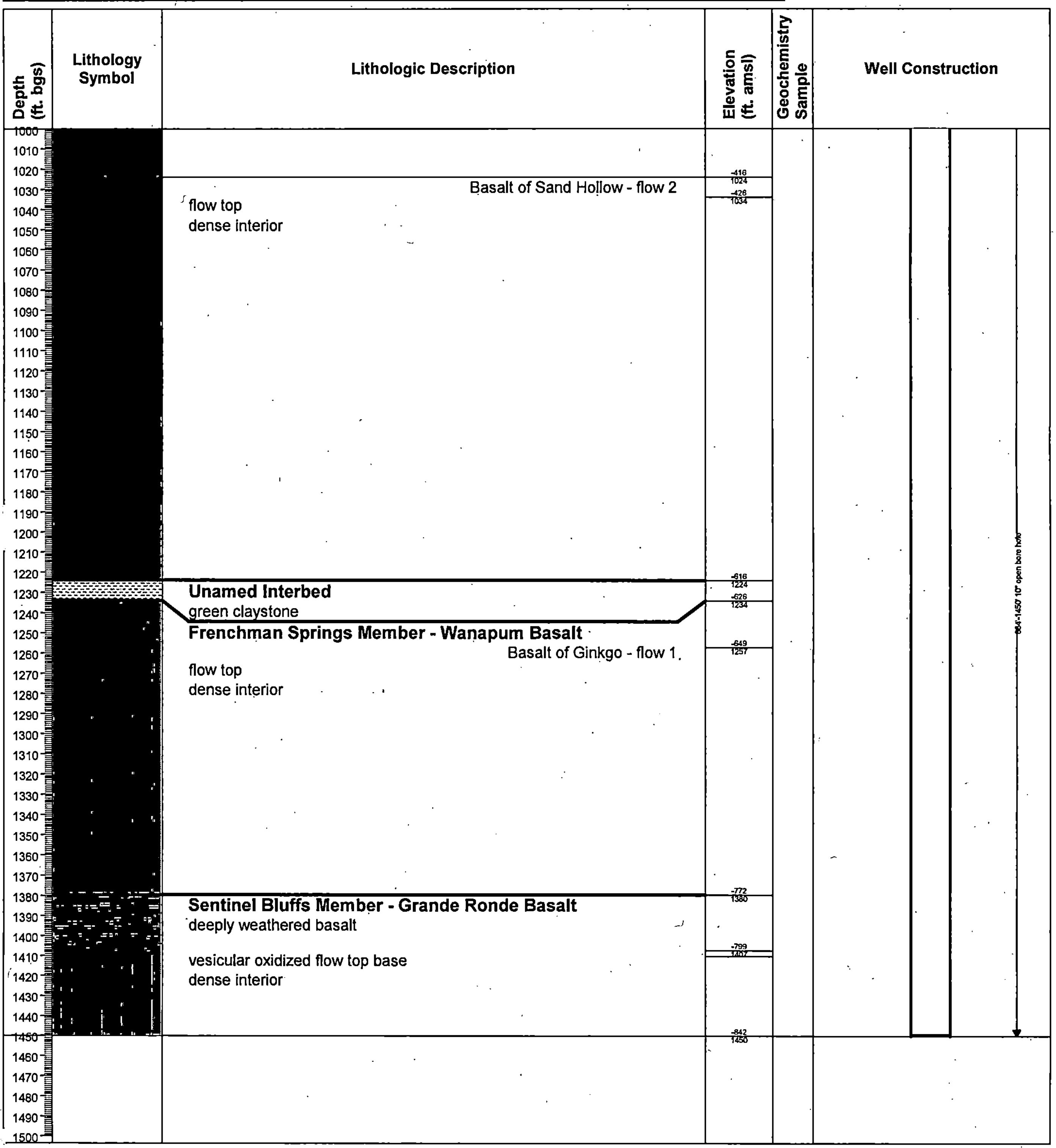

Drilled By: Person Pump and Drilling
Drilling Method: mud/air rotary
Date Completed: 1/23/2013

Total Depth: 1450 ft.
Static Water Level: 190.97 ft bgs (1-29
Page: 3 of 3

Figure 4. Geologic and Construction Log for Inland Well #2

Geologic Log of: Inland Well 2

Project: TMCF Inland Wells | **State Well ID: MORR 52045**

Logged By: Jon Travis R.G. | **Borehole Diameter: 24", 19"**

Location: SE, SW, sec. 1, T3N, R24E

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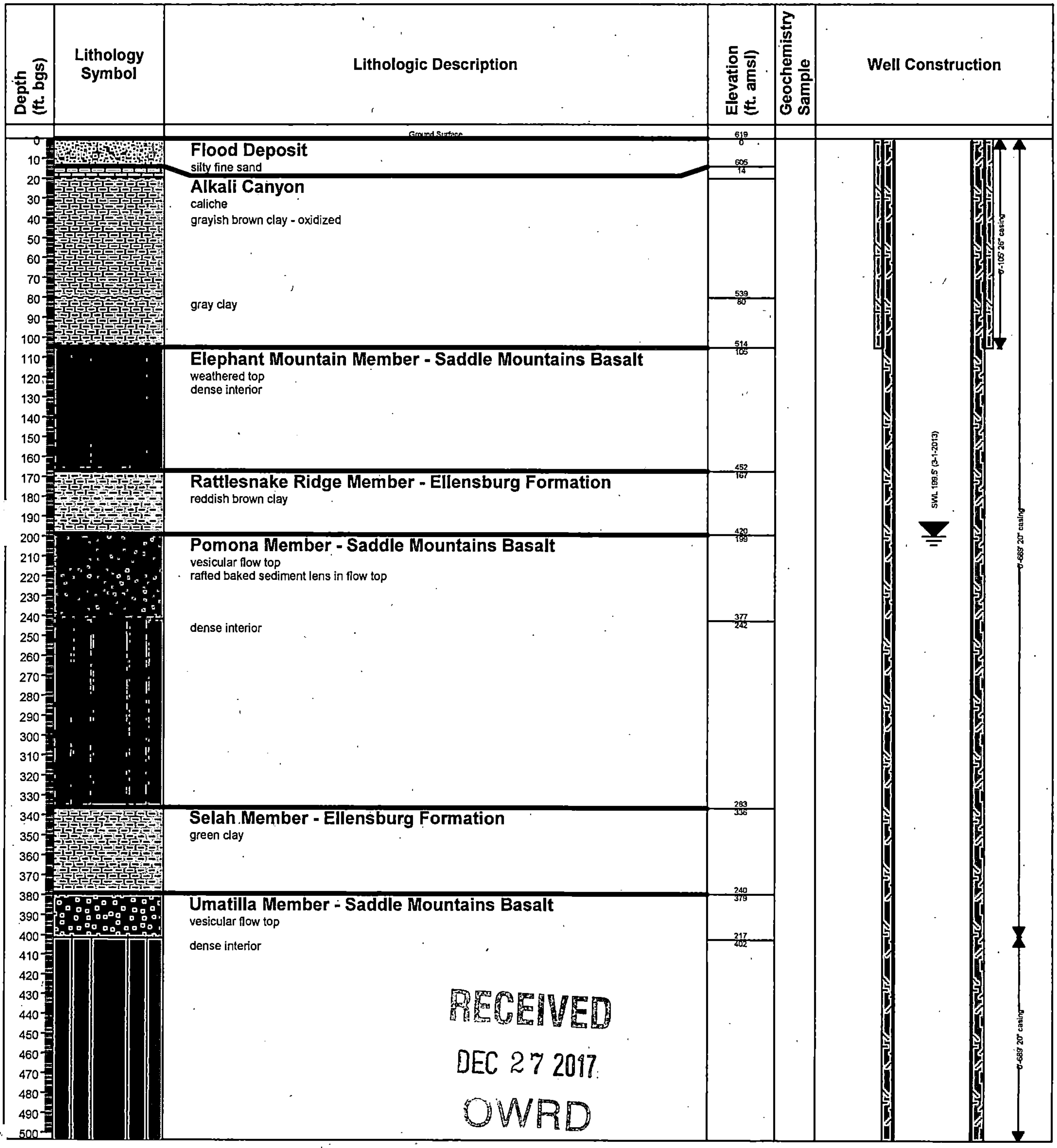

Drilled By: Person Pump and Drilling
Drilling Method: Air/Mud Rotary
Date Completed: 4-3-2013

Total Depth: 1053 ft. (4-3-2013)
Static Water Level: 199.5' bgs (3-1-201

Figure 4. Geologic and Construction Log for Inland Well #2

Geologic Log of: Inland Well 2

Project: TMCF Inland Wells | **State Well ID: MORR 52045**

Logged By: Jon Travis R.G. | **Borehole Diameter: 24", 19"**

Location: SE, SW, sec. 1, T3N, R24E

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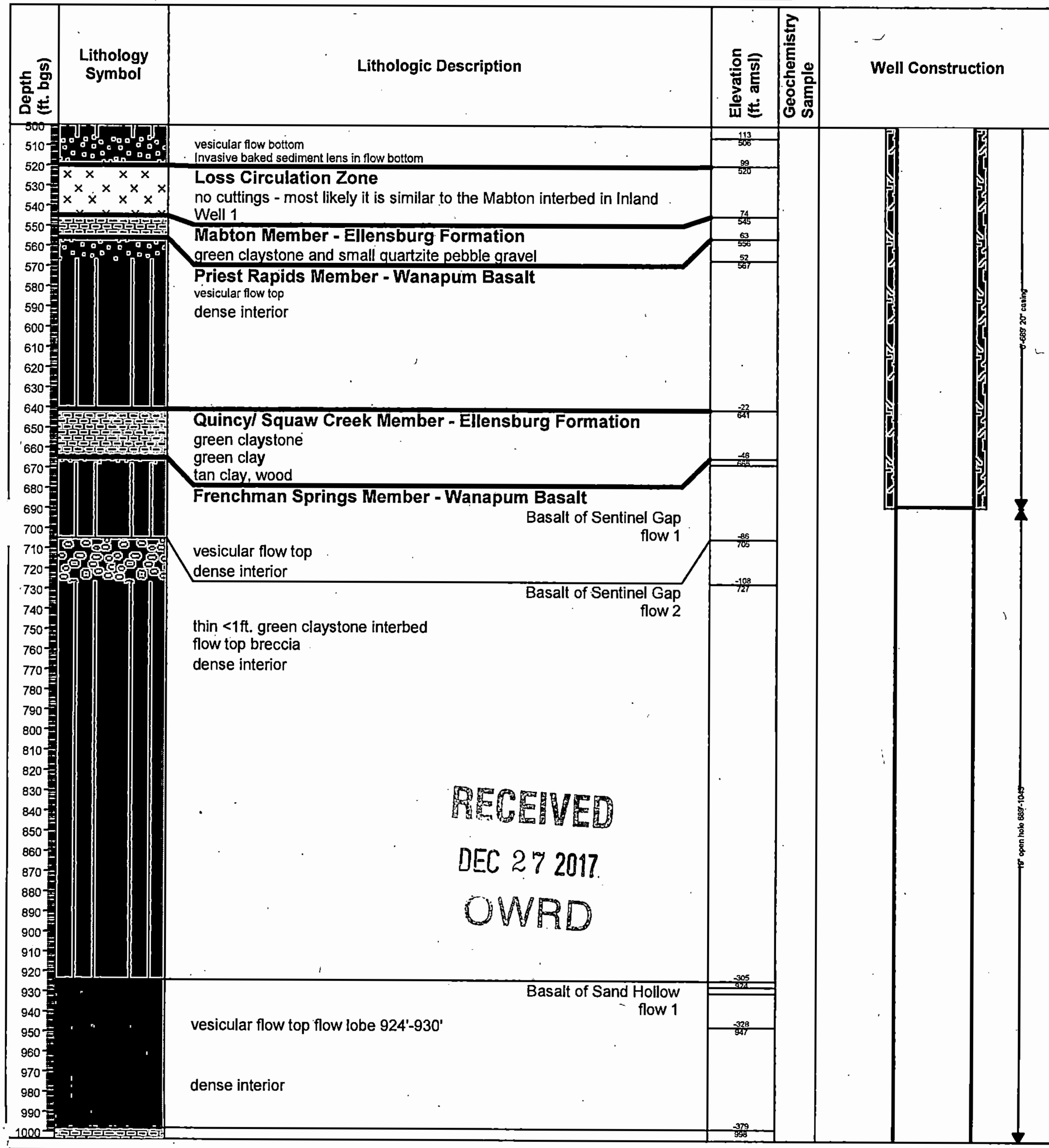

Drilled By: Person Pump and Drilling
Drilling Method: Air/Mud Rotary
Date Completed: 4-3-2013

Total Depth: 1053 ft. (4-3-2013)
Static Water Level: 199.5' bgs (3-1-201

Figure 4. Geologic and Construction Log for Inland Well #2

Geologic Log of: Inland Well 2

Project: TMCF Inland Wells | **State Well ID: MORR 52045**

Logged By: Jon Travis R.G. | **Borehole Diameter: 24", 19"**

Location: SE, SW, sec. 1, T3N, R24E

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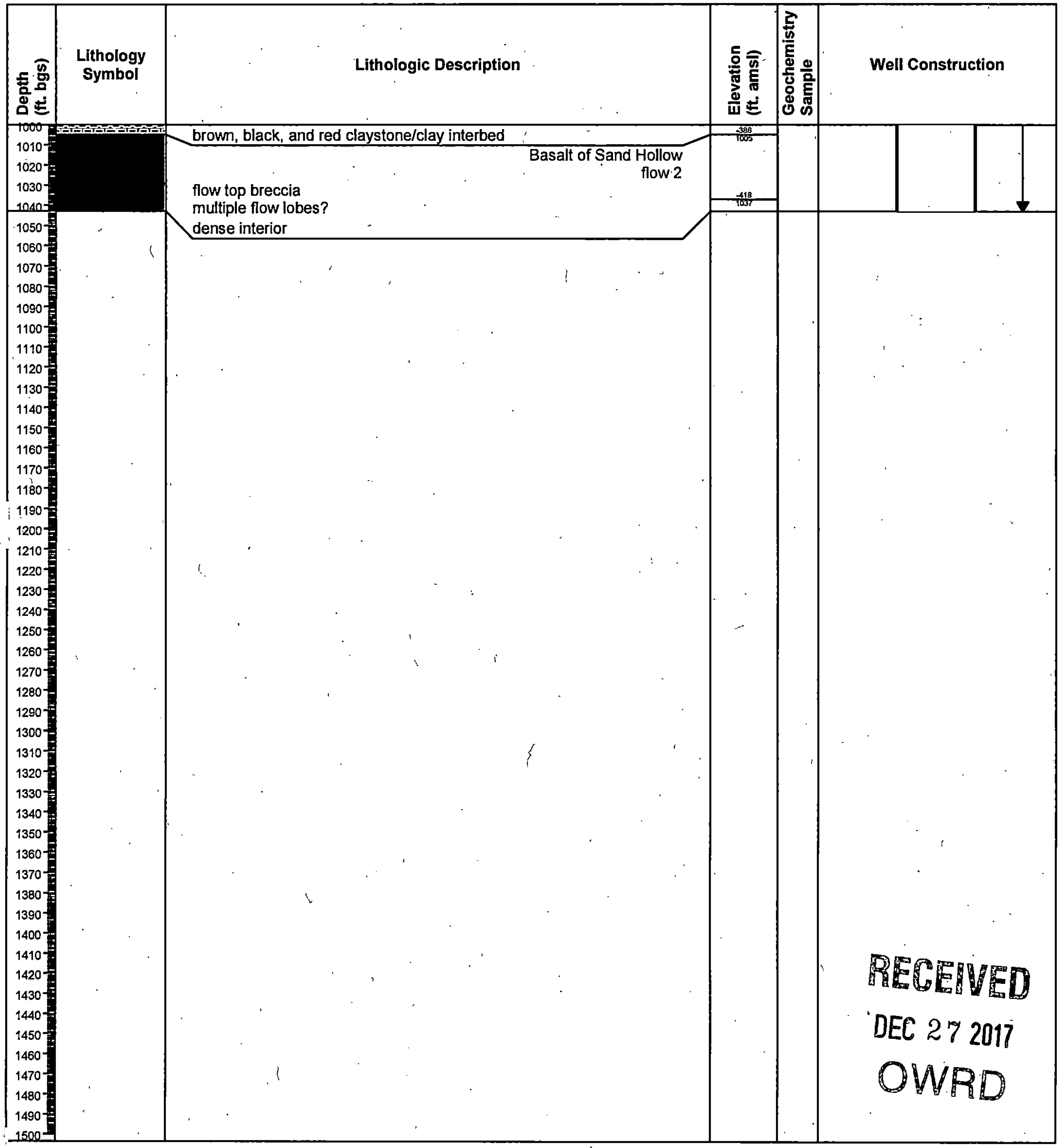

Drilled By: Person Pump and Drilling
Drilling Method: Air/Mud Rotary
Date Completed: 4-3-2013

Total Depth: 1053 ft. (4-3-2013)
Static Water Level: 199.5' bgs (3-1-201

Figure 5. Geologic and Construction Log for Inland Well #3

Geologic Log of: Inland Well 3

Project: TMCF Inland Wells — **State Well ID: MORR 52132**

Logged By: Jon Travis R.G. — **Borehole Diameter: 30", 24", 19"**

Location: NE, NW, sec. 13, T3N, R24E

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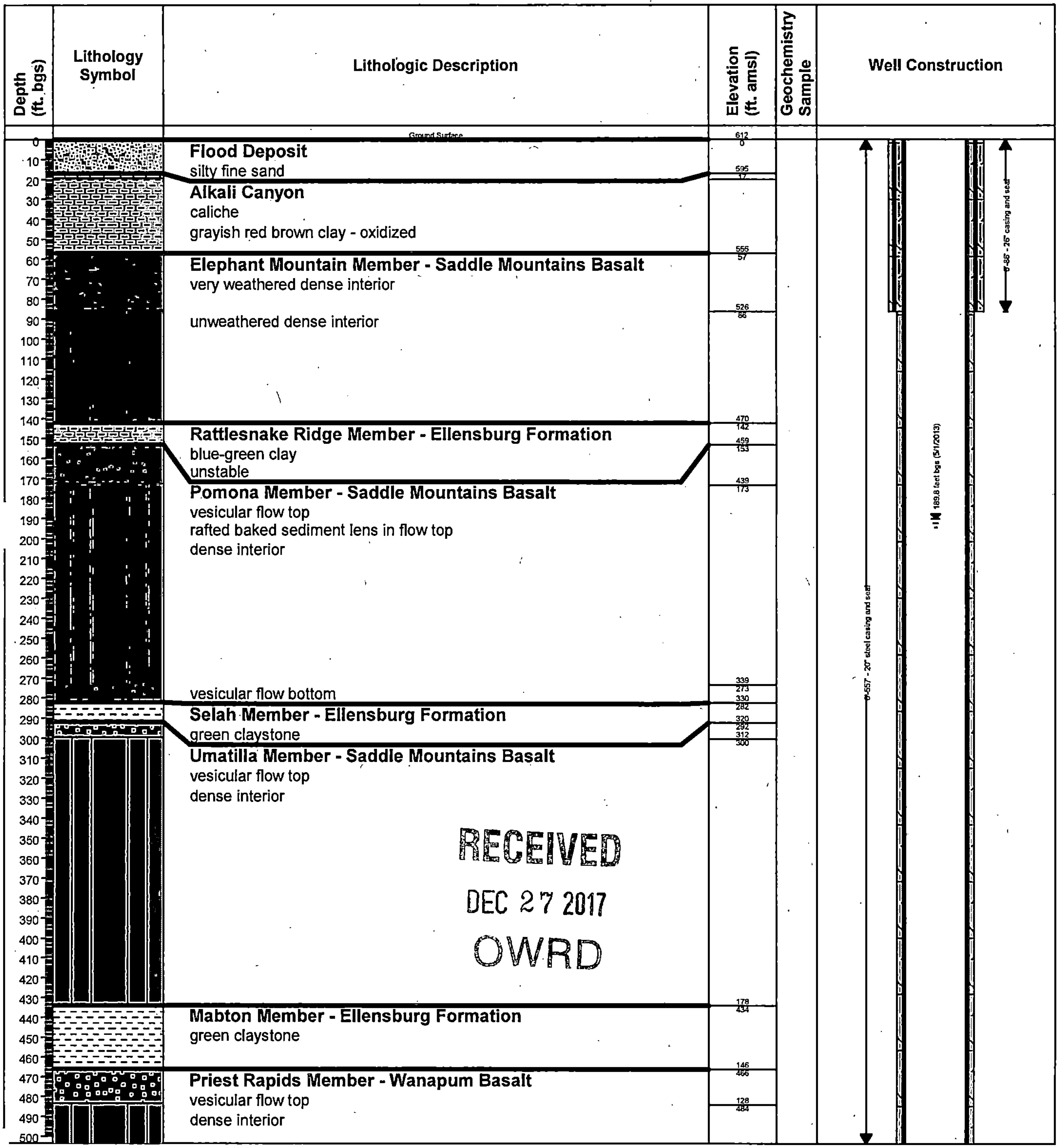
Phone: 509.591.0264



Drilled By: Person Pump and Drilling
Drilling Method: Air/Mud Rotary
Date Completed: 4/25/2013

Total Depth: 926 ft. (4/25/2013)
Static Water Level: 189.8 feet bgs (4/2
Page: 1 of 2

Figure 5. Geologic and Construction Log for Inland Well #3

Geologic Log of: Inland Well 3

Project: TMCF Inland Wells | **State Well ID: MORR 52132**

Logged By: Jon Travis R.G. | **Borehole Diameter: 30", 24", 19"**

Location: NE, NW, sec. 13, T3N, R24E

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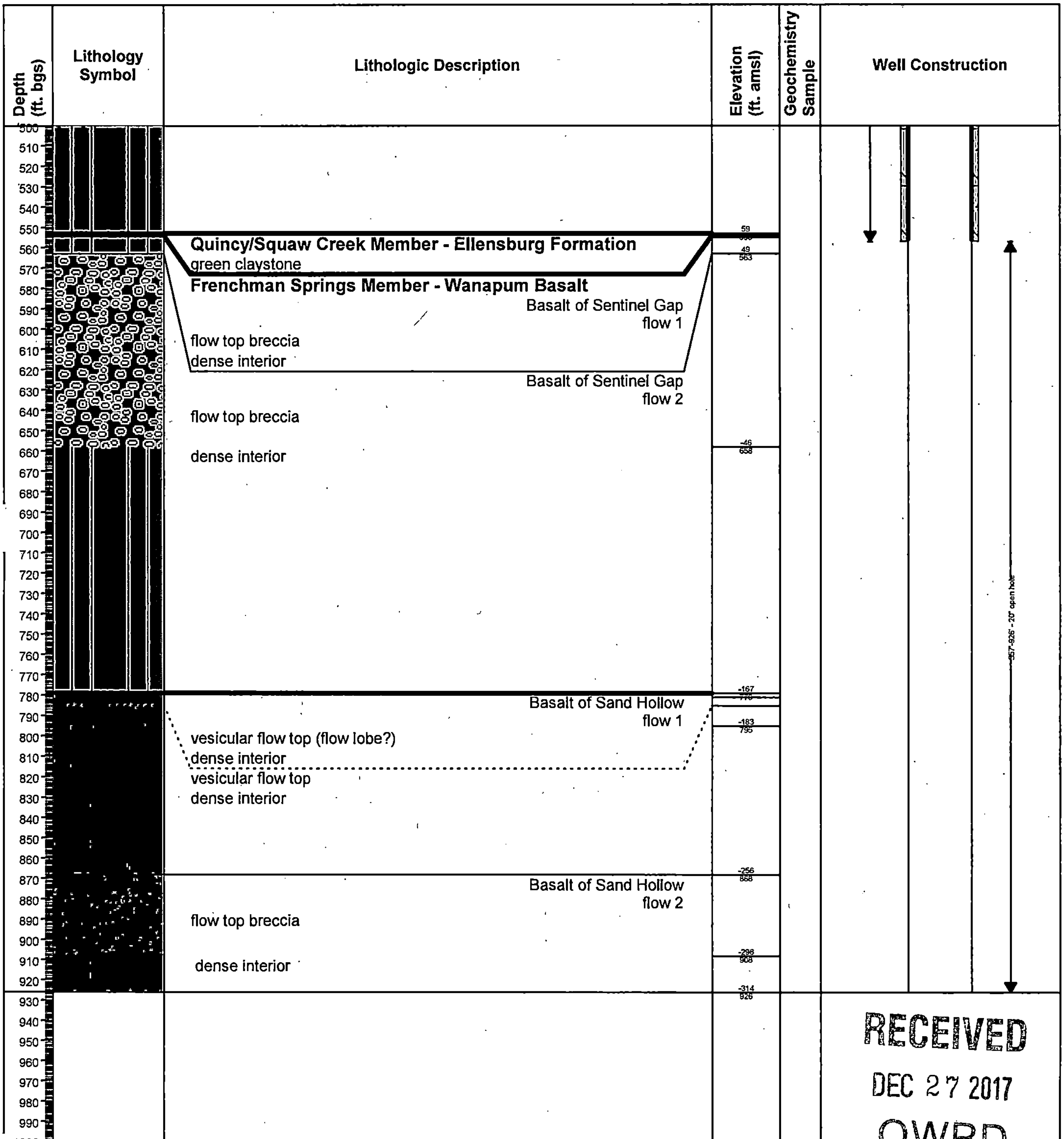
8019 W. Quinault Ave, Suite 201
Kennewick, WA 99336
Phone: 509.591.0264



Drilled By: Person Pump and Drilling
Drilling Method: Air/Mud Rotary
Date Completed: 4/25/2013

Total Depth: 926 ft. (4/25/2013)
Static Water Level: 189.8 feet bgs (4/2

Figure 6. Geologic and Construction Log for Inland Well #4

Geologic Log of: Inland Well 4

Project: TMCF Inland Wells | **State Well ID: MORR 52131**

Logged By: Jon Travis R.G. | **Borehole Diameter: 30", 24", 19"**

Location: NW, SE, sec. 14, T3N R24E

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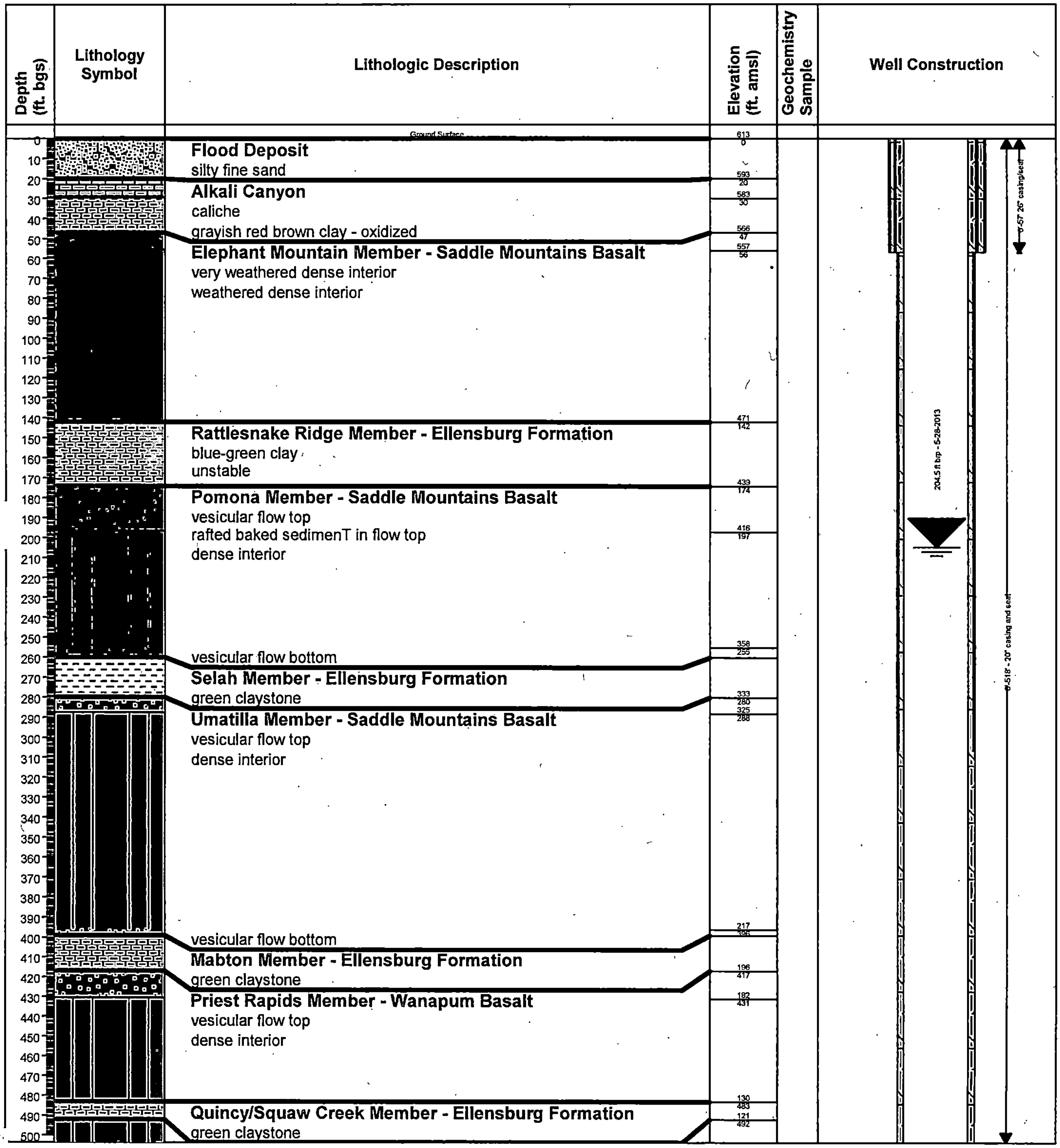
Kennewick, WA 99336
Phone: 509.591.0264



Drilled By: Person Pump and Drilling | **Total Depth: 966 ft.**

Drilling Method: Air/Mud Rotary | **Static Water Level: 204.5 - 5-28-2013 (**

Date Completed: 5-19-2013 | **Page: 1 of 2**

Figure 6. Geologic and Construction Log for Inland Well #4

Geologic Log of: Inland Well 4

Project: TMCF Inland Wells | **State Well ID: MORR 52131**

Logged By: Jon Travis R.G. | **Borehole Diameter: 30", 24", 19"**

Location: NW, SE, sec. 14, T3N R24E

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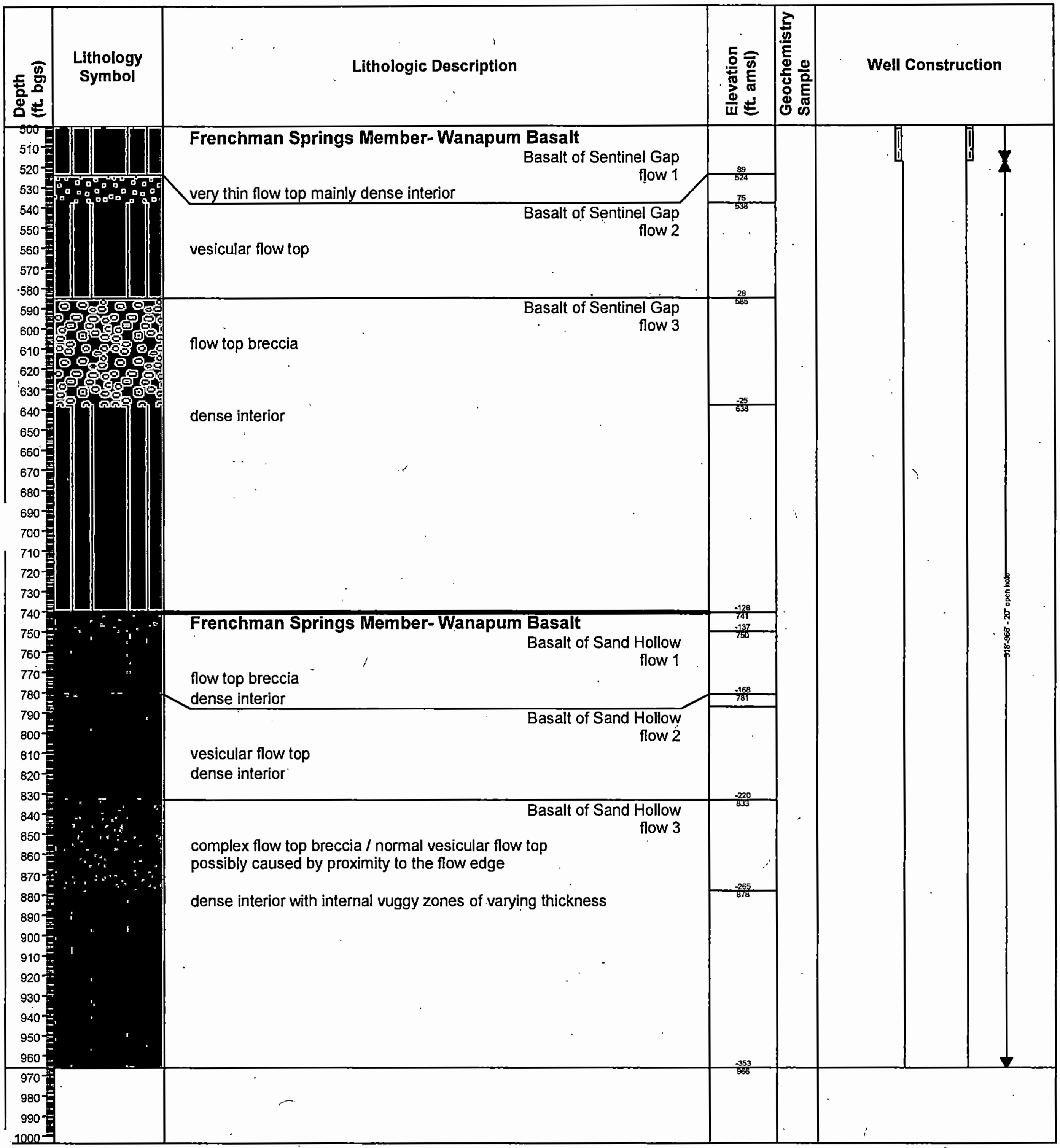
Phone: 509.591.0264



Drilled By: Person Pump and Drilling
Drilling Method: Air/Mud Rotary
Date Completed: 5-19-2013

Total Depth: 966 ft.
Static Water Level: 204.5 - 5-28-2013 (
Page: 2 of 2

Figure 7. Geologic and Construction Log for Inland Well #5

Geologic Log of: Inland Well #5

Project: TMCF Inland Wells | **State Well ID: MORR 52130**

Logged By: Jon Travis R.G. | **Borehole Diameter: 30", 24", 19"**

Location: SE, NW, sec. 11, T3N, R24E

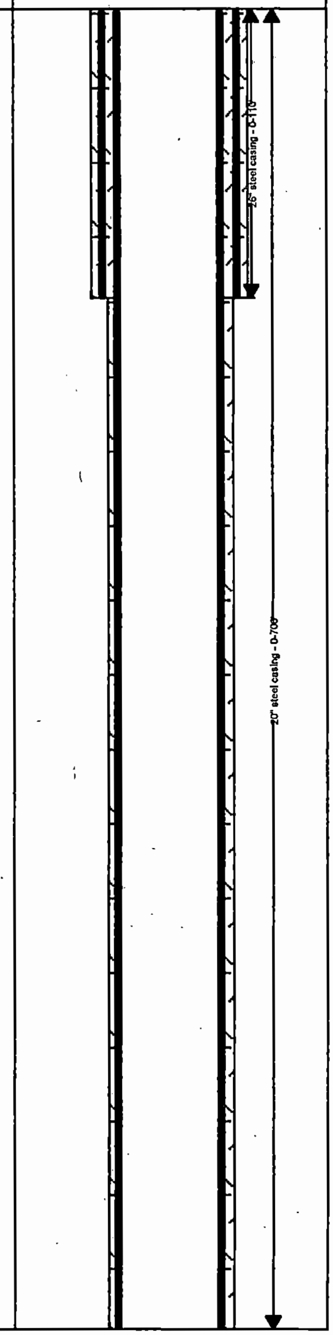
EA Engineering, Science, and Technology, Inc., PBC
8019 W. Quinault Ave, Suite 201
Kennewick, WA 99336
Phone: 509.591.0264

Depth (ft. bgs): 0–500

Lithology Symbol

Lithologic Description	Elevation (ft. amsl) / Depth	Geochemistry Sample
Ground Surface	608 / 0	
Flood Deposit fine sand		
caliche	594 / 14	
Alkali Canyon Formation tan clay	571 / 37	
Elephant Mountain Member - Saddle Mountains Basalt red weathered flow top	511 / 97	
dense interior	473 / 135	
Rattlesnake Ridge Member - Ellensburg Formation brown clay	453 / 155	
gravelly green-brown clay	423 / 185	
Pomona Member - Saddle Mountains Basalt red weathered flow top	413 / 195	
dense interior		
Selah Member - Ellensburg Formation green claystone	278 / 330	
Umatilla Member - Saddle Mountains Basalt flow top	246 / 362	
dense interior	238 / 370	
dense interior with invasive baked claystone pods	193 / 415	

Well Construction



Drilled By: Person Pump and Drilling
Drilling Method: mud/air rotary/reverse circ.
Date Completed: 5-16-2013

Total Depth: 1020 ft.
Static Water Level: 198.8' (5-16-2013)

Figure 7. Geologic and Construction Log for Inland Well #5

Geologic Log of: Inland Well #5

Project: TMCF Inland Wells | **State Well ID: MORR 52130**

Logged By: Jon Travis R.G. | **Borehole Diameter: 30", 24", 19"**

Location: SE, NW, sec. 11, T3N, R24E

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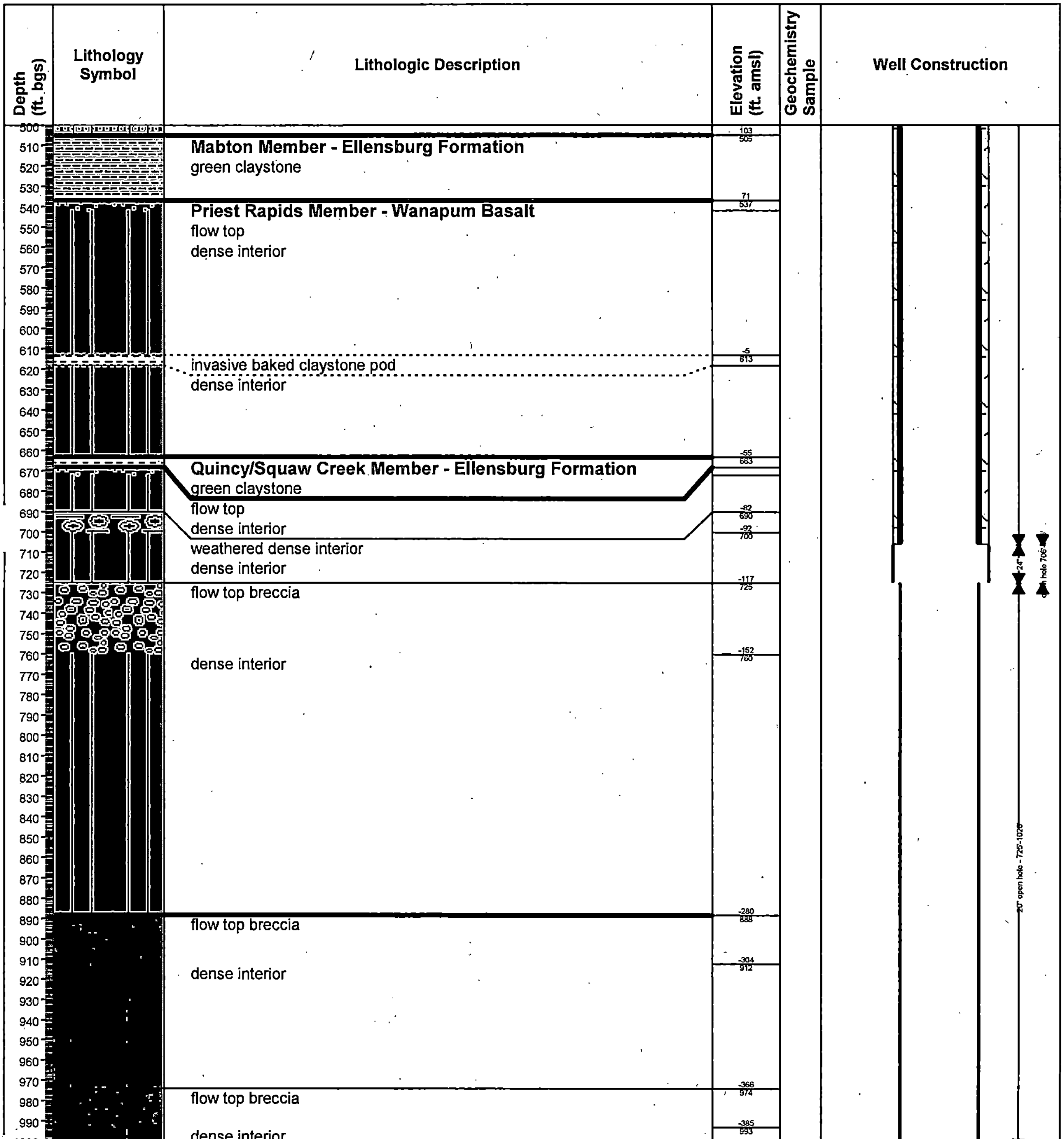
Kennewick, WA 99336
Phone: 509.591.0264



Drilled By: Person Pump and Drilling
Drilling Method: mud/air rotary/reverse circ.
Date Completed: 5-16-2013

Total Depth: 1020 ft.
Static Water Level: 198.8' (5-16-2013)
Page: 2 of 3

Figure 7. Geologic and Construction Log for Inland Well #5

Geologic Log of: Inland Well #5

Project: TMCF Inland Wells — **State Well ID: MORR 52130**

Logged By: Jon Travis R.G. — **Borehole Diameter: 30", 24", 19"**

Location: SE, NW, sec. 11, T3N, R24E

EA Engineering, Science, and Technology, Inc., PBC
8019 W. Quinault Ave, Suite 201
Kennewick, WA 99336
Phone: 509.591.0264

Depth (ft. bgs)	Lithology Symbol	Lithologic Description	Elevation (ft. amsl)	Geochemistry Sample	Well Construction
1000					
1010					
1020			-412 1020		
1030					
1040					
1050					
1060					
1070					
1080					
1090					
1100					
1110					
1120					
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1440					
1450					
1460					
1470					
1480					
1490					
1500					

Drilled By: Person Pump and Drilling — **Total Depth: 1020 ft.**

Drilling Method: mud/air rotary/reverse circ. — **Static Water Level: 198.8' (5-16-2013)**

Date Completed: 5-16-2013 —

Attachments

ATTACHMENT A

Threemile Canyon Farms – Inland Project
Limited License Application for Aquifer Recharge

Project Description:

At its potential full build-out the Inland AR Project could involve the injection of 2,500 gallons per minute (gpm) per well into one or more of the five TMCF Inland Area irrigation wells. At full potential build out a maximum instantaneous injection rate of 12,500 gpm and a maximum annual volume of approximately 10,000 acre-feet is possible. Given that, the work to be conducted under the proposed Limited License will be implemented incrementally, or in phases, starting with a source water treatability phase and pilot testing at one Inland well in calendar year 2018. In subsequent years the project will expand to include additional wells as needed to achieve the mitigation target and based on previous results.

The water source for the proposed Inland AR project would be diverted from Willow Creek (Columbia River-John Day Pool) between November 1 and April 15 under the LL. Source water would be pumped to the project area using the existing irrigation system.

The Inland Area consists of 2 subdivisions, 71 irrigated circles on the Inland Farm and 23 irrigated circles on the Radar Range. The total water requirement for the Inland Area is approximately 82,700 gpm. The Inland booster pump station, with its maximum capacity of approximately 65,000 gpm, is sufficient to irrigate approximately 79% of the 94 combined Inland Farm and Radar Range circles simultaneously. The balance of the required irrigation water is supplied by the 5 Inland irrigation wells.

As noted above, the project will focus on a phased approach. Initial AR work is currently planned to be will be done at Inland Well #1 (MORR 52037), with potential expansion to Inland Well #2 (MORR 52045) the following year. Given that, before injection testing begins the targeted well may change based on TMCF infrastructure contraints. In the even that such a change becomes necessary, TMCF will disucss those changes, and the need for them, with OWRD and DEQ staff before finalizing any plans. Use of additional Inland wells will be contingent on the results of work at Inland Wells 1 and 2. The existing wells will require some modifications for AR including interties to main pipelines to allow delivery of water to the wells. These modifications are discussed further in the attachments.

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem Oregon 97301-1271
(503) 986-0900
www.wrd.state.or.us

Application for Limited Water Use License

License No.:__________

Applicant Information

NAME				PHONE (HM)
Greg Harris, Manager, Threemile Canyon Farms, Inc.				
PHONE (WK) (541) 481-9274	CELL			FAX
ADDRESS 75906 Threemile Road				
CITY Boardman	STATE OR	ZIP 97818	E-MAIL * gharris@rdoffut.com	

Agent Information

NAME			PHONE	FAX
Kevin Lindsey, Ph.D. EA Engineering, Science, & Technology,				
ADDRESS 8019 W. Quinault Avenue, Suite 201				CELL (509) 947-5729
CITY Kennewick	STATE WA	ZIP 99336	E-MAIL * klindsey@eaest.com	

I (We) make application for a Limited License to use or store the following described surface waters or groundwater – not otherwise exempt, or to use stored water of for a use of a short-term or fixed-duration:

1. **SOURCE(S) OF WATER:** **Columbia River** a tributary of Pacific Ocean
2. **AMOUNT OF WATER** to be diverted; Maximum and instantaneous rate (cubic feet or gallons per minute): 27.85 cfs
3. Total volume (gallons or acre-feet): 10,000 acre feet.
   If water is to be used from more than one source, give the quantity from each: N/A - Water to be injected in up to 5 wells at 2500 gpm each for a total maximum injection of 12,500 gpm.

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4. **INTENDED USE(S) OF WATER:** (check all that apply)
   - ☐ Road construction or maintenance
   - ☐ General construction
   - ☐ Forestland and rangeland management; or
   - ☐ Other: **Aquifer Recharge**

4. **DESCRIPTION OF PROPOSED PROJECT:** Include a description of the place of use as shown on the accompanying site map, the method of water diversion, the type of equipment to be used (including pump horsepower, if applicable), length and dimensions of supply ditches and pipelines: **See Attachment A**

5. **PROJECT SCHEDULE:** (List day, month, and year)
   Date water use will begin: as soon as limited license is issued if prior to April 14, 2018
6. Date water use will be completed: December 31, 2023

   Months of the year water would be diverted and used: Diverting water from October 1 thru April 14 annually for recharge injection. Water will remain in underground storage for the duration of the limited license.

   If for other than irrigation from stored water, how and where will water be discharged after use:

   No withdrawal of stored water. This application is for artificial groundwater recharge only.

[signature] Greg Harris Farm Manager 12/21/2017
Applicant Signature — Print Name *and title if applicable* — Date

Land Use Information Form

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1266
(503) 986-0900
www.wrd.state.or.us

Applicant(s): Threemile Canyon Farms, (Greg Harris - Farm Manager)

Mailing Address: 75906 Threemile Road

City: Boardman State: OR Zip Code: 97818 Daytime Phone: (541) 481-9274

A. Land and Location

Please include the following information for all tax lots where water will be diverted (taken from its source), conveyed (transported), and/or used or developed. Applicants for municipal use, or irrigation uses within irrigation districts may substitute existing and proposed service-area boundaries for the tax-lot information requested below.

Township	Range	Section	¼ ¼	Tax Lot #	Plan Designation (e.g., Rural Residential/RR-5)	Water to be:	Proposed Land Use:
4-N	22-E	36	NWSE	100	EFU	☒ Diverted ☐ Conveyed ☐ Used	Aquifer Recharge
3-N	24-E	1 2	SESW NESE	100	EFU	☒ Diverted ☒ Conveyed ☒ Used	Aquifer Recharge
3-N	24-E	11	SENW	100	EFU	☒ Diverted ☒ Conveyed ☒ Used	Aquifer Recharge
3-N	24-E	13 14	NENW NWSE	100	EFU	☒ Diverted ☒ Conveyed ☒ Used	Aquifer Recharge

List all counties and cities where water is proposed to be diverted, conveyed, and/or used or developed:

Morrow - conveyed and stored; Gilliam - diverted

B. Description of Proposed Use

Type of application to be filed with the Water Resources Department:

☐ Permit to Use or Store Water ☐ Water Right Transfer ☐ Permit Amendment or Ground Water Registration Modification
☒ Limited Water Use License ☐ Allocation of Conserved Water ☐ Exchange of Water

Source of water: ☐ Reservoir/Pond ☐ Ground Water ☒ Surface Water (name) Columbia River

Estimated quantity of water needed: 5.57 ☒ cubic feet per second ☐ gallons per minute ☐ acre-feet

Intended use of water: ☐ Irrigation ☐ Commercial ☐ Industrial ☐ Domestic for ______ household(s)
☐ Municipal ☐ Quasi-Municipal ☐ Instream ☒ Other Aquifer Recharge

Briefly describe:

Applicant proposes to divert 5.57 cfs from their Columbia River point of diversion in the months of November through mid-April for the purpose of aquifer recharge. The applicant will inject the water into one to five basalt wells (Inland wells) to build up a reservoir underground to offset groundwater declines in the basalt aquifer. The Columbia River water will be piped directly from the surface water diversion using the existing infrastructure, to the wells. Water will be cleaned to drinking water standards prior to injecting into the wells.

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Land Use Information Form

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1266
(503) 986-0900
www.wrd.state.or.us

NOTE TO APPLICANTS

In order for your application to be processed by the Water Resources Department (WRD), this Land Use Information Form must be completed by a local government planning official in the jurisdiction(s) where your water right will be used and developed. The planning official may choose to complete the form while you wait, or return the receipt stub to you. Applications received by WRD without the Land Use Form or the receipt stub will be returned to you. Please be aware that your application will not be approved without land use approval.

This form is NOT required if:

1) Water is to be diverted, conveyed, and/or used only on federal lands; **OR**
2) The application is for a water right transfer, allocation of conserved water, exchange, permit amendment, or ground water registration modification, and **all** of the following apply:
   a) The existing and proposed water use is located entirely within lands zoned for exclusive farm-use or within an irrigation district;
   b) The application involves a change in place of use only;
   c) The change does not involve the placement or modification of structures, including but not limited to water diversion, impoundment, distribution facilities, water wells and well houses; and
   d) The application involves irrigation water uses only.

NOTE TO LOCAL GOVERNMENTS

The person presenting the attached Land Use Information Form is applying for or modifying a water right. The Water Resources Department (WRD) requires its applicants to obtain land-use information to be sure the water rights do not result in land uses that are incompatible with your comprehensive plan. Please complete the form or detach the receipt stub and return it to the applicant for inclusion in their water right application. You will receive notice once the applicant formally submits his or her request to the WRD. The notice will give more information about WRD's water rights process and provide additional comment opportunities. You will have 30 days from the date of the notice to complete the land-use form and return it to the WRD. If no land-use information is received from you within that 30-day period, the WRD may presume the land use associated with the proposed water right is compatible with your comprehensive plan. Your attention to this request for information is greatly appreciated by the Water Resources Department. If you have any questions concerning this form, please contact the WRD's Customer Service Group at 503-986-0801.

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For Local Government Use Only

The following section must be completed by a planning official from each county and city listed unless the project will be located entirely within the city limits. In that case, only the city planning agency must complete this form. This deals only with the local land-use plan. Do not include approval for activities such as building or grading permits.

Please check the appropriate box below and provide the requested information

☒ Land uses to be served by the proposed water uses (including proposed construction) are allowed outright or are not regulated by your comprehensive plan. Cite applicable ordinance section(s): Morrow County Zoning Ordinance 3.010.

☐ Land uses to be served by the proposed water uses (including proposed construction) involve discretionary land-use approvals as listed in the table below. (Please attach documentation of applicable land-use approvals which have already been obtained. Record of Action/land-use decision and accompanying findings are sufficient.) **If approvals have been obtained but all appeal periods have not ended, check "Being pursued."**

Type of Land-Use Approval Needed (e.g., plan amendments, rezones, conditional-use permits, etc.)	Cite Most Significant, Applicable Plan Policies & Ordinance Section References	Land-Use Approval:	
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued

Local governments are invited to express special land-use concerns or make recommendations to the Water Resources Department regarding this proposed use of water below, or on a separate sheet.

Name: Stephanie Loving Title: Planner I

Signature: [signature] Phone: 541-922-4624 Date: 11/27/17

Government Entity: Morrow County Planning Department.

Note to local government representative: Please complete this form or sign the receipt below and return it to the applicant. If you sign the receipt, you will have 30 days from the Water Resources Department's notice date to return the completed Land Use Information Form or WRD may presume the land use associated with the proposed use of water is compatible with local comprehensive plans.

Receipt for Request for Land Use Information

Applicant name: ______

City or County: ______ Staff contact: ______

Signature: ______ Phone: ______ Date: ______

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Note to applicant: If the Land Use Information Form cannot be completed while you wait, please have a local government representative sign the receipt at the bottom of the next page and include it with the application filed with the Water Resources Department.

See bottom of Page 3. →

Land Use Information Form

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1266
(503) 986-0900
www.wrd.state.or.us

Applicant(s): Threemile Canyon Farms, (Greg Harris - Farm Manager)

Mailing Address: 75906 Threemile Road

City: Boardman State: OR Zip Code: 97818 Daytime Phone: (541) 481-9274

A. Land and Location

Please include the following information for all tax lots where water will be diverted (taken from its source), conveyed (transported), and/or used or developed. Applicants for municipal use, or irrigation uses within irrigation districts may substitute existing and proposed service-area boundaries for the tax-lot information requested below.

Township	Range	Section	¼ ¼	Tax Lot #	Plan Designation (e.g., Rural Residential/RR-5)	Water to be:	Proposed Land Use:
4-N	22-E	36	NWSE	100	_____	☒ Diverted ☐ Conveyed ☐ Used	Aquifer Recharge
3-N	24-E	1 2	SESW NESE	100		☒ Diverted ☒ Conveyed ☒ Used	Aquifer Recharge
3-N	24-E	11	SENW	100	_____	☒ Diverted ☒ Conveyed ☒ Used	Aquifer Recharge
3-N	24-E	13 14	NENW NWSE	100	_____	☒ Diverted ☒ Conveyed ☒ Used	Aquifer Recharge

List all counties and cities where water is proposed to be diverted, conveyed, and/or used or developed:

Gilliam - diverted; Morrow - conveyed and stored

B. Description of Proposed Use

Type of application to be filed with the Water Resources Department:

☐ Permit to Use or Store Water ☐ Water Right Transfer ☐ Permit Amendment or Ground Water Registration Modification
☒ Limited Water Use License ☐ Allocation of Conserved Water ☐ Exchange of Water

Source of water: ☐ Reservoir/Pond ☐ Ground Water ☒ Surface Water (name) Columbia River

Estimated quantity of water needed: 5.57 ☒ cubic feet per second ☐ gallons per minute ☐ acre-feet

Intended use of water: ☐ Irrigation ☐ Commercial ☐ Industrial ☐ Domestic for ______ household(s)
☐ Municipal ☐ Quasi-Municipal ☐ Instream ☒ Other Aquifer Recharge

Briefly describe:

Applicant proposes to divert 5.57 cfs from their Columbia River point of diversion in the months of November through mid-April for the purpose of aquifer recharge. The applicant will inject the water into one to five basalt wells (Inland wells) to build up a reservoir underground to offset groundwater declines in the basalt aquifer. The Columbia River water will be piped directly from the surface water diversion using existing infrastructure, to the wells. Water will be cleaned to drinking water standards prior to injecting it into the wells.

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For Local Government Use Only

following section must be completed by a planning official from each county and city listed unless the project will be located entirely within the city limits. In that case, only the city planning agency must complete this form. This deals only with the local land-use plan. Do not include approval for activities such as building or grading permits.

Please check the appropriate box below and provide the requested information

☒ Land uses to be served by the proposed water uses (including proposed construction) are allowed outright or are not regulated by your comprehensive plan. Cite applicable ordinance section(s):

☐ Land uses to be served by the proposed water uses (including proposed construction) involve discretionary land-use approvals as listed in the table below. (Please attach documentation of applicable land-use approvals which have already been obtained. Record of Action/land-use decision and accompanying findings are sufficient.) **If approvals have been obtained but all appeal periods have not ended, check "Being pursued."**

Type of Land-Use Approval Needed (e.g., plan amendments, rezones, conditional-use permits, etc.)	Cite Most Significant, Applicable Plan Policies & Ordinance Section References	Land-Use Approval:	
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued
		☐ Obtained ☐ Denied	☐ Being Pursued ☐ Not Being Pursued

Local governments are invited to express special land-use concerns or make recommendations to the Water Resources Department regarding this proposed use of water below, or on a separate sheet.

This is specifically for Threemile Canyon Farms

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Name: Michelle Colby Title: Planning Director

Signature: Michelle Z Colby Phone: 541-384-2381 Date: 11-7-17

Government Entity: Gilliam County

Note to local government representative: Please complete this form or sign the receipt below and return it to the applicant. If you sign the receipt, you will have 30 days from the Water Resources Department's notice date to return the completed Land Use Information Form or WRD may presume the land use associated with the proposed use of water is compatible with local comprehensive plans.

Receipt for Request for Land Use Information

Applicant name: ____________________

City or County: ____________________ Staff contact: ____________________

ature: ____________________ Phone: __________ Date: __________

ATTACHMENT B

Threemile Canyon Farms – Inland Project
Limited License Application for Aquifer Recharge

Water Availability Statement

Note:
Water availability form with attached maps have been submitted to regional watermaster in Pendleton, Oregon office.

Reference email on 12/4/2017 from M. Reid for application that was received by Watermasters Ken Thiemann + Meg Silleman.

This page to be completed by the local Watermaster.

WATER AVAILABILITY STATEMENT

Name of Applicant: Greg Harris - Three Mile Canyon Farms. Limited License Number: LL-1725

1. To your knowledge, has the stream or basin that is the source for this application ever been regulated for prior rights?

O Yes X No

If yes, please explain:

2. Based on your observations, would there be water available in the quantity and at the times needed to supply the use proposed by this application?

X Yes O No

3. Do you observe this stream system during regular fieldwork?

O Yes X No

If yes, what are your observations for the stream?

4. If the source is a well and if WRD were to determine that there is the potential for substantial interference with nearby surface water sources, would there still be ground water and surface water available during the time requested and in the amount requested without injury to existing water rights?

O Yes O No X N/A

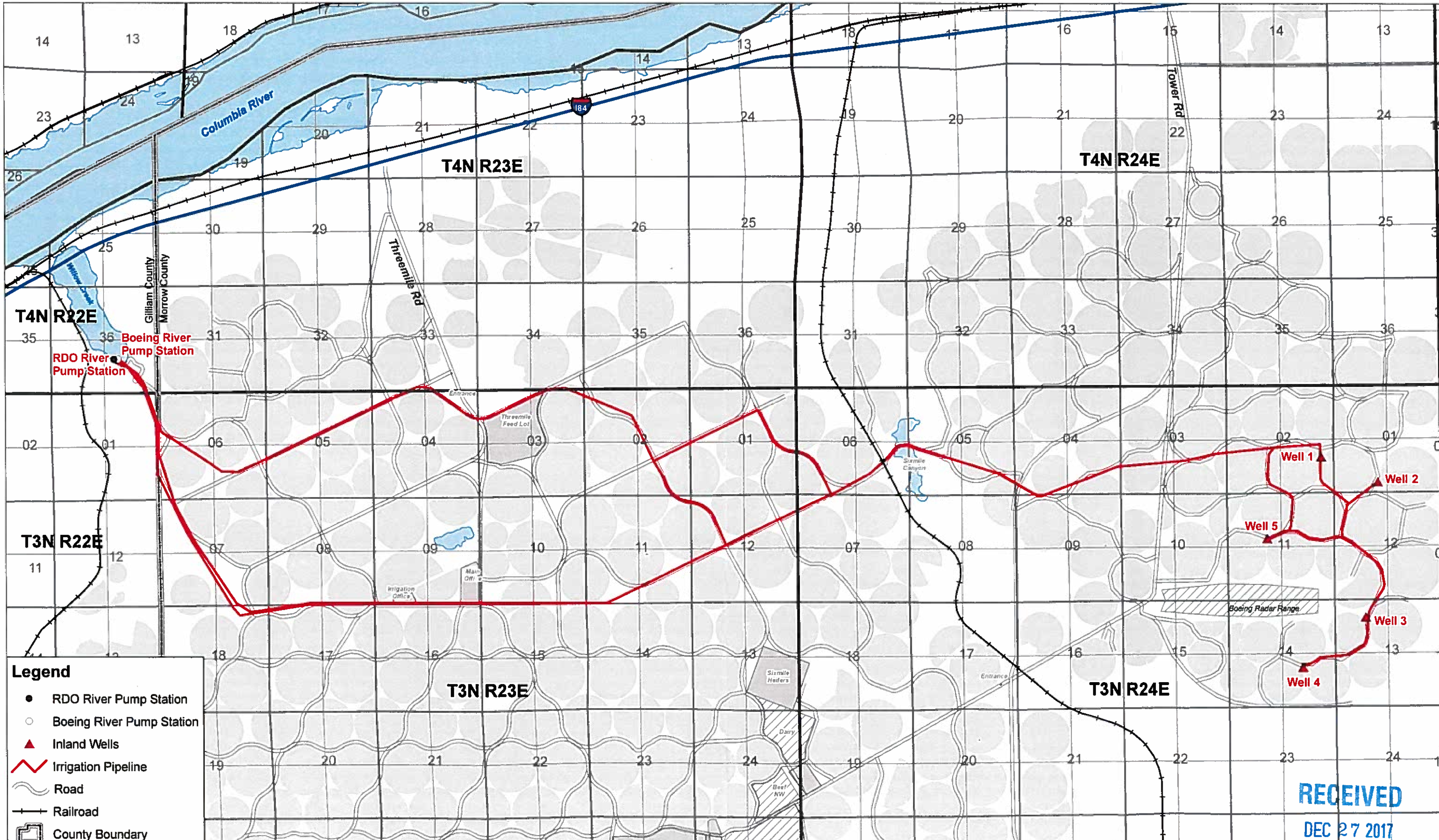
What would you recommend for conditions on a limited license that may be issued approving this application?

- Defer to Groundwater section of OWRD.
- Check length of limited license requested by applicant. Can not exceed five years.

5. Any other recommendations you would like to make?

1) A totalizing flowmeter is required that measures water diverted at POD and water injected into AR wells.
2) Annual report documenting water diverted and injected.
3) Static water levels reported before water injected and before withdrawn

Signature: Meg Silleman WM District#: Date: 12/4/2017



Delivery System

Threemile Canyon Farms Limited License Application for Aquifer Recharge

Map Date: 11/18/2016
Coordinate System: NAD 1983 StatePlane Oregon North FIPS 3601 Feet
Drawn By: Will Anderson | will@anderson-geographics.com
Data: Anderson Geographics, Threemile Canyon Farms

N W E S

1 inch = 4,500 feet

Miles
0 0.25 0.5 1 1.5 2

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anderson GEOGRAPHICS

Source Water
Points of Diversion
Threemile Canyon Farms Limited License
Application for Aquifer Recharge

Map Date: 11/18/2016
Coordinate System: NAD 1983 StatePlane Oregon North FIPS 3601 Feet
Drawn By: Will Anderson | will@anderson-geographics.com
Data: Anderson Geographics, Threemile Canyon Farms

N W E S

1 inch = 1,320 feet

Miles
0 0.125 0.25 0.5 0.75 1

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Legend

- ▲ Well
- Irrigation Pipeline
- Road

Legal Descriptions:

Well 1
NE 1/4 of the SE 1/4 of Section 2, T3N R24E W.M., being 1777 feet North and 624 feet West from the SE Corner of Section 2.

Well 2
SE 1/4 of the SW 1/4 of Section 1, T3N R24E W.M., being 506 feet North and 851 feet East from the SW Corner of Section 1.

Well 3
NE 1/4 of the NW 1/4 of Section 13, T3N R24E W.M., being 866 feet South and 1522 feet East from the NW Corner of Section 13.

Well 4
NW 1/4 of the SE 1/4 of Section 14, T3N R24E W.M., being 1956 feet North and 1628 feet West from the SE Corner of Section 14.

Well 5
SE 1/4 of the NW 1/4 of Section 11, T3N R24E W.M., being 2239 feet South and 1958 feet East from the NW Corner of Section 11.

Aquifer Recharge Injection Wells

Threemile Canyon Farms Limited License Application for Aquifer Recharge

Map Date: 11/18/2016
Coordinate System: NAD 1983 StatePlane Oregon North FIPS 3601 Feet
Drawn By: Will Anderson | will@anderson-geographics.com
Data: Anderson Geographics, Threemile Canyon Farms

N W E S

1 inch = 1,320 feet

Miles
0 0.125 0.25 0.5 0.75 1

anderson GEOGRAPHICS

ATTACHMENT C

Threemile Canyon Farms – Inland Project Limited License Application for Aquifer Recharge: Pilot Test Work Plan

REGISTERED OREGON JONATHON S. TRAVIS G 2450 GEOLOGIST
expires 2/1/18

ATTACHMENT C
Threemile Canyon Farms – Inland AR Pilot Testing Program
Pilot Test Work Plan

INTRODUCTION AND BACKGROUND

Threemile Canyon Farms (TMCF) is requesting an Aquifer Recharge (AR) Limited License to develop a recharge program on the Inland Area portion of the TMCF facility to make continued use of the aquifer more (or fully) sustainable. This project is referred to herein as the Inland AR Project. The objective of the proposed Inland AR Project is to slow, stop, and/or reverse the late winter/early spring static water level declines observed in Inland Area irrigation wells. To support meeting that objective, the goals of this Pilot Test Work Plan are two-fold: (1) demonstrate the desired effects on spring static water levels and (2) collect water quality data needed to address DEQ groundwater antidegradation requirements.

AR development is currently planned to begin with conversion to allow recharge at Inland Well #1 (Figure C-1). Other wells may be converted to allow recharge as the project evolves, with up to 5 wells possible. Though this workplan is developed to begin at Well #1, the first AR test well will be selected in consultation with OWRD and DEQ. Whichever well is selected for initial testing, this Pilot Test Work Plan represents the approach to testing the first well converted to AR use.

Attachment C describes the initial testing program and includes the following:

- Pilot Testing Equipment and Infrastructure
- Pilot Testing Program Overview
- Water Level Monitoring
- Water Quality Monitoring and Sampling
- Reporting

Water quality in the basalt aquifer intersected by Inland basalt wells is generally good, and therefore our approach to initial testing phases does not assume that aquifer development is necessary. Consequently, this testing plan is developed to address the long-term hydraulic response within the aquifer and compatibility between source water and native groundwater.

PILOT TESTING EQUIPMENT AND INFRASTRUCTURE

This section provides a conceptual design for the AR testing infrastructure that will be used to treat source water and inject that water into the first well to test. Treatment, injection control, and related infrastructure will need to be built, and the first well to test retrofitted, prior to injection. Descriptions of this infrastructure will be submitted to OWRD and DEQ for review and approval prior to AR operations.

Source Water Treatment

The goal of source water treatment is two-fold: (1) to remove/reduce biological, geochemical, and particulate constituents to the extent necessary to not negatively affect well operations and (2) do the same to meet groundwater antidegradation requirements. At a minimum, proposed treatment will include a filtration system and a disinfection system. The first phase of work to be done for the proposed project is to field test the effectiveness of various filtration and disinfection systems and evaluate the feasibility of meeting water quality goals. The results of these field tests will be provided to OWRD and DEQ prior to any AR injection. The project team will identify the preferred treatment system to install prior to any injection in consultation with these agencies.

Wellhead and In-Well Modification

The first well to be tested currently operates as an irrigation water supply well that is outfitted with a line shaft turbine pump. Wellhead and in-well modifications to be potentially implemented as part of the well retrofit for AR are summarized below.

Treated surface water will be conveyed to the AR wellhead using the existing piping/distribution system. The in-well injection control system will consist of either: (1) a separate injection drop-pipe fit with a designed orifice plate engineered to provide back-pressure sufficient to prevent cascading water at the anticipated system pressures, water levels, and injection rates or (2) a new down-hole control valve installed on the pump column. In either case, the wellhead will have appropriate flow control valve(s), pump-to-waste control valve(s), bi-directional flow meter, water level access tube(s), pressure relief valve, pressure gauge, and transducer access tube and sampling port. TMCF may also conduct an engineering analysis to evaluate the potential for the line-shaft turbine to spin backwards and generate electricity during injection. Final wellhead and in-well infrastructure designs will be submitted to OWRD/DEQ for approval/concurrence prior to construction for injection testing.

PILOT TESTING PROGRAM OVERVIEW

The goal of pilot testing is to confirm AR feasibility at TMCF and provide data to inform DEQ, OWRD, and TMCF of water quality and hydraulic response to support potential system expansion planning. Initial work will focus on field testing of the source treatment system(s). Upon successful completion of that testing, AR injection tests will be conducted. The objectives of the first AR test cycles include:

- Evaluating aquifer response to injection and assessing the long term hydraulic properties of the aquifer;
- Assessing the response of other Inland wells to AR at the first well tested;
- Evaluating the short and long-term water level response in all Inland wells to AR;
- Assessing geochemical compatibility between the source water and native groundwater;
- Demonstrating how the project can meet groundwater protection goals.

The data collected during initial testing cycles will be used to inform longer term AR operation plans and operations.

Pilot Testing Program

The Pilot Testing Program is described below. Injection portions of it also are summarized in Table C-1:

- *Treatment System Testing* – The first phase of the pilot testing program will be to field test the effectiveness of various filtration and disinfection systems in achieving project goals. Water quality samples collected during this phase of the project will be analyzed to measure the effectiveness of the treatment system(s). Testing and sampling will be done in the Inland Area near the Inland wells, at a location that complements future project activities, and is compatible with farming operations. The results of this testing will be provided to OWRD and DEQ prior to any AR injection. In consultation with these agencies the project team will identify the preferred treatment system to install prior to any injection.

- _Baseline Monitoring_ – Baseline monitoring will begin a minimum of two weeks before the start of AR injection testing. Baseline monitoring will include measuring background water level trends, source water quality, and native groundwater quality prior to injection testing. Water levels will be measured using the transducers installed in the Inland wells as part of their normal operations. In addition, manual measurements will be collected weekly during the baseline phase to verify transducer data. Baseline water quality samples will be collected for analysis from the first well to be tested, the nearest up gradient and down gradient Inland wells, and the source water delivery system. If the upgradient and downgradient wells are off-line at the time of baseline sampling, the Inland observation well will be sampled.
- _Cycle 1_ – Cycle 1 is a short duration test that will inject, store, and recover approximately 16.2 million gallons (MG) over an approximately two-week period. The goal of this cycle is to assess the mixing effects of source water on native groundwater. The injection period will be approximately 4.5 days long and be at approximately 2,500 gpm. Following injection, source water will be left in the aquifer for approximately 3 days. After that, the aquifer will be pumped at approximately 3,000 gpm to recover the full 16.2 MG and obtain water quality samples. These samples will be analyzed to evaluate the effects of AR on background aquifer water quality. Throughout Cycle 1 water level data will be collected from all Inland wells to assess the effects of AR injection on aquifer water levels.
- _Cycle 2_ – Cycle 2 will approximate planned operational-scale AR. It will consist of a recharge phase lasting approximately 30 to 45 days at approximately 2,500 gpm. During and following the Cycle 2 injection period water quality will be collected at the AR well and at the nearest two Inland wells, one up gradient and one down gradient. The timing of sampling will depend on when Cycle 2 recharge is completed. If recharge is done in the late winter or early spring, sampling will occur in designated Inland wells monthly during normal irrigation operations. If done in the autumn, samples will be collected monthly in the Inland observation well only as the Inland irrigation wells are offline and winterized during the winter months. Throughout Cycle 2 water level data will be collected from all Inland wells to assess the effects of AR injection on aquifer water levels, and in the case of the irrigation season, the persistence of any recharge water level effects during irrigation pumping. Water level measurement methods and frequency are described later in this attachment.
- _Cycle 3_ – Cycle 3 will begin as soon as water is available for recharge after Cycle 2. Cycle 3 will repeat Cycle 2 in rates, duration, monitoring, testing, and analyses.
- _Cycle 4 (TBD)-_ – Additional cycles, if needed, will consist of recharge in the spring window followed by normal irrigation season pumping throughout the summer using existing valid TMCF groundwater rights, and recharge in the fall followed by normal winter non-pumping static conditions. The decision to conduct additional cycles will be made in consultation with OWRD and DEQ.

- *Additional Wells* – Conversion and recharge at additional wells to expand the AR program will be determined based on the aquifer response to recharge at the first well. This will be addressed in consultation with OWRD and DEQ later in the project, and plans will be modified as appropriate based on these consultations.

Monitoring Well Network

Wells from which monitoring data will be collected throughout the project include the five Inland wells, the Inland observation well, and Well 7 in the dairy area (referred to hereafter as Dairy Well 7). These wells are equipped with pressure transducers. Their locations are shown in Figure C-1 and Table C-2 describes these wells, their distance from Inland Well #1 (under the assumption that this well is the first well tested, if it is not, this table will be modified prior to injection testing), and their well construction information. Designations for these wells are as follows:

- Inland Well #1 (MORR 52307)
- Inland Well #2 (MORR 52045)
- Inland Well #3 (MORR 52132)
- Inland Well #4 (MORR 52131)
- Inland Well #5 (MORR 52130)
- Inland OBS Well (MORR 52279)
- Dairy Well 7 (MORR ID pending)

WATER LEVEL MONITORING

Water levels will be monitored manually and electronically to assess buildup during AR injection, drawdown during normal irrigation pumping, to evaluate the presence of potential aquifer boundary conditions, and the ability of the AR project to mitigate for the observed water level declines (as assessed by tracking spring static water level trends). The project team will monitor each well with pressure transducers verified with periodic manual measurements. Data will be tracked through the TMCF supervisory control and data acquisition system (SCADA). Pressure transducers will be factory calibrated prior to use and pressure ratings will be selected based on the potential anticipated water level changes at each monitoring location. Manual water levels will be used to confirm transducer data and will be used as backup should a transducer fail. Barometric pressure will also be recorded with a dedicated barometric sensor and the barometric efficiency of monitored wells will be evaluated and corrections will be made as needed to facilitate response assessments.

A summary of the water level monitoring program is described below:

- Baseline measurements:
  - First tested well – Continuous digital measurements will be taken every 15 minutes via automated pressure transducer to evaluate for antecedent trends prior to AR. At a minimum, manual measurements will be collected weekly over the baseline period to corroborate the transducer data.
  - Observations wells (which are the other existing Inland Area wells) – Continuous digital measurements will be collected at 15-minute fixed interval via automated pressure transducer. At a minimum, manual measurements will be collected weekly over the baseline period to corroborate the transducer data.
- Injection measurements:

- First tested well – Continuous digital measurements will be taken for one or more log cycles, culminating in a 15-minute fixed frequency interval via automated pressure transducer to evaluate water levels during injection. Manual measurements will be collected to corroborate the transducer data.
- Observations wells – Continuous digital measurements will be collected at 15 minute intervals via automated pressure transducer to evaluate water level changes in the other wells. Manual measurements will be collected to corroborate the transducer data.

- Non-pumping measurements:
  - First tested well – Continuous digital measurements will be taken for one or more log cycles, culminating in a 15-minute fixed frequency interval via automated pressure transducer to evaluate water levels during injection. Manual measurements will be collected during the non-pumping period to corroborate the transducer data.
  - Observations wells – Continuous digital measurements will be taken every 15-minutes via automated pressure transducer to evaluate water levels during non-pumping periods. Manual measurements will be collected during the non-pumping period to corroborate the transducer data.
- Irrigation season pumping measurements:
  - First tested well – Continuous digital measurements will be taken every 15-minutes via automated pressure transducer to evaluate water levels during the irrigation season. Manual measurements will be collected to corroborate the transducer data.
  - Observations wells – Continuous digital measurements will be taken every 15-minutes via automated pressure transducer to evaluate water levels during the irrigation season. Manual measurements will be collected to corroborate the transducer data.

All manual measurements will be recorded in a dedicated field notebook.

WATER QUALITY MONITORING AND SAMPLING

Water quality monitoring will be conducted to compare source to native groundwater chemistry and assess the ability of the project to meet groundwater quality standards. The water quality information also will be used to assess injection and groundwater compatibility with respect to chemical precipitation and dissolution reactions that have the potential to alter well performance. A Quality Assurance and Quality Control (QA/QC) plan is provided in Attachment F as a supplement to this Attachment.

The proposed water quality monitoring plan is shown in Table C-3, and the analytical suite is detailed in Table C-4. The analytical program includes cations, anions, metals, and applicable biological analytes. This list may be refined after initial treatability studies are completed and the final treatment method for surface water is established. Water quality sampling will include the injection well and the nearest operating downgradient well in the project area.

Field parameter measurements of the source and recovered water will be collected at the tested well concurrent with all manual water level measurements and sampling events during injection and recovery activities. Temperature, specific conductance, pH, turbidity, oxidation-reduction potential and dissolved oxygen will be recorded electronically along with manual measurements recorded in the field notebook. Additional field parameters (i.e. total suspended solids, free chlorine, and total chlorine) may be monitored depending on their levels observed in treated surface water or groundwater. These parameters will be measured using a Hach™ field test kit or other in-line sensor.

REPORTING

The results of each phase of the testing program will be reported prior to the beginning of the next phase, as noted above. These reports will be provided to OWRD and DEQ for review, comment, discussion, and concurrence where decisions about the next phase are needed. These reports will include descriptions of test operations, analytical results, hydraulic monitoring, and interpretations of those data. Data including field measurements, laboratory reports, and electronic transducer data files will be provided in OWRD format.

Figures

C-1 Location Map

Tables

C-1 Phase 1 Pilot Testing Plan
C-2 Observation Wells
C-3 Phase 1 Water Quality Monitoring Plan
C-4 Full Analytical Suite

Figures

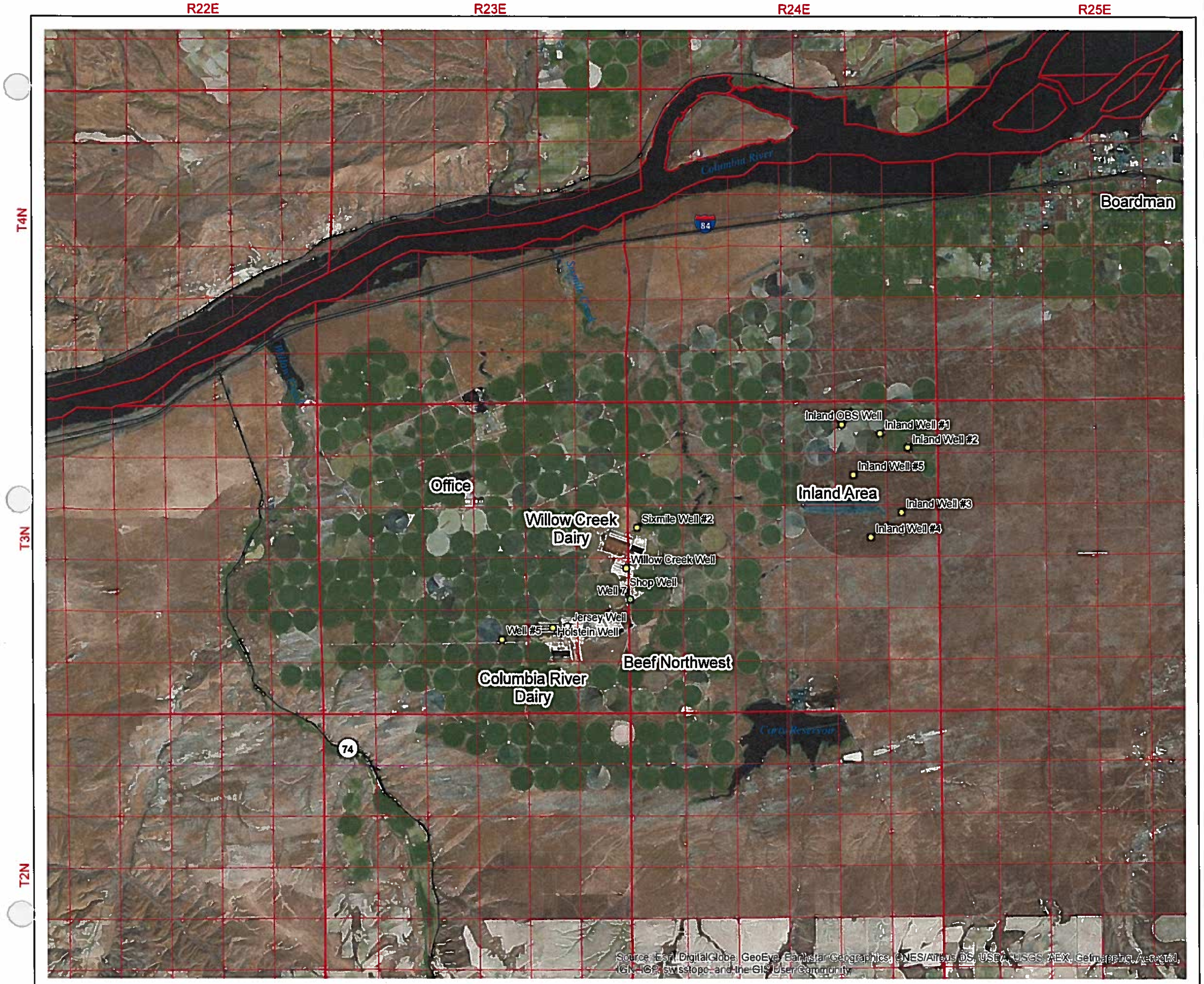

Figure C-1.

Threemile Canyon Farm

Location Map

Legend

- TMCF Wells
- TMCF APOA
- highways
- Section
- Township

0 0.75 1.5 3 4.5 Miles

N

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Tables

Table C-1 Pilot Testing Plan

	Cycle 1			**Cycle 2***			**Cycle 3***			**After Cycle 3 (if needed)**		
	Rate (gpm)	Duration (Days)	Total Volume (MG)	Rate (gpm)	Duration (Days)	Total Volume (MG)	Rate (gpm)	Duration (Days)	Total Volume (MG)	Rate (gpm)	Duration (Days)	Total Volume (MG)
Aquifer Recharge (Injection)	2,500	4.5	16.2	2,500	45	162	2,500	45	162.0	2,500	45	162
Non-Pumping	--	3	--	--	TBD	--	--	TBD	--	--	TBD	--
Aquifer Sampling	3,000	3.80	16.2	monthly sampling**			monthly sampling**			monthly sampling**		

Notes:

MG = Million Gallons TBD = To Be Determined

* The first AR report will be completed after Cycle 2 or 3, depending on actual operations and OWRD and DEQ consultation.

** In the injection well and the nearest operating downgradient well.

Table C-2 - Observation Wells

Well	Well Log ID	Distance from Inland Well #1 (feet)	Distance from Inland Well #1 (miles)	Casing Depth (feet)	Casing Diameter (inches)	Total Depth (feet)	Open interval Diameter (inches)
Inland Well #1	MORR 52037	0	0	640	20	1450	19, 10
Inland Well #2	MORR 52045	3082	0.58	689	20	1053	19
Inland Well #3	MORR 52132	8238	1.56	545	20	926	19
Inland Well #4	MORR 52131	10471	1.98	518	20	966	19
Inland Well #5	MORR 52130	4863	0.92	706	20	1020	19
Inland OBS Well	MORR 52279	4061	0.77	731	8	1081	8
Dairy Well 7	MORR 52387	30914	5.85	867	12, 8	1008	12

Table C-3 Water Quality Monitoring Plan, Cycles 1 through 3 at injection well and nearest operating downgradient well.

Cycle	Cycle 1	Cycle 2	Cycle 3
Recharge Sampling	Day 1 - FS (within 4 hours of start of injection) Day 4 - FS	Day 1- FS (within 4 hours of start of injection) Day 23 - FS Day 45 - FS	Day 1 - FS Day 30 - FS Day 45 - FS
Non-Pumping Conditions	--	--	--
Aquifer Water Sampling	Day 1 - FS (within in an hour of start of pumping) Day 2 - FS Day 3 - FS (at 100% recovery)	Day 1 - FS (within in an hour of start of pumping) Day 23 - FS Day 45 - FS	Day 1 - FS (within in an hour of start of pumping) Day 23 - FS Day 45 - FS

Notes:

FS = Full Suite (all parameters listed in Table 4)

Table C-4 - Proposed Full Analytical Suite

Analyte	OHA Drinking Water Standards	DEQ Groundwater Standards
INORGANIC CHEMICALS (IOCs)		
Alkalinity (as $CaCO_3$) *(mg/L)*		
Aluminum (total) *(mg/L)*	0.05-0.2 (SMCL)	
Antimony (total) *(mg/L)*	0.006 (MCL)	
Arsenic (total) *(mg/L)*	0.010 (MCL)	0.050 (DEQ MML)
Barium (total) *(mg/L)*	2 (MCL)	1 (DEQ MML)
Bicarbonate *(as CaCO3) (mg/L)*		
Beryllium (total) *(mg/L)*	0.004 (MCL)	
Cadmium (total) *(mg/L)*	0.005 (MCL)	0.01 (DEQ MML)
Calcium (total) *(mg/L)*		
Carbonate (as $CaCO_3$) *(mg/L)*		
Chloramine *(mg/L)*		
Chloride (total) *(mg/L)*	250 (SMCL)	250 (DEQ MML)
Chromium (total) *(mg/L)*	0.1 (MCL)	0.05 (DEQ MML)
Copper (total) *(mg/L)*	1.3 (Action Level) (1.0 SMCL)	1.0 (DEQ MML)
Cyanide (total) *(mg/L)*	0.2 (MCL)	
Fluoride (total) *(mg/L)*	4 (MCL), 2.0 (SMCL)	4 (DEQ MML)
Hardness (as $CaCO_3$) *(mg/L)*	250 (SMCL)	
Iron (total) *(mg/L)*	0.3 (SMCL)	0.3 (DEQ MML)
Lead (total) *(mg/L)*	0.015 (MCL)	0.05 (DEQ MML)
Magnesium (total) *(mg/L)*		
Manganese (total) *(mg/L)*	0.05 (SMCL)	0.05 (DEQ MML)
Mercury (total inorganic) *(mg/L)*	0.002 (MCL)	0.002 (DEQ MML)
Nickel (total) *(mg/L)*	0.1**	
Nitrate (as N) *(mg/L)*	10 (MCL)	10 (DEQ MML)
Nitrite *(mg/L)*	1 (MCL)	
Nitrate+Nitrite (total N) *(mg/L)*	10 (MCL)	
Perchlorate (ug/L)		
Phosphate *(mg/L)*		
Phosphorus (total) *(mg/L)*		
Potassium *(mg/L)*		
Selenium (total) *(mg/L)*	0.05 (MCL)	0.01 (DEQ MML)
Silica *(mg/L)*		
Silicon *(mg/L)*		
Silver (total) *(mg/L)*	0.1 (SMCL)	0.05 (DEQ MML)
Sodium *(mg/L)*		
Sulfate *(mg/L)*	250 (SMCL)	250 (DEQ MML)
Sulfide *(mg/L)*		
Thallium *(mg/L)*	0.002 (MCL)	
Uranium *(mg/L)*		
Zinc (total) *(mg/L)*	5 (SMCL)	5 (DEQ MML)
MISCELLANEOUS		
Color *(color units)*	15 (SMCL)	15 (DEQ MML)
Corrosivity[†] *(S.U.)*	NON-CORROSIVE	
Foaming Agents (MBAS); *(mg/L)*	0.5 (SMCL)	0.5 (DEQ MML)

Table C-4 - Proposed Full Analytical Suite

Analyte	OHA Drinking Water Standards	DEQ Groundwater Standards
Odor *(T.O.N.)*	3 TON (SMCL)	3 TON (DEQ MML)
Total Dissolved Solids *(mg/L)*	500 (MCL)	500 (DEQ MML)
Total Organic Carbon *(mg/L)*		
Total Suspended Solids *(mg/L)*		
VOLATILE ORGANIC COMPOUNDS (VOCs)		
1,1-Dichloroethylene *(ug/L)*	7 (MCL)	7 (DEQ MML)
1,1,1-Trichloroethane *(ug/L)*	200 (MCL)	200 (DEQ MML)
1,2-Dichloroethane *(ug/L)*	5 (MCL)	5 (DEQ MML)
Benzene *(ug/L)*	5 (MCL)	5 (DEQ MML)
Carbon tetrachloride *(ug/L)*	5 (MCL)	5 (DEQ MML)
Dacthal (ug/L)		
p-Dichlorobenzene (1,4-) *(ug/L)*	75 (MCL)	75 (DEQ MML)
Trichloroethylene (TCE) *(ug/L)*	5 (MCL)	5 (DEQ MML)
Vinyl chloride *(ug/L)*	2 (MCL)	2 (DEQ MML)
DISINFECTION BY-PRODUCTS (DBPs) & RESIDUAL DISINFECTANTS		
Total Trihalomethanes (TTHM) *(ug/L)*	80 (MCL)	10 (DEQ MML)
MICROBIAL		
Total Coliforms *(cell count per 100 mL)*	< 5% positive	<1/100mL
Fecal Coliforms *(cell count per 100 mL)*	Confirmed presence	Confirmed presence
E. Coli *(cell count per 100 mL)*	Confirmed presence	Confirmed presence
SYNTHETIC ORGANIC COMPOUNDS (SOCs)		
2,4-D *(ug/L)*	7 (MCL)	10 (DEQ MML)
2,4,5-TP (Silvex) *(ug/L)*	5 (MCL)	10 (DEQ MML)
Endrin *(ug/L)*	2 (MCL)	0.2 (DEQ MML)
Lindane (BHC-gamma) *(mg/L)*	0.0002 (MCL)	0.004 (DEQ MML)
Methoxychlor *(mg/L)*	0.04 (MCL)	0.100 (DEQ MML)
Toxaphene *(ug/L)*	3 (MCL)	0.005 (DEQ MML)
RADIOLOGICALS		
Gross Alpha *(pCi/L)*	15 (MCL)	15 (DEQ MML)
Gross Beta *(pCi/L)*	4 mrem/year (official) 50 pCi/L (trigger)	50 pCi/L (DEQ MML)

ATTACHMENT D

Threemile Canyon Farms – Inland Project Limited License Application for Aquifer Recharge: Conceptual Hydrogeologic Model

EA Engineering, Science, and Technology, Inc., PBC

REGISTERED OREGON JONATHON S. TRAVIS G 2450 GEOLOGIST expires 2/1/18

ATTACHMENT D
Threemile Canyon Farms - Conceptual Hydrogeologic Model

This document provides the conceptual hydrogeologic model for Threemile Canyon Farms (TMCF) in support of their Inland Aquifer Reccharge (AR) Limited License application. Candidate Inland AR wells are listed in Table D-1, which also includes their construction information.

PHYSIOGRAPHIC SETTING AND CLIMATE

TMCF lies within the Umatilla Basin (Basin), a structural basin bounded by the Columbia Hills on the north and the Blue Mountains on the south (Figure D-1). The Umatilla Basin is located in northcentral Oregon. The basin supports agriculture and the dairy industry amidst rolling hills covered with grassland vegetation and irrigated agriculture. The climate is semi-arid with an average of 8.5 inches of rainfaill a year, of which an average of 6.7 inches of snowfall is observed at the Western Regional Climate Center station located in Boardman, Oregon. Temperatures peak in July at 100 degrees farenheit, or higher, with winter lows observed in January averaging 27 degrees farenheit. Sub zero winter temperatures can occur for several days at a time in any give year.

STRATIGRAPHY

A number of geologic mapping studies have been conducted within the Umatilla Basin (Hogenson, 1964; Robison, 1971; Farooqui et al., 1981a,b; Swanson et al., 1981; USDOE, 1988; Wozniak, 1995; Kahle, et al. 2011). They provide a basic understanding of the regional hydrogeologic framework and the following summary of the stratigraphy in this portion of the Basin is based on these, and other reports as cited.

Columbia River Basalt Group

The oldest exposed bedrock unit in the TMCF area, and the primary aquifer hosting unit, is the Columbia River Basalt Group (CRBG). The CRBG consists of a thick sequence of more than 300 continental tholeiitic flood-basalt lava flows (Tolan et al., 1989). Regional studies and mapping of the CRBG have demonstrated that there are consistent and systematic variations in lithology, geochemical compositions, and paleomagnetic polarity among flows and groups of flows. These differences have allowed for the establishment of stratigraphic units within the CRBG that can be reliably identified and mapped on a regional basis (e.g., see Swanson et al., 1979, 1981; Beeson et al., 1985; Reidel et al., 1989). In the TMCF area these units include, in descending order, the Saddle Mountains Basalt, Wanapum Basalt and the Grande Ronde Basalt. Subdivisions of these units present in water wells that are the focus of this effort are:

- Saddle Mountain Basalt – This includes the Elephant Mountain, Pomona, and Umatilla Members. These units are typically interpreted to be cased and sealed off in TMCF wells (Table D-2).
- Wanapum Basalt - This includes the Priest Rapids and the Frenchman Springs Members. Both of these units are typically interpreted to be open to Dairy wells at TMCF while

Inland wells are only open to the Frenchman Springs Member (Table D-2).

- Grande Ronde – This includes the Sentinel Bluffs Member. Only one TMCF well being considered for this project is interpreted to be open to this unit, and even then only the uppermost part of this unit is intersected (Table D-2).

Of these units, the Frenchman Springs Member of the Wanapum Basalt is the primary focus of the proposed AR effort. Multiple water-bearing zones in three subdivisions of the Frenchman Springs Member, the Sentinel Gap, Sand Hollow, and Ginkgo, are generally found in the TMCF area.

Columbia River Basalt Group Flow Characteristics

Regional studies have demonstrated that CRBG flows display the same basic three-part internal arrangement of features. These features, termed intraflow structures, originated during the emplacement and cooling of the lava flow and are referred to as the flow top, flow interior, and flow bottom (Figure D-2). The basic characteristics of these zones are generally as follows.

Flow Tops

Flow tops commonly consist of glassy to very fine-grained basalt that is riddled with numerous spherical and elongate voids, or vesicles. The physical character of a flow top falls between two basic end-members, simple vesicular flow top and flow top breccia Simple vesicular flow tops consist of glassy to fine-grained basalt that displays a rapid increase in the density of vesicles near the top of the flow (USDOE, 1988). Vesicles may be isolated or interconnected, resulting respectively in lower and higher permeability and porosity (USDOE, 1988). Flow top breccia consists of angular, scoriaceous to vesicular fragments of basaltic rubble that lie above a zone of non-fragmented, vesicular basalt. Flow top breccias can be very thick, laterally extensive and in some cases comprise half the entire thickness of the flow (USDOE, 1988). Laterally expansive flow top breccia can have a high degree of interconnected pore space resulting in formation of widespread, permeable, water-bearing aquifers at the tops of individual basalt flows (USDOE, 1988).

Flow Interiors

CRBG flow interiors typically consist of dense, non-vesicular, glassy to crystalline basalt that contains numerous contraction joints (cooling joints) that formed when the lava shrank as it solidified. CRBG cooling joints often form regular patterns or styles, with the two most common being termed entablature-colonnade and columnar-blocky jointing. Entablature-colonnade jointed basalt flows display a complex pattern of numerous, rather irregular jointed small columns to apparently random oriented joints, called the entablature and the entablature generally overlies a thinner zone displaying well-developed columnar jointing and referred to as the colonnade. Studies on the nature and characteristics of cooling joints (USDOE, 1988; Lindbergh, 1989) have found that joints are typically 77 to >99 percent filled with secondary minerals (clay, silica, zeolite) and open spaces (voids) that do occur are not well connected. Groundwater movement through undisturbed, dense flow interiors is expected to be inconsequential (Wozniak, 1995).

Flow Bottoms

Flow bottom physical characteristics are largely dependent on the paleoenvironmental conditions the molten lava encountered as it flowed across the Earth's surface. If the lava flow encountered relatively dry ground conditions, the flow bottom typically consists of a narrow (less than 3 feet-thick) zone of sparsely vesicular, glassy to very fine-grained basalt. This type of flow bottom structure is very common within the CRBG. However, if advancing flows encountered lakes, rivers, and areas of water-saturated, unconsolidated sediments more complex flow bottom structures formed (Mackin, 1961; Grolier and Bingham, 1971; Swanson et al., 1979; USDOE, 1988; Beeson et al., 1989). Flow bottom structures can be either highly localized or widespread. The combination of a flow top of one flow and the flow bottom of the overlying flow is commonly referred to as the interflow zone (Figure D-2). Individual interflow zones are laterally extensive, extending as far as the flows that they separate.

Sedimentary Units

A number of sedimentary units are interbedded with, and overlie, the CRBG, including Ellensburg Formation, Alkali Canyon Formation, Plio-Pleistocene strata, Pleistocene loess, Pleistocene cataclysmic flood deposits, and Holocene deposits. Of these, only the Ellensburg Formation, the unit interbedded with the CRBG, is discussed.

Ellensburg Formation strata include mudstone, siltstone, sandstone, conglomerate, diatomite, and tuff. Ellensburg sandstone and conglomerate interbeds can serve as aquifers in portions of the Umatilla Basin while silt- and clay-dominated interbeds can act as aquitards (e.g., Newcomb, 1966, 1971; Wozniak, 1995). Stratigraphic relationships between the Ellensburg Formation and the CRBG are shown in Table D-2. Individual Ellensburg Formation interbeds range from less than 1 foot-thick too many tens of feet-thick, can extend laterally for many miles (Smith, 1988; Smith et al., 1989), and are generally referred to, in the TMCF area, as follows:

- Rattlesnake Ridge Member - The interbed between the Elephant Mountain and the Pomona Members, Saddle Mountains Basalt.
- Selah Member - The interbed between the Pomona Member and the Umatilla Member, Saddle Mountains Basalt.
- Mabton Member - The interbed between the Saddle Mountains Basalt and the Wanapum Basalt.
- Quincy/Squaw Creek Interbed - The interbed between the Priest Rapids Member and the Frenchman Springs Member, Wanapum Basalt.
- Vantage Member - The interbed between the Frenchman Springs Member, Wanapum Basalt and the Sentinel Bluffs Member, Grande Ronde Basalt.

As noted above, Ellensburg Formation units, where present, comprise a portion of the interflow zone interbedded between adjacent CRBG units.

STRUCTURAL FEATURES

TMCF lies in the west-central portion of the generally east-west oriented Umatilla Basin, south of the axis of the basin. The northern boundary of the Umatilla Basin is delineated by the Columbia Hills and the southern Boundary of the basin is formed by the Blue Mountain uplift. The TMCF area is cross-cut by several faults and smaller folds, including the northwest-trending Dalreed Butte fault zone and the northeast-trending Sixmile Creek fault (Figure D-3).

Dalreed Butte Fault Zone

The Dalreed Butte fault zone is a northwest-trending fault zone. The fault zone, with approximately 150 feet of apparent vertical offset (down to the southwest) at Dalreed Butte, can be traced from Dalreed Butte northwest to the Columbia River. Narrow, low amplitude, asymmetric, northwest-trending anticlinal and homoclinal folds are associated with this fault zone.

Upper Sixmile Creek Fault Zone

A northeast-trending fault coincides with the trend of upper Sixmile Creek. The amount of apparent vertical stratigraphic offset across this fault is less than 40 feet. Throw on the fault changes from down to the north at its southwest end to down to the southeast near Sixmile Canyon. The fault offsets the Elephant Mountain basalt.

Additional Potential Fault

A third potential northwest-trending fault may be present at Sixmile Canyon. The elevation of the top of the Elephant Mountains flow increases by as much as 50 feet from the west side to the east side of the canyon. However, there are no outcrops along, or in, the creek that can be used to accurately determine if this apparent offset is due to faulting, or simply a manifestation of post-basalt erosion. Nevertheless, the northwest-trending linear orientation of Sixmile Canyon (parallel to the Dalreed Butte fault zone), coupled with the apparent offset of the basalt surface across the canyon is suggestive of a fault or faults along the trace of the canyon.

Faulting in the CRBG tends to produce a roughly planer zone composed of coarsely shattered basalt that grades into very fine rock flour. It has also been suggested that the presence of water within intraflow zones may decrease the relative strength of the rock and may be another factor that contributes to deformational behavior of flow tops and flow bottoms (USDOE, 1988). Fault zone shatter breccias often display significant degrees of alteration (clays) and/or secondary mineralization (silica, zeolite, calcite, and pyrite). These materials can cement shatter breccias and create a rock that is so strong that CRBG fault breccias are commonly more resistant to erosion than unbrecciated CRBG (Myers and Price, 1981; Price, 1982; Anderson, 1987). The types of secondary minerals present within CRBG fault zones appears to be dependant both environmental conditions (oxidizing vs. reducing) and in situ conditions (e.g., water chemistry, thermal regime, hydrologic regime; Myers and Price, 1981; Price, 1982; USDOE, 1988).

HYDROGEOLOGY

Succesful AR programs rely on the capability of an aquifer to recieve, store and transmit water. This section describes the principal hydrogeologic characteristics of the stratigraphic units within the Umatilla Basin. This section focuses on the the Columbia River Basalt Group which is the target aquifer for AR.

Numerous hydrogeologic investigations have been conducted within the Columbia Basin to develop models of how various factors (e.g., CRBG flow physical characteristic/properties, tectonic features/properties, erosional features, climate, sediment type etc.) interact to effect the semi-confined to confined CRBG groundwater system and the unconfined suprabasalt sediment groundwater system (e.g., Hogenson, 1964; Newcomb, 1961, 1969; Brown, 1978; Gephart et al., 1979; Oberlander and Miller, 1981; Drost and Whiteman, 1986; Lite and Grondin, 1988; Davies-Smith et al., 1988; USDOE, 1988; Johnson et al., 1993; Hansen et al., 1994; Spane and Webber, 1995; Wozniak, 1995; Steinkampf and Hearn, 1996; Sabol and Downey, 1997; Tolan et al., 2009; Kahle et al., 2011). Given the typical distribution and physical characteristics of CRBG intraflow structures, groundwater primarily resides within the interflow zones (Newcomb, 1969; Oberlander and Miller, 1981; Lite and Grondin, 1988; USDOE, 1988; Davies-Smith et al., 1988; Wozniak, 1995). The physical properties of undisturbed, laterally extensive, dense interiors of CRBG flows make this portion of the flow essentially impermeable (Newcomb, 1969; Oberlander and Miller, 1981; Lite and Grondin, 1988; USDOE, 1988; Davies-Smith et al., 1988; Lindberg, 1989; Wozniak, 1995; Tolan et al., 2009).

Conceptual Hydrogeologic Model

The initial candidate AR wells (Inland Well #1, within the Inland Area designated in Figure D-3) is open to the Wanapum and to the Grande Ronde. The water-bearing intervals intepreted for additional candidate AR wells at TMCF can be seen in Table D-3 and a general schematic cross section can be seen in Figure D-4 for the Inland area. For conceptual model purposes we define a shallow Saddle Mountains groundwater system and a deeper Wanapum groundwater system in the CRBG. The uppermost Grande Ronde is included in the Wanapum system.

Saddle Mountains Basalt Aquifers

Generally, the Saddle Mountains Basalt aquifer system, which includes interbedded Ellensburg Formation sediments, is a confined to semi-confined aquifer system (Wozniak, 1995). Groundwater in the Saddle Mountains aquifer generally flows north towards the Columbia River (Oberlander and Miller, 1981; Wozniak, 1995). The shallowest part of the Saddle Mountains aquifer in the Umatilla Basin is recharged by large-scale irrigated agriculture and leakage from water storage and conveyance systems and in many areas it is an artificial system (Wozniak, 1995). Historical information (Wozniak, 1995) indicates that the uppermost parts of the Saddle Mountains' aquifer in the western Umatilla Basin (near the Farm) was unsaturated (or contained only insignificant quantities of water) prior to the 1970s, and since then water levels in this aquifer system have risen several tens of feet (Oberlander and Miller, 1981; Wozniak, 1995). In the western Umatilla Basin, the source of artificial recharge that lead to increased water levels in the upper portions of the Saddle Mountains aquifer system has been identified as leakage from Carty Reservoir (after it was filled in 1977) and, to a lesser extent, water from large-scale irrigated agriculture (Wozniak, 1995).

Physical geologic constraints on the confined Saddle Mountains aquifer system are summarized as follows:

- Saddle Mountains Basalt flows pinch out and interfinger with the sedimentary sequence (Figure 17; Wozniak, 1995) providing natural pathways connecting water- bearing suprabasalt sediments with "shallow" Saddle Mountains Basalt interflow-hosted aquifers. Depending on the local hydraulic gradient, these pathways provide for both recharge and discharge from the Saddle Mountains aquifer system.
- Saddle Mountains Basalt flows are exposed, or only shallowly buried, throughout much of the Umatilla Basin. Consequently, the top of the Saddle Mountains Basalt has been eroded by Pleistocene Cataclysmic Flood waters and normal, Neogene fluvial processes. The result of this is that "erosional windows" have been cut into the Saddle Mountains Basalt, connecting shallower and deeper Saddle Mountains interflow-hosted aquifers with each other, suprabasalt sediments, and the Columbia River (Wozniak, 1995). Depending on the local hydraulic gradient, these pathways also provide for both recharge and discharge from the Saddle Mountains aquifer system.
- Groundwater recharge to the Saddle Mountains aquifer system comes from a number of potential sources including precipitation, infiltration of irrigation water, and leakage from streams, canals, and reservoirs (Oberlander and Miller, 1981; Davies-Smith et al., 1988; Wozniak, 1995). The potential recharge area for the Saddle Mountains groundwater system is relatively extensive (Wozniak, 1995) because it is widespread, generally shallow, and in direct hydraulic communication with widespread, permeable suprabasalt sediments through the natural pathways (Figure 17; Wozniak, 1995) described above.
- In addition to natural pathways, unsealed water wells through both the suprabasalt and

Saddle Mountains aquifers allows intercommunication between them. Depending on the local hydraulic gradient, unsealed wells provide for both recharge and discharge from the Saddle Mountains aquifer system.

To summarize, groundwater flows laterally through Saddle Mountains Basalt interflow zones and interbedded sediments until it encounters natural and/or manmade pathways.

Depending on the local hydraulic gradient, these pathways form zones of discharge or recharge for Saddle Mountains Basalt aquifers. Generally, Saddle Mountains Basalt aquifers discharge to the Columbia River through these pathways. In the western Umatilla Basin, at least the upper part of this aquifer system is artificial.

Wanapum Basalt and Grande Ronde Basalt Aquifers

Groundwater in the Wanapum and Grande Ronde aquifer system, like the Saddle Mountains aquifers, is flowing towards the Columbia River situated in the Dalles-Umatilla syncline (Figure 3) (Oberlander and Miller, 1981; Wozniak, 1995). Groundwater in the Wanapum and Grande Ronde aquifer system is confined and natural recharge to it, and discharge from it to shallower aquifers and the Columbia River is minimal. Groundwater flows laterally through the system in widespread, dense flow interior-capped, interflow zones. These interflow zones extend from outcrop areas along the fringe of the Blue Mountains (where recharge occurs) into the center of the basin. Vertical groundwater movement, if any, is found predominantly in association with erosional windows, flow pinchouts, open faults, and unsealed wells.

Recharge to the Wanapum system is inferred to be limited to slow, deep percolation through locally disrupted dense flow interiors where they occur in up dip areas south of TMCF. In the western Umatilla Basin modern recharge sources are rare because of scarce precipitation, as such, most Wanapum groundwater is inferred to be relatively old, potentially Pleistocene in age. The lack of modern recharge, or slowness of recharge is reflected in water level declines seen at TMCF and the reason for exploring an AR program.

As noted earlier faults have the potential to effect CRBG groundwater flow systems in a number of ways. They can form barriers to the lateral and vertical movement of groundwater; a series of faults can create hydrologically isolated areas. They can provide a vertical pathway (of varying length) for groundwater movement allowing otherwise confined CRBG aquifers to be in direct hydrologic communication. In addition, they can expose interflow zones creating local opportunities for aquifer recharge and/or discharge. Faults are interpreted to form hydrologic barriers that separate the project area into several subdivisions. The degree of hydrologic connection across these faults has not yet been demonstrated, and the location of the potential faults and TMCF wells can be seen in Figure D-3.

Hyraulic Properties

In the TMCF area the primary water-bearing interflow zones encountered in the Inland area wells are part of the Wanapum Basalt (Tables D-2 and D-3). Water levels in these wells are summarized in Table D-4. While we generally interpret that Wanapum Basalt groundwater flows to the north, towards the axis of the Umatilla Basin, however data collected to date and summarized in Table 4 show that there is variation in static water levels between different wells. These variations are interpreted to indicate that there is compartmentalization in the Wanapum groundwater flow system in the TMCF area.

Specific capacity for portions of the Wanapum groundwater system intercepted by several of the wells have been estimated from aquifer pumping tests. These data, summarized in Table D-5, are interpreted to show that the portions of the Wanapum tested to-date are generally very productive. However, static water level data summarized in Table D-4 show water levels are declining. Taken together, these data are interpreted to indicate the physical properties of these water-bearing intervals are highly transmissive and permeable, although pumping appears to be exceeding short-term recharge capacity.

Predicted Response to AR

To estimate the potential aquifer response to to the proposed Inland AR project, a 48-hour, 4,100 gpm aquifer pumping test in Inland Well #1 was evaluated. AR will operate at injection rates of approximately 2,500, therefore this test represents a very conservative estimate of the AR response due to the higher rate of withdrawl than anticipated for AR injection operations.

The Cooper and Jacob 1946 analytical solution to the Theis Equation did not provide a good projection of drawdown to estimate transmissivity for Inland Well #1 as the drawdown on a semi-log plot was not linear. The data was plotted on a log-log scale to better represent the drawdown response. As shown in Figure D-5, approximately 17 feet of drawdown was observed at Inland Well #1 after 48-hours. At 4,100 gpm, the projected drawdown after 60 days of pumping (estimated injection cycle duration) is approximately 58 feet. The Inland Well #1 test was conducted in 2013, prior to the installation of Inland Well's #2, #3, #4 #5 and the Inland Observation Well, therefore no observation well data is available and aquifer storativity was not calculated. During AR operations, observation well data will be available and the hydraulic parameters of the aquifer (i.e. transmissivity, storativity) will be calculated.

The response to AR will be tracked at all of TMCF's wells using automated pressure transducers and that data will be used to refine the hydraulic properties of the aquifer. Due to the considerable distance between Inland Well #1 (the initial anticipated AR well), and the nearest observation well (Inland Well #2; 3,082 feet away), and relatively little drawdown observed at 4,100 gpm at Inland Well #1 we do not ancipate significant interference. One well (Boeing Well, Figure D-3) exists within the inland project area that is not owned and operated by TMCF. Inland Well #5 lies between Inland Well #1 and the Boeing Well and water levels at Inland Well #5 will be evaluated to project a potential response at the Boeing Well although we do not anticipate significant interference.

These estimates assume that only one well will be utilized for AR initially. Site-specific hydraulic response data collected from the Inland Well #1 well during AR operations will be reported after each year of pilot testing. Additional interference will be evaluated and be accounted for if AR is expanded to incorporate addition wells.

WATER QUALITY

Coumbia River water quality and Inland well groundwater quality is discussed in detail in Attachment E. Groundwater samples (and source water characterization samples) will be collected as described in pilot testing plan and geochemical compatibility modeling will be completed after the source water treatment is finalized and source water is tested.

Given that, water quality for Inland Well #5 was tested and is shown in Table D-6. Cation concentrations, in particular lower concentrations of calcium and magnesium in groundwater versus surface water, and higher sodium concentrations in groundwater versus surface water suggest that the groundwater sampled to-date from the Wanapum groundwater is relatively old.

These data are consistent with other wells sampled in the region (GWMA, 2009a, 2009b, 2011, 2013) and the water level declines noted above that are consistent with limited, or very slow, recharge to deeper portions of the CRBG groundwater system..

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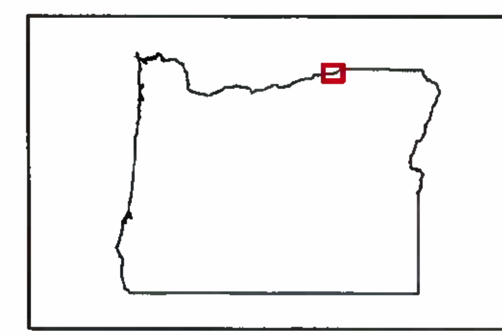
Figures

Figure D-1

Threemile Canyon Farms
Conceptual Hydrogeologic Model
Location Map

Legend

▮▮▮▮▮▮▮▮▮ Approximate Umatilla Basin outline



0 2.5 5 10 15 Miles

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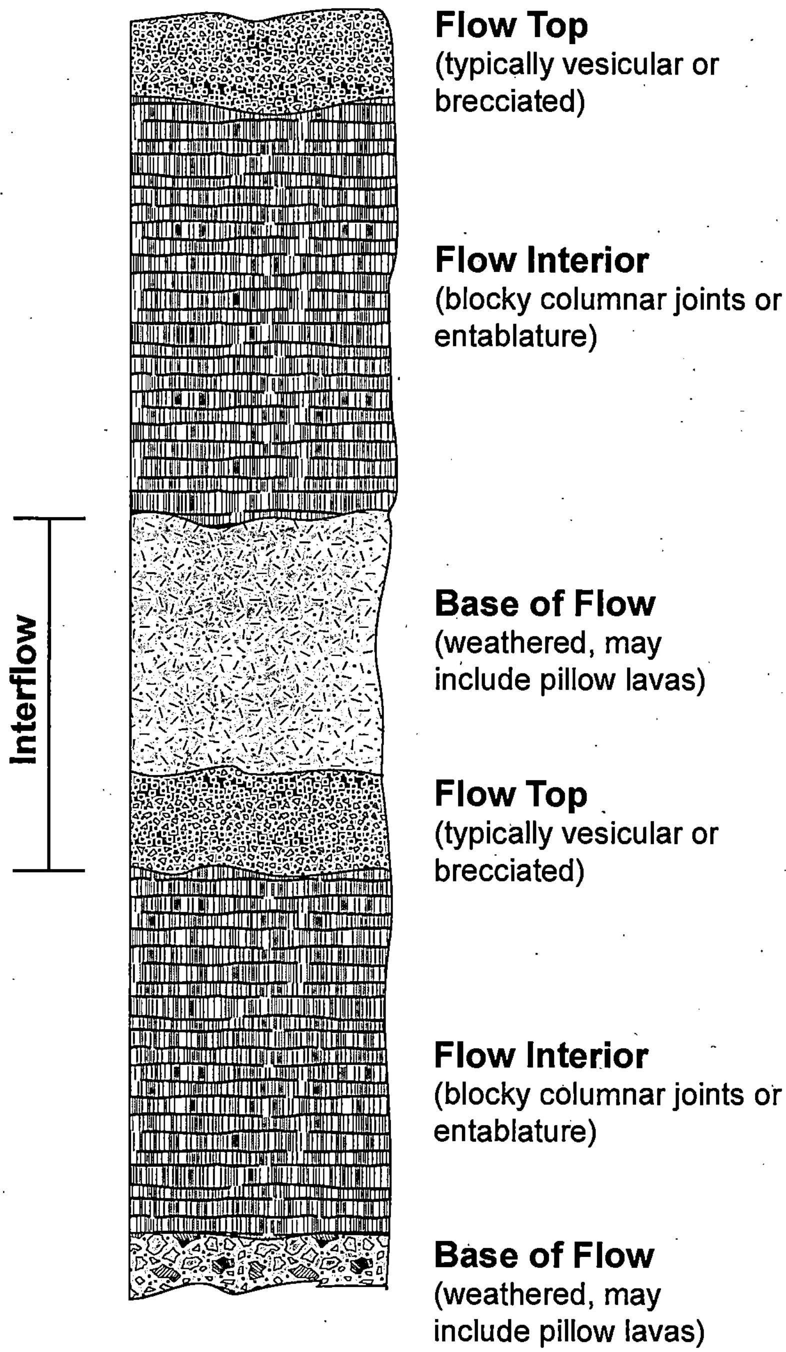

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Threemile Canyon Farms Conceptual Hydrogeologic Model

Figure D-2
CRBG Structures

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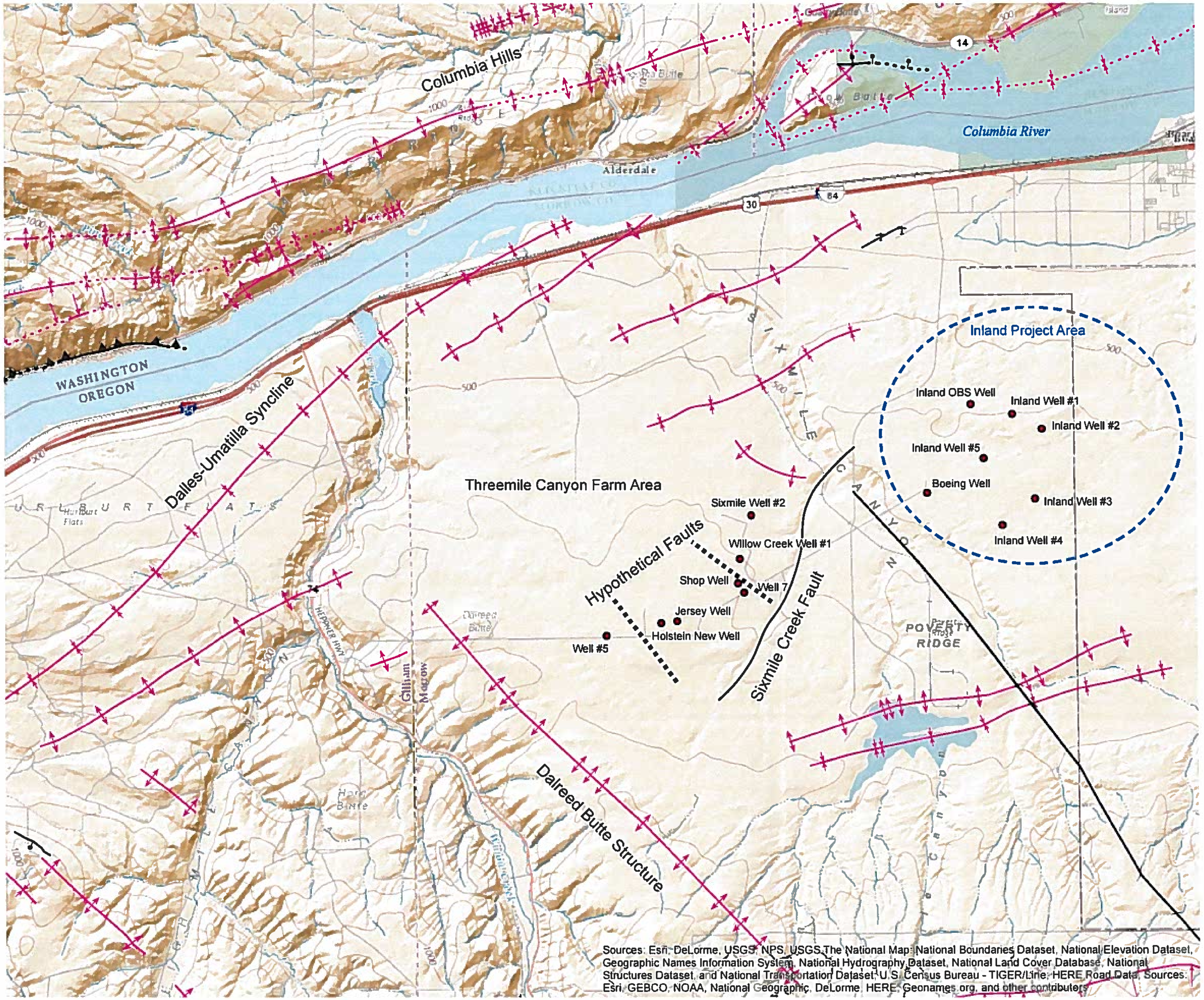


Figure D-3

Threemile Canyon Farms Conceptual Hydrogeologic Model

Local Structural Geology

Legend

WA Folds

- Anticline - Identity and existence certain, location accurate [1]
- Anticline - Identity and existence certain, location concealed [3]
- Syncline - Identity and existence certain, location accurate [13]
- Syncline - Identity and existence certain, location concealed [15]
- Monocline, synclinal bend - Identity and existence certain, location accurate [25]
- Monocline, synclinal bend - Identity and existence certain, location concealed [27]

WA Faults

Dip-Slip Movement

- Normal fault - Identity and existence certain, location accurate. Bar and ball on downthrown block [43]
- Normal fault - Identity and existence certain, location concealed. Bar and ball on downthrown block [45]
- Thrust fault - Identity and existence certain, location accurate. Sawteeth on upper plate [7]
- Thrust fault - Identity and existence certain, location concealed. Sawteeth on upper plate [9]

OR Folds

- Anticline - Identity and existence certain, location accurate [1]
- Syncline - Identity and existence certain, location accurate [13]
- Monocline, synclinal bend - Identity and existence certain, location accurate [25]

OR Faults

Dip-Slip Movement

- Normal fault - Identity and existence certain, location accurate. Bar and ball on downthrown block [43]

Movement Unknown

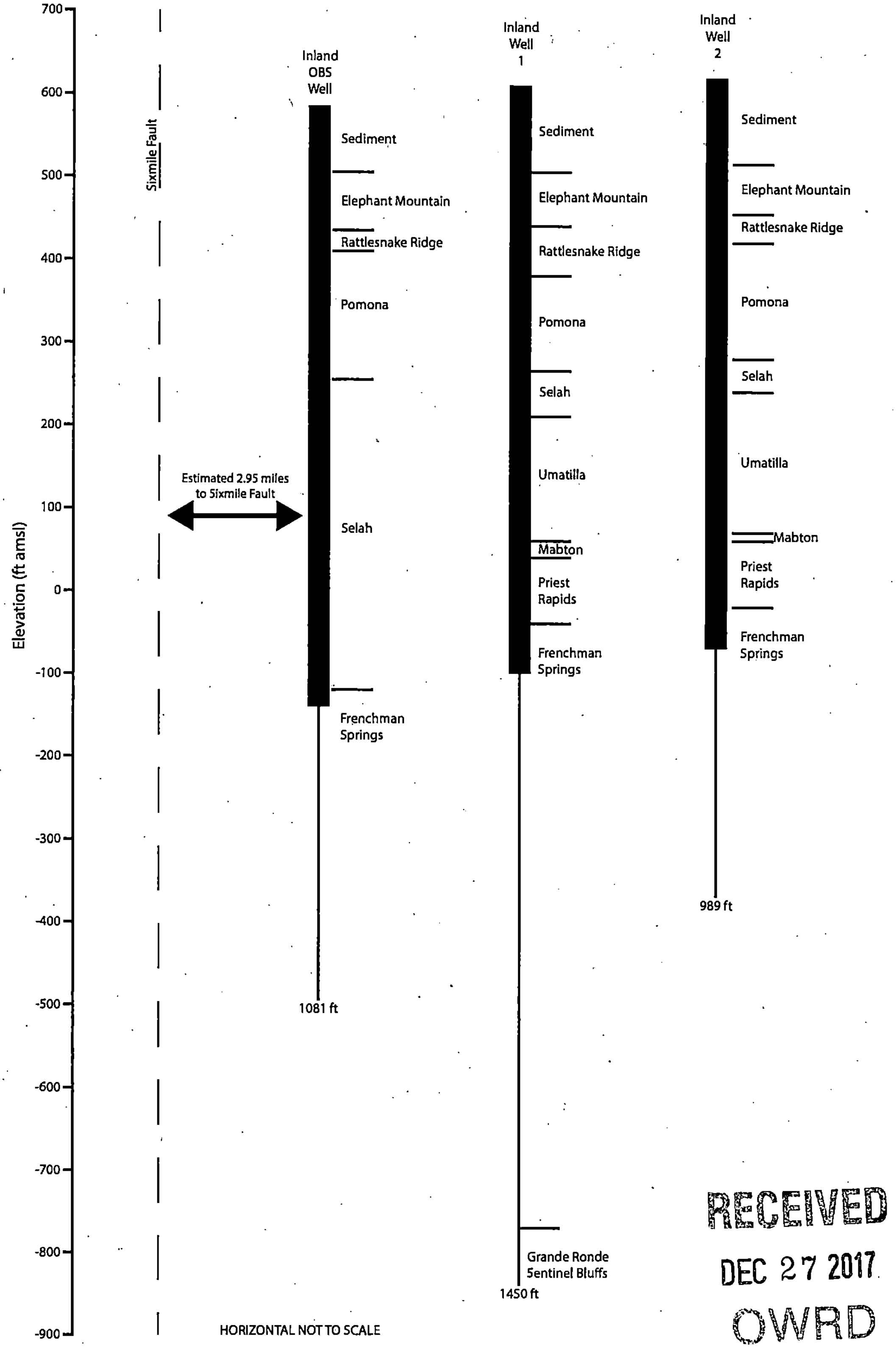
- Fault, unknown offset - Identity and existence certain, location accurate [1]
- TMCF Wells

Note: WA and OR fold and fault data are from different data sets.

0 0.75 1.5 3 4.5 Miles

N

EA Engineering, Science, and Technology, Inc., PBC



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Threemile Canyon Farms Conceptual Hydrogeologic Model

Figure D-4
Inland Wells Schematic Cross Section

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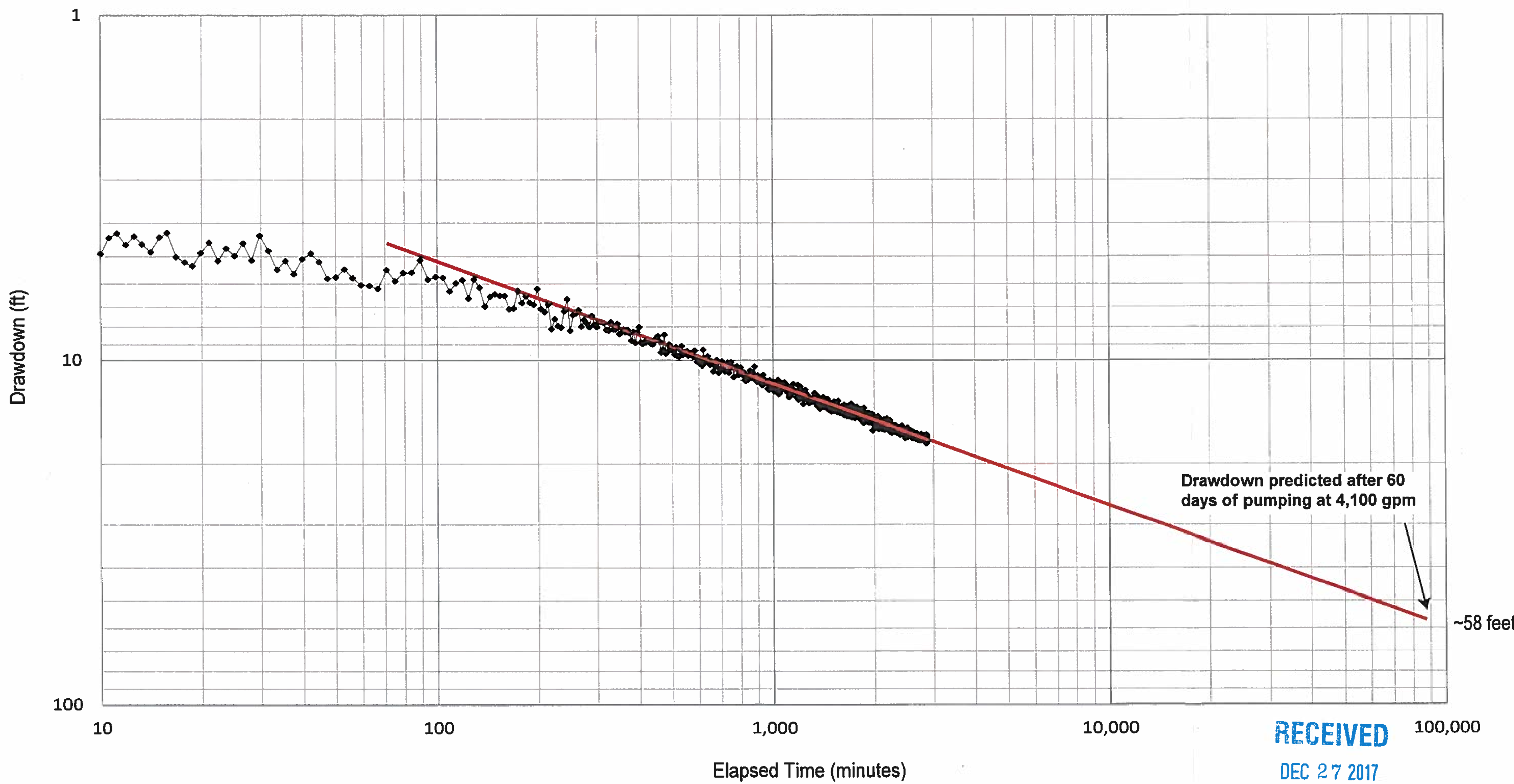

EA Engineering, Science, & Technology, Inc., PBC	Inland Well #1	Threemile Canyon Farms Hydrogeologic Conceptual Model EA Project No. 0741343 File Location: \\kennewick\Projects\Threemile Canyon Farms - TMCF\4.ASR Feasability study 1538302\Inland ASR File Name: Figure 4	FIGURE D-5 Inland Well #1 Hydraulic Response

Tables

Table D-1. Well Construction Summary for Candidate Inland AR Wells

Well	Month/ Year completed	Surface elevation (feet amsl)	Seal Depth (feet bgs)	Casing Depth (feet bgs)	Casing Diameter (inches)	Open Hole (feet bgs)	Open Hole Diameter (inches)
Inland #1	Jan-13	608	0-640 655-705*	0-640	20	705-884 884-1450	19
Inland #2	Apr-13	619	0-689	0-689	20	689-1043	19
Inland #3	Apr-13	605	0-545	0-545	20	545-926	19
Inland #4	May-13	605	0-518	0-518	20	518-966	19
Inland #5	Jul-16	617	0-706	0-706	20	706-1020	19
Notes:							

*cement seal placed for borehole stability

AMSL - Above Mean Sea Level

BGS - Below Ground Surface

Table D-2. Surface Elevation (feet amsl) and Depth of Geologic Units (feet bgs) Encountered in Inland Wells

	Inland #1	Inland #2	Inland #3	Inland #4	Inland #5
Surface El. (ft amsl)	608	619	605	605	617
Alluvial and backfill	0-100	0-105	0-57	0-47	0-97
Elephant Mountain	100-166	106-167	57-142	47-142	97-155
Rattlesnake Ridge	166-228	167-199	142-153	142-174	155-195
Pomona	228-345	199-336	153-282	174-260	195-330
Selah	345-398	366-379	282-292	260-280	330-362
Umatilla	398-548	379-520	292-434	280-398	362-505
Mabton	548-568	520-545	434-466	398-417	505-537
Priest Rapids	568-650	545-641	466-553	417-483	537-663
Quincy/Squaw Creek	650-705	641-665	553-554	483-493	663-668
Frenchman Springs	705-1379*	665-998*	554-926*	493-966*	668-1020*
Sentinel Bluffs	1379-1450*	-	-	-	-
Total depth	1450	998	926	966	998
Notes:					

*indicates open interval in well is partially too completely in this unit.

Table D-3. Interpreted Depths of Water-Bearing Intervals in Inland AR Wells.

Unit	Inland #1	Inland #2	Inland #3	Inland #4	Inland #5
Priest Rapids					
Frenchman	775-795 940-956 1024-1035 1224-1232	705-727 924-947 998-1006	563-658 785-795 868-908	524-538 585-638 740-750 781-786 833-878	725-760 888-912 974-993
Grande Ronde	1379-1407				
Note:					

All depts are feet below ground surface

Table D-4. Water Level Summary for TMCF Candidate AR Wells.

Well	Surface Elevation (feet amsl)	Water level (feet amsl)	Date	Water level (feet amsl)	Date
Inland #1	608	394.35	3/5/2014	330.92	10/28/2016
Inland #2	619	398.78	3/5/2014	334.62	10/28/2016
Inland #3	605	402.31	3/5/2014	337.94	10/28/2016
Inland #4	605	403.34	3/5/2014	339.15	10/28/2016
Inland #5	617	385.9	3/5/2014	321.72	10/28/2016

Notes:

AMSL - Above Mean Sea Level

Table D-5. Pumping Test Summary for Potential Inland Candidate AR Wells.

Well	Units pumped	Pump rate (gpm)	Drawdown (feet)	Duration (hours)	Specific Capacity (gpm/ft)
Inland #1	Frenchman Springs and upper Grand Ronde	4,163	17	50	244.9
Inland #2	Frenchman Springs	4,000	74.9	48	53.4
Inland #3	Frenchman Springs	3,957	20.5	53	193.0
Inland #4	Frenchman Springs	Not Tested			
Inland #5	Frenchman Springs	Not Tested			

Table D-6 Inland Well #5 Water Quality

ANALYTE GROUP / Analyte	Units	Drinking Water Standard / Criteria	Inland Well #5	
GENERAL CHEMISTRY (GC)			**MRL**	**Result**
Alkalinity (total)	mg CaCO3/L		5	186
Ammonia	mg/L as N		--	--
Bicarbonate	mg/L as CaCO3		5	186
Carbonate	mg/L as CaCO3		5	ND
Chemical Oxygen Demand	mg/L		--	--
Chloride	mg/L	250	0.1	7.43
Dissolved Organic Carbon	mg/L		NA	0.27
Fluoride	mg/L	2.0 (SMCL), 4.0 (MCL)	0.1	1.83
Hardness	mg CaCO3/L	250 (SMCL)	10	28.5
Nitrate+Nitrite (total N)	mg/L as N	10	0.1	ND
Nitrate-N	mg/L as N	10	0.1	ND
Nitrite-N	mg/L as N	1	0.1	ND
Orthophosphate as P	mg/L		0.1	ND
Oxidation-Reduction Potential	millivolts		NA	-374.1
pH	pH units	6.5 to 8.5 (SMCL)	NA	8.42
Phosphorous (total)	mg/L		0.01	ND
Silica (as SiO2)	mg/L		0.1	64.4
Specific Conductance	µS/cm	700 (SMCL)	NA	462
Sulfate	mg/L	250 (SMCL)	0.1	1.33
Sulfide	mg/L		--	--
Total Dissolved Solids	mg/L	500 (SMCL)	10	322
Total Organic Carbon	mg/L		0.5	0.252
Total Suspended Solids	mg/L		1	ND
Turbidity	NTU	1	--	--
METALS (M)				
Aluminum	mg/L	0.05 - 0.2 (SMCL)	0.01	ND
Antimony	mg/L	0.006	0.001	ND
Arsenic	mg/L	0.010	0.001	ND
Barium	mg/L	2	0.001	0.0232
Beryllium	mg/L	0.004	0.001	ND
Cadmium	mg/L	0.005	0.001	ND
Calcium	mg/L		0.1	7.43
Chromium	mg/L	0.1	0.001	0.00152
Copper	mg/L	1.3**	0.001	0.00199
Iron	mg/L	0.3 (SMCL)	0.01	ND
Iron (dissolved)	mg/L		--	--
Lead	mg/L	0.015**	0.001	ND
Magnesium	mg/L		0.1	2.4
Manganese	mg/L	0.05 (SMCL)	0.001	ND
Manganese (dissolved)	mg/L		--	--
Mercury	mg/L	0.002	0.001	ND
Nickel	mg/L	MCL being re-evaluated by EPA	0.001	ND
Potassium	mg/L		0.1	18.2

Selenium	mg/L	0.05	0.001	ND
Silver	mg/L	0.1 (SMCL)	0.001	ND
Sodium	mg/L	20**	0.1	75.3
Thallium	mg/L	0.002	0.001	ND
Uranium	mg/L	0.03	0.001	ND
Zinc	mg/L	5	0.001	0.00159
DISINFECTION BY-PRODUCTS & RESIDUAL DISINFECTANTS (DBP)				
Bromate	mg/L	0.01	--	--
Chlorite	mg/L	1	--	--
Residual Chlorine	mg/L	4	--	ND
Dibromoacetic Acid (HAA)	µg/L	See total HAA's	1	ND
Dichloroacetic Acid (HAA)	µg/L	See total HAA's	1	ND
Monobromoacetic Acid (HAA)	µg/L	See total HAA's	1	ND
Monochloroacetic Acid (HAA)	µg/L	See total HAA's	2	ND
Trichloroacetic Acid (HAA)	µg/L	See total HAA's	1	ND
Total Haloacetic Acids (Total HAA's)	µg/L	60	1	ND
Bromodichloromethane (THM)	µg/L	See Total THM's	0.5	ND
Bromoform (THM)	µg/L	See Total THM's	0.5	ND
Chloroform (THM)	µg/L	70	0.5	ND
Dibromochloromethane (THM)	µg/L		0.5	ND
Total Trihalomethane (TTHM)	µg/L	80	0.5	ND
MISCELLANEOUS (MISC)				
Color	Color units	15	5	ND @ pH 8.12
Corrosivity	Standard units	Non-corrosive	NA	-0.190
MBAS (foaming agents)	mg/L	0.5 (SMCL)	0.05	ND
Cyanide (HCN) (Total)	mg/L	0.2	NR	ND
Odor	T.O.N	3 Threshold Nos.	1	ND
BACTERIOLOGICALS (BAC)				
E. Coli	cfu/100mL		1	Absent
Fecal Coliform (Presence/Absence)	cfu/100mL	absent	--	--
Heterotrophic Plate Count	cfu/100mL		--	--
Total Coliform (Presence/Absence)	cfu/100mL	absent	1	Absent
RADIOLOGICALS (RAD)				
Gross Alpha	pCi/L	15	1	0.604 ± 1.56
Gross Beta	pCi/L	50	1	2.59 ± 1.69
Radium-226/228	pCi/L	5 (combined Radium-226 and -228)	1	2.59 ± 1.69
Radon	pCi/L			183 ± 30
Uranium Activity	pCi/L	20	0.67	ND
SYNTHETIC ORGANIC CHEMICALS (SOC)				
Alachlor	µg/L	2	0.2	ND
Atrazine	µg/L	3	0.1	ND
Benzo(a)pyrene	µg/L	0.2	0.02	ND
Carbofuran	µg/L	40	0.9	ND
Chlordane, Technical	µg/L	2	0.2	ND
Dalapon	µg/L	200	1	ND
Dibromochloropropane	µg/L	0.2	0.02	ND
Dinoseb	µg/L	7	0.2	ND

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Diquat	µg/L	20	0.4	ND
Di(2-Ethylhexyl)-Adipate	µg/L	400	0.2	ND
Di(2-Ethylhexyl)-Phthalate	µg/L	6	0.6	ND
Endothall	µg/L	100	9	ND
Endrin	µg/L	2	0.02	ND
Ethylene Dibromine	µg/L	0.05	0.001	ND
Glyphosate	µg/L	700	5	ND
Heptachlor	µg/L	0.4	0.04	ND
Heptachlor Epoxide	µg/L	0.2	0.04	ND
Hexachlorobenzene	µg/L	1	0.2	ND
Hexachlorocyclopentadiene	µg/L	50	0.1	ND
Lindane (BHC - GAMMA)	µg/L	0.2 as total PAH's	0.02	ND
Methoxychlor	µg/L	40	0.2	ND
Oxamyl (Vydate)	µg/L	200	2	ND
Picloram	µg/L	500	0.1	ND
Aroclor 1016 (PCB)	µg/L	0.5 as total PCB's	0.5	ND
Aroclor 1221 (PCB)	µg/L	0.5 as total PCB's	0.5	ND
Aroclor 1232 (PCB)	µg/L	0.5 as total PCB's	0.5	ND
Aroclor 1242 (PCB)	µg/L	0.5 as total PCB's	0.5	ND
Aroclor 1248 (PCB)	µg/L	0.5 as total PCB's	0.5	ND
Aroclor 1254 (PCB)	µg/L	0.5 as total PCB's	0.5	ND
Aroclor 1260 (PCB)	µg/L	0.5 as total PCB's	0.5	ND
Pentachlorophenol	µg/L	1	0.04	ND
Simazine	µg/L	4	0.07	ND
Toxaphene	µg/L	3	2	ND
2,4 – D	µg/L	70	0.1	ND
2,4,5 - TP (SILVEX)	µg/L	50	0.2	ND
VOLATILE ORGANIC CHEMICALS (VOC)				
Benzene	µg/L	5	0.5	ND
Carbon Tetrachloride	µg/L	5	0.5	ND
cis -1,2- Dichloroethylene	µg/L	70	0.5	ND
Methylene Chloride (Dichloromethane)	µg/L	5	0.5	ND
Ethylbenzene	µg/L	700	0.5	ND
Monochlorobenzene	µg/L	100	0.5	ND
1,2 Dichlorobenzene (*o* -Dichlorobenzene)	µg/L	600	0.5	ND
1,4 Dichlorobenzene (*p* -dichlorobenzene)	µg/L	75	0.5	ND
Styrene	µg/L	100	0.5	ND
Tetrachloroethylene	µg/L	5	0.5	ND
Toluene	µg/L	1000	0.5	ND
trans - 1,2-Dichloroethylene	µg/L	100	0.5	ND
Trichloroethylene	µg/L	5	0.5	ND
Vinyl Chloride	µg/L	2	0.5	ND
Total Xylenes	µg/L	10000	10	ND
1,1 - Dichloroethylene	µg/L	7	0.5	ND
1,1,1 - Trichloroethane	µg/L	200	0.5	ND
1,1,2 - Trichloroethane	µg/L	5	0.5	ND
1,2 - Dichloroethane	µg/L	5	0.5	ND

1,2 - Dichloropropane	µg/L	5	0.5	ND
1,2,4, - Trichlorobenzene	µg/L	70	0.5	ND
FIELD PARAMETERS (FP)				
Temperature	Celcius		NA	23.37
Conductivity	µS/cm		NA	462
Dissolved Oxygen	mg/L		NA	0.27
pH	Units		NA	8.42
Turbidity	NTU		NA	--
Oxidation-Reduction Potential	mV		NA	-374.1

Notes:

--+ Indicated analyte is listed on the EPA Contaminant Candidate List

** Action level set by the Environmental Protection Agency

MCL = Maxiumim Contaminant Level

SMCL = Secondary Maximum Contaminant Level

MDL = Method Detection Limit

RL = Reporting Limit

pCi/L = Picocuries per liter

µg/L = Micrograms per liter

µS/cm = Micro-Siemens per centimeter

mg/L = Milligrams per liter

NTU = Nephelometric turbidity unit

MV = Millivolts

-- Data not provided

ATTACHMENT E

Threemile Canyon Farms – Inland Project Limited License Application for Aquifer Recharge: Water Quality Assessment

EA Engineering, Science, and Technology, Inc., PBC

REGISTERED OREGON JONATHON S. TRAVIS G 2459 GEOLOGIST expires: 2/1/18

ATTACHMENT E
Threemile Canyon Farms – Water Quality Assessment for Aquifer Recharge

Attachment E provides a description of water quality in the portions of the CRBG aquifer intersected by Inland Wells 1 through 5 and the observation well; the portion of the aquifer system proposed for use for mitigation through AR. The quality of the water proposed for the source of recharge, and the anticipated result of mixed source/groundwater quality. Potential source water treatment methods are also summarized.

WATER QUALITY

Groundwater and source water quality data was initially evaluated for AR feasibility by GSI Water Solutions, Inc (GSI) in 2013. A more comprehensive evaluation was performed in 2016 and 2017 by EA Engineering, Science, Technology, Inc., PBC (EA) to support this limited license application. Quality characteristics of both groundwater and source water is described below, and compared to Oregon Department of Environmental Quality (DEQ) regulatory water quality standards.

Groundwater Characterization

Water quality analytical results for samples collected at Inland Wells 1, 2, 3 in 2012 and 2013, and Inland Well 5 in 2016 and 2017 are included in Table E-1. Groundwater pH ranged from 8.17 to 8.47 in these wells. The absence of nitrate and the low concentration of sulfate observed in groundwater, suggesting conditions are within the sulfidic range (Appelo and Postma, 2005).

Groundwater composition is dominated by sodium, potassium and bicarbonate (Na-K-HCO3) water type (Figure E-1). Other general water quality observations for native groundwater include:

- Arsenic was not detected.
- Other trace metals were observed at very low concentrations.
- Iron and manganese were detected in very low concentrations in Inland Well 1 and 2 samples.
- Sodium concentrations (72.0mg/L to 82.4 mg/L) are above the EPA recommended value of 20 mg/l.

Regulated volatile organic compounds (VOCs) and synthetic volatile organic compounds (SVOCs) were not detected in the 2012, 2013, 2016 and 2017 samples. Radiounuclides were present, but below regulatory standards. Based on the groundwater quality data collected to date the Inland Wells are interpreted to all have similar water quality.

Source Water Characterization

Source water for the project is proposed to be treated surface water from the Willow Creek/Columbia River diversion. An initial assessment of raw and filtered source water quality was performed in October 2013 (GSI, 2013). Based on recommendations from that evaluation pre- and post-filtration water quality sampling of Willow Creek source water for the comprehensive suite of analytes listed in Table E-1 was done in August 2016, when samples were collected both upstream of and downstream of the dairy filter. In June 2017, an additional source water sample was collected at the Inland booster pump.

Some variability was observed in major anions, cations and TDS relative to the October 2013 samples (Figure E-1). In general, the August 2016 and June 2017 samples are more dilute (lower alkalinity and ion concentrations) than the October 2013 sample. Given the observed seasonal variability, additional recharge-season samples will be collected to better characterize source water quality. Water quality monitoring performed by TMCF at the Willow Creek pump station suggests that higher concentrations of total dissolved solids may occur in the spring (Figure E-2). Nitrate and chloride concentrations are observed to be slightly higher during spring runoff, a pattern that may be seen in other constituents also (Figure E-2). These pump station sampling results do not commonly show nitrate and chloride above the DEQ groundwater standard. In fact, concentrations have been relatively low and stable since 2010.

Water quality results for the raw and filtered source water collected in 2013, 2016, and 2017 meet or fall below all applicable DEQ groundwater quality standards except iron, color and TDS. Most post-filtration concentrations were less than 50 percent of established DEQ MML levels for drinking water, a target requirement under Oregon Administrative Rule OAR 340-40-020 and 340-40-090. Exceptions are:

- In the August 2016 filtered sample, the total iron concentration was 0.186 mg/L, slightly exceeding the ½ MML threshold of 0.15 mg/l by 0.036 mg/l.
- In the October 2013 pre- and post-filtration sample, TDS of 268 mg/L and 257 mg/L were observed, slightly exceeding the ½ MML threshold of 250 mg/l. However, background groundwater at some Inland wells exhibit similar TDS concentrations.
- Color was at ½ MML or exceeded the DEQ MML in August 2016 and June 2017 samples.
- If these concentrations persist above ½ the MML, TMCF will either modify the treatment approach or pursue approval to allow slightly higher concentrations below the MML.

All regulated VOCs and SVOCs were below analytical method detection limits. Radionuclides were observed to be present, but below regulatory criteria. In addition to the standard list of VOC and SVOC drinking water contaminants, perchlorate and unregulated herbicide Dacthal were also evaluated. Perchlorate was detected at concentrations of 0.202 to 0.337 ppb in surface water. Perchlorate is both a naturally occurring and anthropogenic contaminant and is currently a candidate on the Contaminant Candidate List (CCL) for drinking water and the observed concentrations are less than ½ the proposed MCL of 1 ppb. Dacthal was added to the contaminant evaluation based on conversations with Oregon Department of Environmental Quality (DEQ) previous studies performed in the Umatilla Basin showing its persistence in shallow groundwater and surface water. TMCF also periodically samples source water for other pesticides, herbicides, and fungicides to meet requirements of their USDA permit.

Total coliforms and E. Coli samples were evaluated as part of this preliminary evaluation. As expected, they are observed to be present in raw water (historically sampled at Willow Creek), and filtered source water (2016) but absent in groundwater (Table E-1). The presence of coliform bacteria in the filtered and disinfected source water sample collected in 2016 may be a sampling artifact due to the condition of the sample port and field conditions during sampling. However, it should also be noted that the existing filtration system is not designed to disinfect source water samples. Coupled with disinfection, filtration such as is currently in use would likely be effectiveness at reducing levels of some microbial contaminants that could be present in unfiltered surface water, including coliforms.

Based on these samples, and with proper treatment to address potential surface water pathogens, the source water appears acceptable for AR operations from an anti-degradation perspective. Some constituents slighlty exceed ½ the MML, though these can likely be addressed through treatment modification and/or alternative permit compliance standards.

GEOCHEMICAL COMPATIBILITY

Undesirable reactions between the recharge water and native groundwater have the potential to reduce the efficiency of the recharge well or impact water quality in the aquifer. The potential for such reactions to take place were evaluated using an aqueous geochemical software program developed by the U.S. Geological Survey (PHREEQC v. 2.18.3). Like the 2013 approach, the saturation indices for the common anions, cations and metals and their tendency to precipitate as minerals or go into solution was predicted based on mixing various rations of filtered source water and groundwater quality at the proposed AR well Inland Well 5. This section provides a preliminary evaluation of the chemical compatibility between Columbia River source water (post-filtration) and native basalt aquifer groundwater (Inland Well 5).

The dissolved oxygen concentration was observed to range from 9.28 to 8.68 mg/L indicating that the recharge source water is oxygen-rich and near saturation. The presence of dissolved oxygen (DO), low concentrations of total iron (<0.3 mg/L), and a highly oxidized (i.e. positive) ORP value are characteristic of oxidizing conditions present in source water. The source water pH ranged from 8.2 to 8.53, slightly lower but very similar to groundwater. The concentrations of many source water constituents are less than (or very similar to) basalt groundwater. However, concentrations of major anions and cations indicate that the source water type is calcium-bicarbonate (Ca-HCO3), which is compositionally dissimilar to the groundwater in that it contains a higher proportion of calcium (Figure E-1).

Compatibility and Mixing Results

A compatibility and mixing analysis was completed for a previous, but now inactive, ASR LL Application submitted to OWRD by EA (on behalf of TMCF) in January 2017 (*Threemile Canyon Farms Inland Area ASR Limited License Application*). Although that ASR LL application is no longer active and being considered by TMCF, the compatibility and mixing analysis in it is relevant to this AR LL application. The results of that previously completed compatibility and mixing analysis are summarized below.

Source water and groundwater mixing simulations were evaluated for three water-water mixing ratios intended to cover conditions that may occur throughout the aquifer during recharge: (1) a groundwater-dominated system (10% source water and 90% groundwater), (2) an equal mix of 50% source water and 50% groundwater, and (3) a source-water dominated system (90% source water and 10% groundwater). These mixtures are representative of the range of conditions that will be present in the aquifer near the aquifer recharge well from near the recharge well to water quality that is likely to be present at more distant irrigation wells.

Results of the mixing simulations are summarized below:

- Mixing of the filtered source and groundwater in various proportions results in a water that is oversaturated with respect to ferric hydroxide [Fe(OH)3] and goethite, and slightly oversaturated with respect to dolomite and calcite. Oversaturated conditions do not necessarily mean the mineral will precipitate; only that it tends to do so based on calculated saturation indices.
- If ferric hydroxide were to precipitate, its mass would be expected to be similar to the mass of available iron in the filtered source water (total iron was detected at very low concentrations in October source water which is assumed to be more representative of actual injection water quality), and therefore a decrease in aquifer permeability is not anticipated if precipitation does occur. This condition has been observed at several other artificial recharge projects with no significant change in well performance.
- The water quality data collected to date indicate that the precipitation of chalcedony and quartz is unlikely.

This mixing assessment does not include the potential for rock-water reactions. Observations made during drilling of the Inland Wells identified the presence of pyrite and other secondary sulfide minerals in the interflow zones within the CRBG. Depending upon redox conditions, basalt geochemistry and other secondary minerals present within the interflow zones, mineral dissolution or precipitation within the aquifer could occur causing minor changes in recharged water quality and/or well performance. However, experience with other AR systems completed in the CRBG aquifer has not demonstrated substantial changes in stored water quality where sulfide minerals are present. Nevertheless, metal concentrations, in particular arsenic, will be monitored closely during testing.

Based on projects that store treated surface water of very similar composition in basalt aquifers of very similar composition near this site, it appears that the potential for chemical clogging problems or significant water quality changes are limited. However, physical clogging of the well by suspended particulate in source water remains a concern. TSS greater than 1 mg/L has the potential to affect well performance via the buildup of solids in the well and aquifer matrix over time. Observed post-filtration TSS concentrations were 2.18 and 6.06 mg/l, suggesting that additional filtration to enhance removal may be required to maintain well performance and/or limit operations and maintenance effort.

Removal of suspended solids is commonly accomplished by periodic back-flushing of the AR well on a routine basis.

SOURCE WATER TREATMENT

TMCF operates an irrigation system that delivers Columbia River water to over 30,000 acres of agricultural ground. The pump station is comprised of two lineups of vertical turbine pumps that deliver water at two different heads (pressures). The proposed AR project is located on the Inland Area of the farm.

Water Treatment Options

The primary treatment target for the proposed Inland AR project is to produce injected source water quality compatible with native aquifer water quality. Numerous methods exist for treating surface water to meet anti-degradation standards, though these methods are typically only practical for municipal water systems with relatively low demand (compared to agricultural use) and high population density. For this reason, most ASR systems currently operating in Oregon and Washington are associated with already existing public drinking water systems.

Treatment methods used for most municipal ASR projects include Slow Sand Filtration (SSF), membrane filters with disinfection, Membrane Bio-Reactor (MBR), and a combination of disinfection using ultra-violet (UV) light and chlorine. Oregon non-municipal ASR projects have utilized riverbank filtration or natural filtration using shallow alluvial sands and gravels. A practical approach that TMCF currently uses for diary water supply is to filter the water to remove solids using pressurized sand filters and use chlorination for disinfection. Such an approach, and modifications of it, are the preferred options for the proposed AR project. It is explored further in the following pages.

Pressurized Filters

The use of carbon steel tank media filters such as those used for pre-filtering water prior to drip irrigation as currently used on the farm, may be a good alternative for pre-injection treatment. Pressure filters (such as those manufactured by Lakos) use a sand media to remove contaminants from the water such as algae, sediment, and some bacteria. The water discharged from the pressure filters would have TSS suitable for injection into AR wells. Adding disinfection to such filtration, it is estimated that a 2,500 gpm installation at an Inland well would be $60,000 to $100,000.

This this type of system would meet the Oregon state regulations as a "Technically feasible, practical and cost-effective method" to treat the injected water, though additional investigation is needed to determine whether media or other treatment train modification, such as activated media, UV and chlorination, can be made to adequately address pathogens and some metals. Such additional investigation would be the first work activity done under the proposed LL. The results of such work would be reviewed with OWRD and DEQ prior to any injection activity.

Disinfection and Disinfection By-Products

Sodium hypochlorite is commonly used for the disinfection of drinking water for humans, it also currently used for TMCF dairy livestock water treatment, providing inactivation of certain pathogens. It is also used to limit biological growth and/or fouling within typical injection well systems during operations. Residual chlorine in disinfected source water can react with natural organic matter to form disinfection by-products (DBPs).

DBPs include trihalomethanes (THMs) and haloacetic acids (HAAs), and are not naturally present in groundwater. Operational data at several ASR projects in the Pacific Northwest have demonstrated the rapid attenuation of DBPs to non-detectable or acceptable levels after residence in the subsurface. If sodium hypochlorite is part of the treatment process for source water DBPs will need to be characterized during AR testing, though organic carbon is not expected to be present in sufficient quantity to be problematic with respect to DBP formation.

UV treatment without the use of chlorination may also be considered. This would remove the potential for the introduction of DBP's into the native groundwater.

DBP evaluations will be a significant part of any injection testing done under the proposed LL.

Treatment Summary

Source water for the proposed Inland AR project will be diverted from the Columbia River. TMCF currently uses Columbia River water for both irrigation and stock water purposes. Water used for dairy livestock purposes is currently treated by filtration using a series of slow sand filter (SSF) pressure vessels followed by disinfection with sodium hypochlorite. This treatment is effective in reducing total suspended solids, turbidity, improving the aesthetic quality of the water for consumption by dairy livestock and meeting U.S. Department of Agriculture requirement for dairy livestock.

The Threemile Canyon Farms irrigation system has the capacity to deliver up to 12,500 gpm to all five Inland wells. Water quality from Willow Creek will need to be managed to reduce suspended solids and surface water pathogens. Standard treatment technologies, such as those used for a typical municipal ASR system are cost-prohibitive for a recharge/mitigation project of this scale. However, methods such as tank media filters and/or engineered infiltration systems could be used to adequately treat the water prior to injection. Further evaluation of these methods via field testing is the cornerstone of the initial work proposed for this project. The goal of such work is to demonstrate produced water suitability prior to injection testing.

The treatment approach selected will need to demonstrate compliance with Oregon Department of Environmental Quality (DEQ) regulations for anti-degradation of an aquifer. AR source water is required comply with DEQ water quality standards, treatment requirements, and performance standards as established by the DEQ and OWRD under OAR 340-40-020, 340-40-090, and 690-350-020. The treatment test phase of the project will attempt to identify the filtration and disinfection system(s)

SUMMARY

Treatment options currently being considered, and which may be field tested, to meet DEQ requirements consist of the following:

- Conventional filtration system consisting of gravity fed slow sand filtration ponds,
- Combined with disinfection or a treatment method to meet maximum contaminant levels for microbial contaminants.

It is possible that other alternatives may be considered during the design phase of the distribution system improvements to deliver source water to the AR wells.

This preliminary evaluation assessed the chemical compatibility between source water and groundwater (water-water interaction). These initial mixing scenarios do not account for possible mineral precipitation or dissolution (water-mineral interaction) reactions with the aquifer matrix or secondary minerals such as sulfides that may occur in the subsurface. Changes in stored water concentrations of dissolved iron, manganese and other trace metals and metalloids that are common in sulfide minerals will need to be assessed observationally as part of the pilot test program.

REFERENCES

Appelo and Postma, 2005. Geochemistry, Groundwater and Pollution, 2nd edition, CRC Press, 649 pages.

GSI Water Solutions, Inc., 2013. Technical Memorandum: TMCF Dairy Well ASR – Initial Water Quality Evaluation, December 2013.

Figures

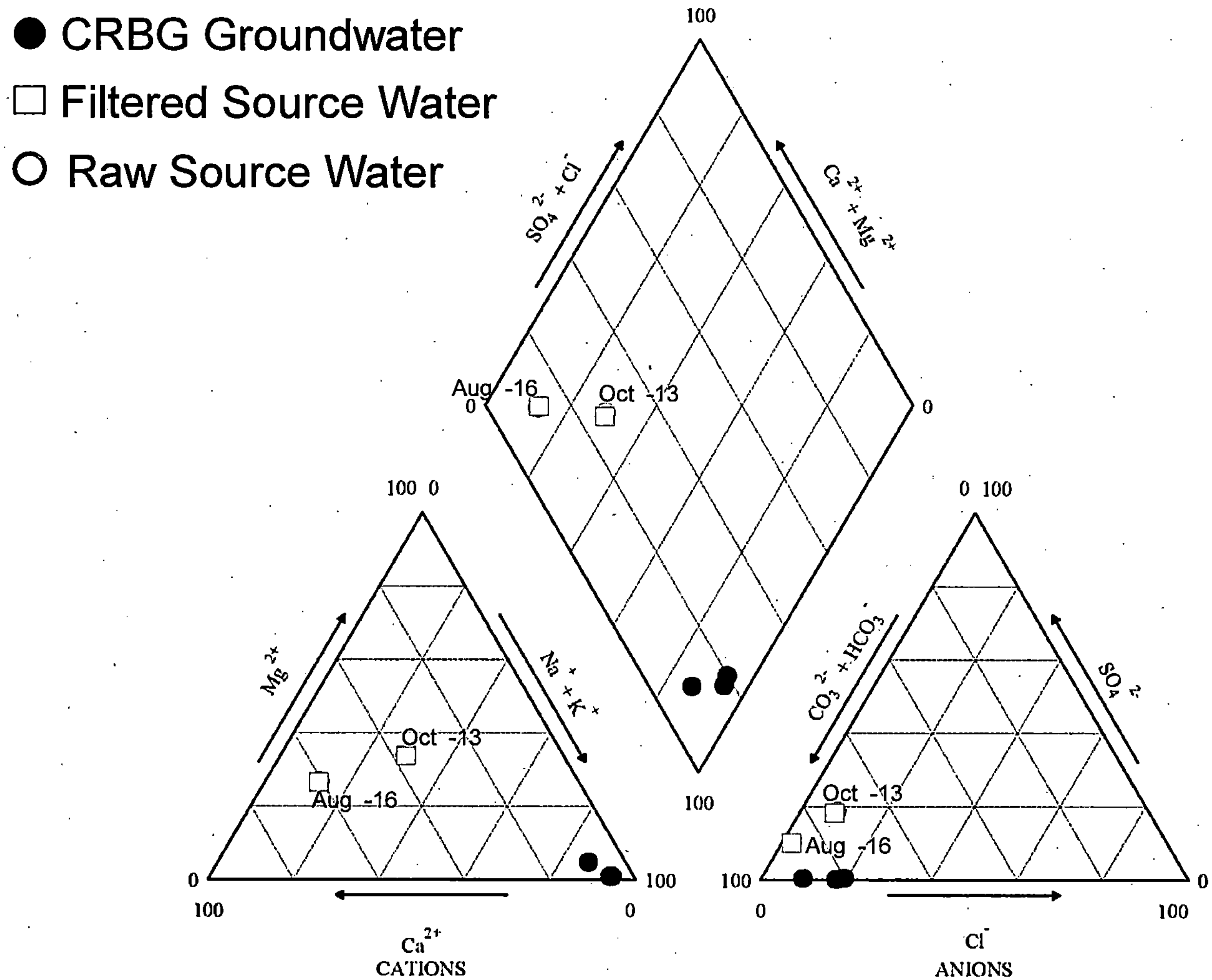
E-1 Trilinear Diagram of Groundwater and Source Water Quality

E-2 TMCF Historical Willow Creek Water Quality Monitoring Results

Tables

E-1 Groundwater and Source Water Quality Summary

Figures



Trilinear Diagram of Source Water and Groundwater

Threemile Canyon Farms Water Quality Assessment for Aquifer Recharge

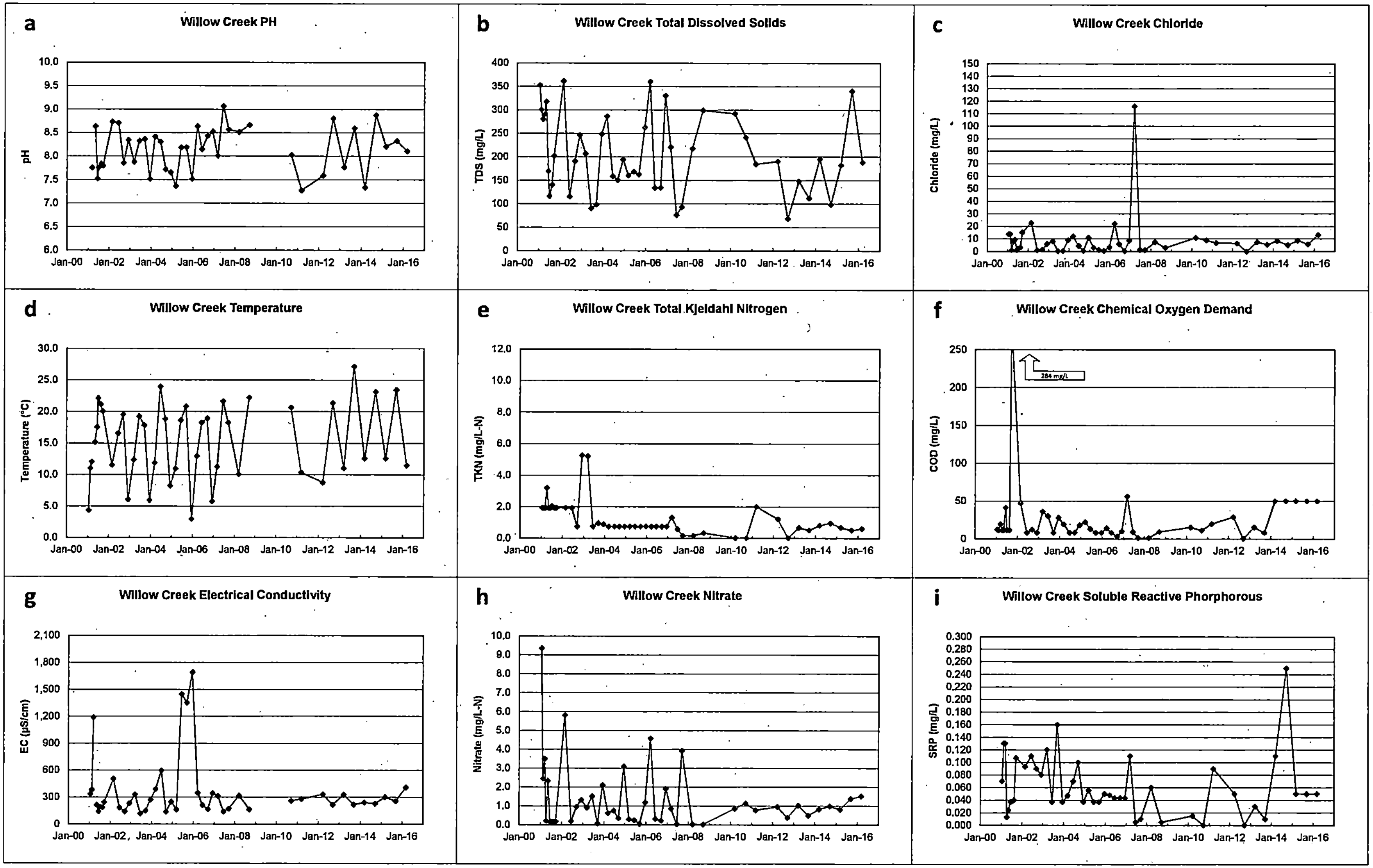
EA Engineering, Science, and Technology, Inc., PBC

Figure E-1

Notes:

1. Major anions and cations percentages are from total concentrations not dissolved concentrations
2. Filtration of surface water consisted of slow sand filtration using pressurized vessels to reduce total suspended solids and turbidity of raw water. No apparent change in relative ionic percentages occurred due to filtration as noted by the overlap of raw and filtered water symbols.

Figure E-2: TMCF Historical Willow Creek Water Quality Monitoring Results
Threemile Canyon Farms Water Quality Assessment



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Tables

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Table E-1

AR LIMITED LICENSE WATER QUALITY TEST RESULTS

			WILLOW CREEK/COLUMBIA RIVER SOURCE WATER											
			PRE-FILTER			POST-FILTER			PRE FILTER			POST FILTER		
		Sample Date:	10/10/2013			10/10/2013			8/15/2016			8/15/2016		
		Lab ID:	131011061-001			131011061-002			160816027-001			160816027-002		
Analyte	**OHA DW Standards**	**Oregon DEQ Standards**	**MRL**	**Result**	**Q**	**MRL**	**Result**	**Q**	**MRL**	**Result**	**Q**	**MRL**	**Result**	**Q**
INORGANIC CHEMICALS (IOCs)														
Alkalinity (as $CaCO_3$) *(mg/L)*			5	124		5	129		5	55		5	52.6	
Aluminum (total) *(mg/L)*	**0.05-0.2 (SMCL)**		0.01	0.142		0.01	0.07		0.01	0.320		0.01	0.162	
Antimony (total) *(mg/L)*	**0.006 (MCL)**		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Arsenic (total) *(mg/L)*	**0.010 (MCL)**	**0.050 (DEQ MML)**	0.001	0.0028		0.001	0.00294		0.001	ND		0.001	ND	
Barium (total) *(mg/L)*	**2 (MCL)**	**1 (DEQ MML)**	0.001	0.11		0.001	0.104		0.001	0.0286		0.001	0.0262	
Bicarbonate *(as CaCO3) (mg/L)*			5	124		5	129		5	55		5	52.6	
Beryllium (total) *(mg/L)*	**0.004 (MCL)**		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Cadmium (total) *(mg/L)*	**0.005 (MCL)**	**0.01 (DEQ MML)**	0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Calcium (total) *(mg/L)*			0.1	32.3		0.1	31.5		0.1	16.6		0.1	16.6	
Carbonate (as $CaCO_3$) *(mg/L)*			5	ND		5	ND		5	ND		5	ND	
Chloramine *(mg/L)*														
Chloride (total) *(mg/L)*	**250 (SMCL)**	**250 (DEQ MML)**	0.1	17		0.1	17.3		0.1	1.71		0.1	1.72	
Chromium (total) *(mg/L)*	**0.1 (MCL)**	**0.05 (DEQ MML)**	0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Copper (total) *(mg/L)*	**1.3 (Action Level) (1.0 SMCL)**	**1.0 (DEQ MML)**	0.001	0.00713		0.001	0.00424		0.001	0.00144		0.001	ND	
Cyanide (total) *(mg/L)*	**0.2 (MCL)**		NR	ND		NR	ND		0.01	ND		0.01	ND	
Fluoride (total) *(mg/L)*	**4 (MCL), 2.0 (SMCL)**	**4 (DEQ MML)**	0.1	0.446		0.1	0.447		0.1	0.100		0.1	0.101	
Hardness (as $CaCO_3$) *(mg/L)*	**250 (SMCL)**		10	154		10	150		10	59.6		10	59.5	
Iron (total) *(mg/L)*	**0.3 (SMCL)**	**0.3 (DEQ MML)**	0.01	0.0665		0.01	0.0337		0.01	0.381		0.01	0.185	
Lead (total) *(mg/L)*	**0.015 (MCL)**	**0.05 (DEQ MML)**	0.001	0.00137		0.001	ND		0.001	ND		0.001	ND	
Magnesium (total) *(mg/L)*			0.1	17.8		0.1	17.4		0.1	4.40		0.1	4.36	
Manganese (total) *(mg/L)*	**0.05 (SMCL)**	**0.05 (DEQ MML)**	0.001	0.014		0.001	ND		0.001	0.0111		0.001	ND	
Mercury (total inorganic) *(mg/L)*	**0.002 (MCL)**	**0.002 (DEQ MML)**	0.0001	ND		0.0001	ND		0.0001	ND		0.0001	ND	
Nickel (total) *(mg/L)*	**0.1****		0.001	0.00393		0.001	0.00206		0.001	0.00155		0.001	0.00102	
Nitrate (as N) *(mg/L)*	**10 (MCL)**	**10 (DEQ MML)**	0.1	ND		0.1	ND		0.1	ND		0.1	ND	
Nitrite *(mg/L)*	**1 (MCL)**		0.1	ND		0.1	ND		0.1	ND		0.1	ND	
Nitrate+Nitrite (total N) *(mg/L)*	**10 (MCL)**		0.1	ND		0.1	ND		0.1	ND		0.1	ND	
Perchlorate (ug/L)									0.05	0.202		0.05	0.203	
Phosphate *(mg/L)*			NA	ND		NA	ND		0.1	ND		0.1	ND	
Phosphorus (total) *(mg/L)*			NA	0.02		NA	0.0109		0.01	ND		0.01	ND	
Potassium *(mg/L)*			0.1	5.22		0.1	5.04		0.1	0.919		0.1	0.892	
Selenium (total) *(mg/L)*	**0.05 (MCL)**	**0.01 (DEQ MML)**	0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Silica *(mg/L)*			0.1	5.63		0.1	4.96		0.1	8.71		0.1	7.83	
Silicon *(mg/L)*			NR	2.63		NR	2.32		0.1	4.07		0.1	3.66	
Silver (total) *(mg/L)*	**0.1 (SMCL)**	**0.05 (DEQ MML)**	0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Sodium *(mg/L)*		**20 (EPA recommended)**	0.1	26.1		0.1	26		0.1	3.47		0.1	3.46	
Sulfate *(mg/L)*	**250 (SMCL)**	**250 (DEQ MML)**	0.1	50.7		0.1	50.7		0.1	9.55		0.1	9.61	
Sulfide *(mg/L)*														
Thallium *(mg/L)*	**0.002 (MCL)**		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Uranium *(mg/L)*									0.001	ND		0.001	ND	
Zinc (total) *(mg/L)*	**5 (SMCL)**	**5 (DEQ MML)**	0.001	0.066		0.001	0.00141		0.001	0.00793		0.001	0.00123	
FIELD PARAMETERS														
pH *(pH units)*	**6.5-8.5 (SMCL)**	**6.5-8.5 (DEQ MML)**	NA	8.42		NA	8.48		NA	8.1		NA	8.2	
Specific Conductance *(µ S/cm)*			NA	342.1		NA	341.1		NA	123		NA	124	
Turbidity *(NTUs)*	**1 (MCL)**	**1 (DEQ MML)**	NA	NA		NA	NA		NA			NA		
Temperature (°C)			NA	18.9		NA	18.9		NA	21.14		NA	21.24	
Dissolved Oxygen *(mg/L)*			NA	9.66		NA	9.28		NA	8.68		NA	8.88	
Oxidation-reduction potential *(mV)*			NA	185.5		NA	216.1		NA	-174.8		NA	-164.9	
MISCELLANEOUS														
Asbestos *(million fibers per liter longer than 10um)*	**7 (MCL)**													
Color *(color units)*	**15 (SMCL)**	**15 (DEQ MML)**							5	20 @ pH 7.60		5	10 @ pH 7.63	
Corrosivity* *(S.U.)*	**NON-CORROSIVE**									-0.792			-0.791	
Foaming Agents (MBAS); *(mg/L)*	**0.5 (SMCL)**	**0.5 (DEQ MML)**							0.05	ND		0.05	ND	
Odor *(T.O.N.)*	**3 TON (SMCL)**	**3 TON (DEQ MML)**							1	ND		1	ND	
Total Dissolved Solids *(mg/L)*	**500 (MCL)**	**500 (DEQ MML)**	10	258		10	257		10	78		10	92	
Total Organic Carbon *(mg/L)*			0.5	3.82		0.5	3.71		0.5	1.46		0.5	1.46	
Total Suspended Solids *(mg/L)*			1	7.42		1	2.18		1	11.4		1	6.06	
VOLATILE ORGANIC COMPOUNDS (VOCs)														
1,1-Dichloroethylene *(ug/L)*	**7 (MCL)**	**7 (DEQ MML)**	0.5	ND		0.5	ND		0.5	ND		0.5	ND	
1,1,1,2-Tetrachloroethane *(ug/L)*														
1,1,2,2-Tetrachloroethane *(ug/L)*														
1,1,1-Trichloroethane *(ug/L)*	**200 (MCL)**	**200 (DEQ MML)**	0.5	ND		0.5	ND		0.5	ND		0.5	ND	
1,1,2-Trichloroethane *(ug/L)*	**5 (MCL)**		0.5	ND		0.5	ND		0.5	ND		0.5	ND	

	WILLOW CREEK/COLUMBIA RIVER SOURCE WATER			Wanapum Groundwater														
	INLAND BOOSTER			I-WELL 5			Inland Well 5			Inland Well 1			Inland Well 2			Inland Well 3		
Sample Date:	6/20/2017			8/16/2016			6/21/2017			11/28/2012			1/31/2013			5/3/2013		
Lab ID:	170621069-001			160817045-001			170622027-001											
Analyte	**MRL**	**Result**	**Q**	**MRL**	**Result**	**Q**	**MRL**	**Result**	**Q**	**MRL**	**Result**	**Q**	**MRL**	**Result**	**Q**	**MRL**	**Result**	**Q**
INORGANIC CHEMICALS (IOCs)																		
Alkalinity (as $CaCO_3$) *(mg/L)*	5	57.4		5	186		5	188		5	179		5	182		5	182	
Aluminum (total) *(mg/L)*	0.01	0.17		0.01	ND		0.01	ND		0.01	ND		0.01	ND		0.01	ND	
Antimony (total) *(mg/L)*	0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Arsenic (total) *(mg/L)*	0.001	0.00182		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Barium (total) *(mg/L)*	0.001	0.0281		0.001	0.0232		0.001	0.0256		0.001	0.0231		0.001	0.0258		0.001	0.0307	
Bicarbonate *(as CaCO3) (mg/L)*	5	57.4		5	186		5	188		5	179		5	182		5	182	
Beryllium (total) *(mg/L)*	0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Cadmium (total) *(mg/L)*	0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Calcium (total) *(mg/L)*	0.1	17.7		0.1	7.43		0.1	7.16		0.1	7.6		0.1	7.38		0.1	8.03	
Carbonate (as $CaCO_3$) *(mg/L)*	5	ND		5	ND		5	ND		5	ND		5	ND		5	ND	
Chloramine *(mg/L)*	0.05	ND					0.05	ND		0.05			0.05			0.05		
Chloride (total) *(mg/L)*	0.1	7.2		0.1	37.1		0.1	36.4		0.1	35.9		0.1	36.1		0.1	34.5	
Chromium (total) *(mg/L)*	0.001	0.00124		0.001	0.00152		0.001	0.00173		0.001	ND		0.001	ND		0.001	0.00142	
Copper (total) *(mg/L)*	0.001	0.00196		0.001	0.00199		0.001	0.00183		0.001	ND		0.001	ND		0.001	0.00273	
Cyanide (total) *(mg/L)*	0.01	ND		0.01	ND		0.01	ND		0.01			0.01			0.01		
Fluoride (total) *(mg/L)*	0.1	0.113		0.1	1.83		0.1	1.76		0.1	1.78		0.1	1.82		0.1	1.6	
Hardness (as $CaCO_3$) *(mg/L)*	10	80.9		10	28.5		10	28.2		10	26.9		10	26.8		10	34.2	
Iron (total) *(mg/L)*	0.01	0.186		0.01	ND		0.01	ND		0.01	0.0148		0.01	0.0199		0.01	ND	
Lead (total) *(mg/L)*	0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Magnesium (total) *(mg/L)*	0.1	8.9		0.1	2.40		0.1	2.49		0.1	2.27		0.1	2.03		0.1	3.44	
Manganese (total) *(mg/L)*	0.001	0.0185		0.001	ND		0.001	ND		0.001	0.0107		0.001	ND		0.001	ND	
Mercury (total inorganic) *(mg/L)*	0.0001	ND		0.0001	ND		0.0001	ND		0.0001	ND		0.0001	ND		0.0001	ND	
Nickel (total) *(mg/L)*	0.001	0.00209		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Nitrate (as N) *(mg/L)*	0.1	2.58		0.1	ND		0.1	ND		0.1	ND		0.1	ND		0.1		
Nitrite *(mg/L)*	0.1	ND		0.1	ND		0.1	ND		0.1	ND		0.1	ND		0.1		
Nitrate+Nitrite (total N) *(mg/L)*	0.1	2.58		0.1	ND		0.1	ND		0.1	ND		0.1	ND		0.1		
Perchlorate (ug/L)	0.05	0.337		0.05	ND		0.05	ND		0.05			0.05			0.05		
Phosphate *(mg/L)*	0.1	ND		0.1	ND		0.1	ND		0.1			0.1			0.1		
Phosphorus (total) *(mg/L)*	0.01	ND		0.01	ND		0.01	ND		0.01			0.01			0.01		
Potassium *(mg/L)*	0.1	1.35		0.1	18.2		0.1	17.3		0.1	16.7		0.1	16		0.1	14	
Selenium (total) *(mg/L)*	0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Silica *(mg/L)*	0.1	10.5		0.1	64.4		0.1	64.6		0.1	63.6		0.1	62.1		0.1	63.8	
Silicon *(mg/L)*	0.1	5.04		0.1	30.1		0.1	30.2		0.1	29.7		0.1	29		0.1	29.8	
Silver (total) *(mg/L)*	0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Sodium *(mg/L)*	0.1	8.19		0.1	75.3		0.1	78.5		0.1	82.4		0.1	73.9		0.1	72	
Sulfate *(mg/L)*	0.1	14.6		0.1	1.33		0.1	0.352		0.1	0.803		0.1	2.76		0.1	2.76	
Sulfide *(mg/L)*	0.48	ND					0.99	ND		0.99			0.99			0.99		
Thallium *(mg/L)*	0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.001	ND	
Uranium *(mg/L)*	0.001	0.00189		0.001	ND		0.001	ND		0.001			0.001			0.001		
Zinc (total) *(mg/L)*	0.001	0.00228		0.001	0.00159		0.001	0.00166		0.001	ND		0.001	0.00112		0.001	0.00875	
FIELD PARAMETERS																		
pH *(pH units)*	NA	8.53		NA	8.42		NA	8.47		NA			NA			NA	8.17	
Specific Conductance *(µ S/cm)*	NA	159		NA	462		NA	431		NA			NA			NA	460	
Turbidity *(NTUs)*	NA			NA			NA			NA			NA			NA		
Temperature (°C)	NA	18.01		NA	23.37		NA	25.89		NA			NA			NA	24.8	
Dissolved Oxygen *(mg/L)*	NA	106.10%		NA	0.27		NA	3.7		NA			NA			NA	0.79	
Oxidation-reduction potential *(mV)*	NA			NA	-374.1		NA			NA			NA			NA	98.1	
MISCELLANEOUS																		
Asbestos *(million fibers per liter longer than 10um)*		<0.197						<0.111										
Color *(color units)*	5	20		5	ND @ pH 8.12		5	ND		5			5			5		
Corrosivity* *(S.U.)*		-0.864			-0.190			-0.249										
Foaming Agents (MBAS); *(mg/L)*	0.05	ND		0.05	ND		0.05	ND		0.05			0.05			0.05		
Odor *(T.O.N.)*	1	ND		1	ND		1	ND		1			1			1		
Total Dissolved Solids *(mg/L)*	10	136		10	322		10	305		10			10			10		
Total Organic Carbon *(mg/L)*	0.5	2.43		0.5	0.232		0.5	0.283		0.5			0.5			0.5		
Total Suspended Solids *(mg/L)*	1	10.3		1	ND		1	ND		1			1			1		
VOLATILE ORGANIC COMPOUNDS (VOCs)																		
1,1-Dichloroethylene *(ug/L)*	0.5	NA		0.5	ND		0.5	NA		0.5			0.5			0.5		
1,1,1,2-Tetrachloroethane *(ug/L)*	0.5	ND					0.5	ND		0.5			0.5			0.5		
1,1,2,2-Tetrachloroethane *(ug/L)*	0.5	ND					0.5	ND		0.5			0.5			0.5		
1,1,1-Trichloroethane *(ug/L)*	0.5	ND		0.5	ND		0.5	ND		0.5			0.5			0.5		
1,1,2-Trichloroethane *(ug/L)*	0.5	ND		0.5	ND		0.5	ND		0.5			0.5			0.5		

Table E-1

AR LIMITED LICENSE WATER QUALITY TEST RESULTS

			WILLOW CREEK/COLUMBIA RIVER SOURCE WATER														
			PRE-FILTER			POST-FILTER			PRE FILTER			POST FILTER			INLAND BOOSTER		
		Sample Date:	10/10/2013			10/10/2013			8/15/2016			8/15/2016			6/20/2017		
		Lab ID:	131011061-001			131011061-002			160816027-001			160816027-002			170621069-001		
Analyte	OHA DW Standards	Oregon DEQ Standards	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q
1,1-Dichloroethane *(ug/L)*															0.5	ND	
1,2-Dichloroethane *(ug/L)*	5 (MCL)	5 (DEQ MML)	0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
1,1-Dichloropropene *(ug/L)*															0.5	ND	
1,1-Dichloroethene *(ug/L)*															0.5	ND	
1,2,3-Trichlorobenzene *(ug/L)*															0.5	ND	
1,2,4-Trichlorobenzene *(ug/L)*	70 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
1,2-Dichloropropane *(ug/L)*	5 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
1,2,3-Trichloropropane *(ug/L)*															0.5	ND	
1,2-Dibromoethane (EDB) *(ug/L)*															0.5	ND	
1,3,5-Trimethylbenzene *(ug/L)*															0.5	ND	
1,2,4-Trimethylbenzene *(ug/L)*															0.5	ND	
1,2-Dichlorobenzene *(ug/L)*															0.5	ND	
1,3-Dichlorobenzene *(ug/L)*															0.5	ND	
1,3-Dichloropropane *(ug/L)*															0.5	ND	
1,3-Dichloropropene *(ug/L)*															0.5	ND	
1,4-Dichlorobenzene *(ug/L)*															0.5	ND	
2,2-Dichloropropane *(ug/L)*															0.5	ND	
2-Chlorotoluene *(ug/L)*															0.5	ND	
4-Chlorotoluene *(ug/L)*															0.5	ND	
Acetone *(ug/L)*															2.5	ND	
Benzene *(ug/L)*	5 (MCL)	5 (DEQ MML)	0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Bromobenzene *(ug/L)*															0.5	ND	
Bromochloromethane *(ug/L)*															0.5	ND	
Bromomethane *(ug/L)*															0.5	ND	
Carbon tetrachloride *(ug/L)*	5 (MCL)	5 (DEQ MML)	0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Chlorobenzene *(ug/L)*	100 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Chloroethane *(ug/L)*															0.5	ND	
Chloromethane *(ug/L)*															0.5	ND	
cis-1,2-Dichloroethylene *(ug/L)*	70 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	NA	
cis-1,2-Cichloroethene *(ug/L)*															0.5	ND	
cis-1,3-Dichloropropene *(ug/L)*															0.5	ND	
Dacthal (ug/L)									0.02	ND		0.02	ND		0.02	0.05	
Dichloromethane (Methylene Chloride) *(ug/L)*	5 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Dibromomethane *(ug/L)*															0.5	ND	
Dichlorodifluoromethane *(ug/L)*															0.5	ND	
Ethylbenzene *(ug/L)*	700 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
o-Dichlorobenzene (1,2-) *(ug/L)*	600 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
p-Dichlorobenzene (1,4-) *(ug/L)*	75 (MCL)	75 (DEQ MML)	0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Hexachlorobutadiene *(ug/L)*															0.5	ND	
Isopropylbenzene *(ug/L)*															0.5	ND	
Methyl-t-butyl ether (MTBE) *(ug/L)*															0.5	ND	
n-Butylbenzene *(ug/L)*															0.5	ND	
n-Propylbenzene *(ug/L)*															0.5	ND	
p-Isopropyltoluene *(ug/L)*															0.5	ND	
sec-Butylbenzene *(ug/L)*															0.5	ND	
Styrene *(ug/L)*	100 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
tert-Butylbenzene *(ug/L)*															0.5	ND	
Tetrachloroethylene (PCE) *(ug/L)*	5 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	NA	
Tetrachloroethene *(ug/L)*															0.5	ND	
Toluene *(ug/L)*	1000 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
trans-1,2-Dichloroethylene *(ug/L)*	100 (MCL)		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	NA	
trans-1,2-Dichloroethene *(ug/L)*															0.5	ND	
trans-1,3-Dichloropropene *(ug/L)*															0.5	ND	
Trichloroethylene (TCE) *(ug/L)*	5 (MCL)	5 (DEQ MML)	0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	NA	
Trichloroethene *(ug/L)*															0.5	ND	
Trichlorofluoromethane *(ug/L)*															0.5	ND	
Vinyl chloride *(ug/L)*	2 (MCL)	2 (DEQ MML)	0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
m+p-Xylene *(ug/L)*			10	ND		10	ND		10	ND		10	ND		0.5	ND	
o-Xylene *(ug/L)*			10	ND		10	ND		10	ND		10	ND		0.5	ND	
Xylenes (total) *(ug/L)*	10,000 (MCL)		10	ND		10	ND		10	ND		10	ND		0.5	ND	
DISINFECTION BY-PRODUCTS (DBPs) & RESIDUAL DISINFECTANTS																	
Chlorine (as Cl_2) *(mg/L)*	4 (MRDL)								0.05	ND		0.05	ND		0.05	ND	
Chlorine Dioxide *(mg/L)*															0.25	ND	
Bromate *(mg/L)*	0.01 (MCL)														0.001	ND	
Chlorite *(mg/L)*	1 (MCL)														0.01	ND	

	Wanapum Groundwater														
	I-WELL 5			Inland Well 5			Inland Well 1			Inland Well 2			Inland Well 3		
Sample Date:	8/16/2016			6/21/2017			11/28/2012			1/31/2013			5/3/2013		
Lab ID:	160817045-001			170622027-001											
Analyte	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q
1,1-Dichloroethane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,2-Dichloroethane *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
1,1-Dichloropropene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,1-Dichloroethene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,2,3-Trichlorobenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,2,4-Trichlorobenzene *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
1,2-Dichloropropane *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
1,2,3-Trichloropropane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,2-Dibromoethane (EDB) *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,3,5-Trimethylbenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,2,4-Trimethylbenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,2-Dichlorobenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,3-Dichlorobenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,3-Dichloropropane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,3-Dichloropropene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
1,4-Dichlorobenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
2,2-Dichloropropane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
2-Chlorotoluene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
4-Chlorotoluene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Acetone *(ug/L)*				2.5	ND		2.5			2.5			2.5		
Benzene *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
Bromobenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Bromochloromethane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Bromomethane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Carbon tetrachloride *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
Chlorobenzene *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
Chloroethane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Chloromethane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
cis-1,2-Dichloroethylene *(ug/L)*	0.5	ND		0.5	NA		0.5			0.5			0.5		
cis-1,2-Cichloroethene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
cis-1,3-Dichloropropene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Dacthal (ug/L)	0.02	ND		0.02	ND		0.02			0.02			0.02		
Dichloromethane (Methylene Chloride) *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
Dibromomethane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Dichlorodifluoromethane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Ethylbenzene *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
o-Dichlorobenzene (1,2-) *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
p-Dichlorobenzene (1,4-) *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
Hexachlorobutadiene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Isopropylbenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Methyl-t-butyl ether (MTBE) *(ug/L)*				0.5	ND		0.5			0.5			0.5		
n-Butylbenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
n-Propylbenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
p-Isopropyltoluene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
sec-Butylbenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Styrene *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
tert-Butylbenzene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Tetrachloroethylene (PCE) *(ug/L)*	0.5	ND		0.5	NA		0.5			0.5			0.5		
Tetrachloroethene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Toluene *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
trans-1,2-Dichloroethylene *(ug/L)*	0.5	ND		0.5	NA		0.5			0.5			0.5		
trans-1,2-Dichloroethene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
trans-1,3-Dichloropropene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Trichloroethylene (TCE) *(ug/L)*	0.5	ND		0.5	NA		0.5			0.5			0.5		
Trichloroethene *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Trichlorofluoromethane *(ug/L)*				0.5	ND		0.5			0.5			0.5		
Vinyl chloride *(ug/L)*	0.5	ND		0.5	ND		0.5			0.5			0.5		
m+p-Xylene *(ug/L)*	10	ND		0.5	ND		0.5			0.5			0.5		
o-Xylene *(ug/L)*	10	ND		0.5	ND		0.5			0.5			0.5		
Xylenes (total) *(ug/L)*	10	ND		0.5	ND		0.5			0.5			0.5		
DISINFECTION BY-PRODUCTS (DBPs) & RESIDUAL DISINFECTANTS															
Chlorine (as Cl_2) *(mg/L)*	0.05	ND		0.05	ND		0.05			0.05			0.05		
Chlorine Dioxide *(mg/L)*				0.25	ND		0.25			0.25			0.25		
Bromate *(mg/L)*				0.001	ND		0.001			0.001			0.001		
Chlorite *(mg/L)*				0.01	ND		0.01			0.01			0.01		

Table E-1

AR LIMITED LICENSE WATER QUALITY TEST RESULTS

			WILLOW CREEK/COLUMBIA RIVER SOURCE WATER												
			PRE-FILTER			POST-FILTER			PRE FILTER			POST FILTER			
		Sample Date:	10/10/2013			10/10/2013			8/15/2016			8/15/2016			
		Lab ID:	131011061-001			131011061-002			160816027-001			160816027-002			
Analyte	OHA DW Standards	Oregon DEQ Standards	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	
Chloroacetic Acid *(ug/L)*	Regulated as total HAA's		2	ND		2	ND		2	ND		2	ND		
Bromoacetic Acid *(ug/L)*	Regulated as total HAA's		1	ND		1	ND		1	ND		1	ND		
Dichloroacetic Acid *(ug/L)*	Regulated as total HAA's		NR	ND		NR	ND		1	ND		1	ND		
Trichloroacetic Acid *(ug/L)*	Regulated as total HAA's		NR	ND		NR	ND		1	ND		1	ND		
Dibromoacetic Acid *(ug/L)*	Regulated as total HAA's		NR	ND		NR	ND		1	ND		1	ND		
Total Haloacetic Acids (HAA-5) *(ug/L)*	60 (MCL)		NR	ND		NR	ND		1	ND		1	ND		
Monobromoacetic Acid (ug/L)															
Monochloroacetic Acid *(ug/L)*															
Chloroform *(ug/L)*	Regulated as total THM's		0.5	ND		0.5	ND		0.5	ND		0.5	ND		
Bromodichloromethane *(ug/L)*	Regulated as total THM's		0.5	ND		0.5	ND		0.5	ND		0.5	ND		
Dibromochloromethane *(ug/L)*	Regulated as total THM's		0.5	ND		0.5	ND		0.5	ND		0.5	ND		
Bromoform *(ug/L)*	Regulated as total THM's		0.5	ND		0.5	ND		0.5	ND		0.5	ND		
Total Trihalomethanes (TTHM) *(ug/L)*	80 (MCL)	10 (DEQ MML)	0.5	ND		0.5	ND		0.5	ND		0.5	ND		
MICROBIAL															
Total Coliforms *(cell count per 100 mL)*	< 5% positive	<1/100mL							1	P		1	P		
Fecal Coliforms *(cell count per 100 mL)*	Confirmed presence	Confirmed presence													
E. Coli *(cell count per 100 mL)*	Confirmed presence	Confirmed presence							1	P		1	P		
SYNTHETIC ORGANIC COMPOUNDS (SOCs)															
2,4-D *(ug/L)*	7 (MCL)	10 (DEQ MML)	0.1	ND		0.1	ND		0.1	ND		0.1	ND		
2,4-DB *(ug/L)*															
4,4-DDD *(ug/L)*			1	ND		1	ND		1	ND		1	ND		
4,4-DDE *(ug/L)*			1	ND		1	ND		1	ND		1	ND		
4,4-DDT *(ug/L)*			0.01	ND		0.01	ND		0.01	ND		0.01	ND		
2,4,5-T *(ug/L)*															
2,4,5-TP (Silvex) *(ug/L)*	5 (MCL)	10 (DEQ MML)							0.2	ND		0.2	ND		
2,4,6-Trichlorophenol *(ug/L)*															
2-Flurobibiphenyl *(ug/L)*															
3,5-Dichlorobenzoic Acid *(ug/L)*															
3-Hydrocarbofuran *(ug/L)*															
Acifluorofen *(ug/L)*															
Aldicarb *(ug/L)*															
Aldicarb Sulfone *(ug/L)*															
Aldicarb Sulfoxide *(ug/L)*															
Aldrin *(ug/L)*															
Alachlor (Lasso) *(mg/L)*	0.002 (MCL)								0.2	ND		0.2	ND		
Alpha-BHC *(ug/L)*															
Beta-BHC *(ug/L)*															
Delta-BHC *(ug/L)*															
Acenaphthene *(ug/L)*															
Acenaphthene-d10 *(ug/L)*															
Acenaphtylene *(ug/L)*															
Anthracene *(ug/L)*															
Atrazine *(mg/L)*	0.003 (MCL)								0.1	ND		0.1	ND		
Baygon *(ug/L)*															
Bentazon *(ug/L)*															
Benzo(ghi)perylene *(ug/L)*															
Benzo(a)anthracene *(ug/L)*															
Benzo(b)fluoranthene *(ug/L)*															
Benzo(k)fluoranthene															
Benzo(a)pyrene *(mg/L)*	0.0002 (MCL)								0.02	ND		0.02	ND		
Bromacil *(ug/L)*															
Bromoxynil *(ug/L)*															
Butachlor *(ug/L)*															
Butylbenzylphthalate *(ug/L)*															
Chloropyrifos *(ug/L)*															
Chrysene *(ug/L)*															
Chrysene-d12 *(ug/L)*															
Cyanizine *(ug/L)*															
Carbaryl *(ug/L)*															
Carbofuran *(mg/L)*	0.04 (MCL)								0.9	ND		0.9	ND		
Chloramben *(ug/L)*															
Chlordane *(mgL)*	0.002 (MCL)								0.2	ND		0.2	ND		
Dalapon *(mg/L)*	0.2 (MCL)								1	ND		1	ND		
Dieldrin (ug/L)															
Dicamba *(ug/L)*															
Dichloroprop *(ug/L)*															

	WILLOW CREEK/COLUMBIA RIVER SOURCE WATER			Wanapum Groundwater														
	INLAND BOOSTER			I-WELL 5			Inland Well 5			Inland Well 1			Inland Well 2			Inland Well 3		
Sample Date:	6/20/2017			8/16/2016			6/21/2017			11/28/2012			1/31/2013			5/3/2013		
Lab ID:	170621069-001			160817045-001			170622027-001											
Analyte	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q
Chloroacetic Acid *(ug/L)*	2	NA		2	ND		2	NA		2			2			2		
Bromoacetic Acid *(ug/L)*	1	NA		1	ND		1	NA		1			1			1		
Dichloroacetic Acid *(ug/L)*	1	ND		1	ND		1	ND		1			1			1		
Trichloroacetic Acid *(ug/L)*	1	ND		1	ND		1	ND		1			1			1		
Dibromoacetic Acid *(ug/L)*	1	ND		1	ND		1	ND		1			1			1		
Total Haloacetic Acids (HAA-5) *(ug/L)*	1	ND		1	ND		1	ND		1			1			1		
Monobromoacetic Acid (ug/L)	1	ND					1	ND		1			1			1		
Monochloroacetic Acid *(ug/L)*	2	ND					2	ND		2			2			2		
Chloroform *(ug/L)*	0.5	ND		0.5	ND		0.5	ND		0.5			0.5			0.5		
Bromodichloromethane *(ug/L)*	0.5	ND		0.5	ND		0.5	ND		0.5			0.5			0.5		
Dibromochloromethane *(ug/L)*	0.5	ND		0.5	ND		0.5	ND		0.5			0.5			0.5		
Bromoform *(ug/L)*	0.5	ND		0.5	ND		0.5	ND		0.5			0.5			0.5		
Total Trihalomethanes (TTHM) *(ug/L)*	0.5	ND		0.5	ND		0.5	ND		0.5			0.5			0.5		
MICROBIAL																		
Total Coliforms *(cell count per 100 mL)*	1			1	ABSENT		1			1			1			1		
Fecal Coliforms *(cell count per 100 mL)*																		
E. Coli *(cell count per 100 mL)*	1			1	ABSENT		1			1			1			1		
SYNTHETIC ORGANIC COMPOUNDS (SOCs)																		
2,4-D *(ug/L)*	0.1	ND		0.1	ND		0.1	ND		0.1			0.1			0.1		
2,4-DB *(ug/L)*	1	ND					1	ND		1			1			1		
4,4-DDD *(ug/L)*	1	ND		1	ND		1	ND		1			1			1		
4,4-DDE *(ug/L)*	1	ND		1	ND		1	ND		1			1			1		
4,4-DDT *(ug/L)*	0.01	ND		0.01	ND		0.01	ND		0.01			0.01			0.01		
2,4,5-T *(ug/L)*	0.1	ND					0.1	ND		0.1			0.1			0.1		
2,4,5-TP (Silvex) *(ug/L)*	0.2	ND		0.2	ND		0.2	ND		0.2			0.2			0.2		
2,4,6-Trichlorophenol *(ug/L)*	1	NA					1	NA		1			1			1		
2-Flurobibiphenyl *(ug/L)*		ND						ND										
3,5-Dichlorobenzoic Acid *(ug/L)*	0.5	ND					0.5	ND		0.5			0.5			0.5		
3-Hydrocarbofuran *(ug/L)*	2	ND					2	ND		2			2			2		
Acifluorofen *(ug/L)*	2	ND					2	ND		2			2			2		
Aldicarb *(ug/L)*	0.5	ND					0.5	ND		0.5			0.5			0.5		
Aldicarb Sulfone *(ug/L)*	1	ND					1	ND		1			1			1		
Aldicarb Sulfoxide *(ug/L)*	1	ND					1	ND		1			1			1		
Aldrin *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Alachlor (Lasso) *(mg/L)*	0.2	ND		0.2	ND		0.2	ND		0.2			0.2			0.2		
Alpha-BHC *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Beta-BHC *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Delta-BHC *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Acenaphthene *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Acenaphthene-d10 *(ug/L)*		ND						ND										
Acenaphtylene *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Anthracene *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Atrazine *(mg/L)*	0.1	ND		0.1	ND		0.1	ND		0.1			0.1			0.1		
Baygon *(ug/L)*	1	ND					1	ND		1			1			1		
Bentazon *(ug/L)*	0.5	ND					0.5	ND		0.5			0.5			0.5		
Benzo(ghi)perylene *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Benzo(a)anthracene *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Benzo(b)fluoranthene *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Benzo(k)fluoranthene	0.2	ND					0.2	ND		0.2			0.2			0.2		
Benzo(a)pyrene *(mg/L)*	0.02	ND		0.02	ND		0.02	ND		0.02			0.02			0.02		
Bromacil *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Bromoxynil *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Butachlor *(ug/L)*	0.4	ND					0.4	ND		0.4			0.4			0.4		
Butylbenzylphthalate *(ug/L)*	0.4	ND					0.4	ND		0.4			0.4			0.4		
Chloropyrifos *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Chrysene *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Chrysene-d12 *(ug/L)*		ND						ND										
Cyanizine *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Carbaryl *(ug/L)*	2	ND					2	ND		2			2			2		
Carbofuran *(mg/L)*	0.9	ND		0.9	ND		0.9	ND		0.9			0.9			0.9		
Chloramben *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Chlordane *(mgL)*	0.2	ND		0.2	ND		0.2	ND		0.2			0.2			0.2		
Dalapon *(mg/L)*	1	ND		1	ND		1	ND		1			1			1		
Dieldrin (ug/L)	0.1	ND					0.1	ND		0.1			0.1			0.1		
Dicamba *(ug/L)*	0.2	ND					0.2	ND		0.2			0.2			0.2		
Dichloroprop *(ug/L)*	0.1	ND					0.1	ND		0.1			0.1			0.1		

Table E-1

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AR LIMITED LICENSE WATER QUALITY TEST RESULTS

			WILLOW CREEK/COLUMBIA RIVER SOURCE WATER														
			PRE-FILTER			POST-FILTER			PRE FILTER			POST FILTER			INLAND BOOSTER		
		Sample Date:	10/10/2013			10/10/2013			8/15/2016			8/15/2016			6/20/2017		
		Lab ID:	131011061-001			131011061-002			160816027-001			160816027-002			170621069-001		
Analyte	OHA DW Standards	Oregon DEQ Standards	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q
Diazinon (ug/L)															0.2	ND	
Bis-(2-Ethylhexyl) adipate (mg/L)	0.4 (MCL)								0.2	ND		0.2	ND		0.2	ND	
Bis-(2-Ethylhexyl) phathalate (mg/L)	0.006 (MCL)								0.6	ND		0.6	ND		0.6	ND	
Dibromochloropropane (DBCP) (mg/L)	0.0002 (MCL)								0.02	ND		0.02	ND		0.02	ND	
Dibenz(a,h)anthracene (ug/L)															0.2	ND	
Diethylphthalate (ug/L)															0.4	ND	
Dimethylphthalate (ug/L)															0.4	ND	
Di-n-butylphthalate (ug/L)															0.1	ND	
Dinoseb (mg/L)	0.007 (MCL)								0.2	ND		0.2	ND		0.2	ND	
Dioxin (2,3,7,8-TCDD) (mg/L)	0.00000003 (MCL)															NA	
Diquat (mg/L)	0.02 (MCL)								0.4	ND		0.4	ND		0.4	ND	
Endothall (mg/L)	0.1 (MCL)								9	ND		9	ND		9	ND	
Endrin (ug/L)	2 (MCL)	0.2 (DEQ MML)	0.02	ND		0.02	ND		0.02	ND		0.02	ND		0.02	ND	
EPTC (ug/L)															0.3	ND	
Ethylene dibromide (EDB) (ug/L)	0.05 (MCL)		0.001	ND		0.001	ND		0.001	ND		0.001	ND		0.01	ND	
Ethyl Parathion (ug/L)															0.2	ND	
Fluoranthene (ug/L)															0.2	ND	
Fluorene (ug/L)															0.2	ND	
Glyphosate (mg/L)	0.7 (MCL)								5	ND		5	ND		5	ND	
g-Chlordane (ug/L)															0.2	ND	
Heptachlor (mg/L)	0.0004 (MCL)								0.04	ND		0.04	ND		0.04	ND	
Dieldrin (ug/L)			0.2	ND		0.2	ND		0.2	ND		0.2	ND		0.2	ND	
Heptachlor epoxide (ug/L)	0.2 (MCL)		0.04	ND		0.04	ND		0.04	ND		0.04	ND		0.04	ND	
Hexachlorobenzene (ug/L)	1 (MCL)		0.2	ND		0.2	ND		0.2	ND		0.2	ND		0.2	ND	
Hexachlorocyclopentadiene (mg/L)	0.05 (MCL)								0.1	ND		0.1	ND		0.1	ND	
Indeno(1,2,3-cd)pyrene (ug/L)															0.2	ND	
Lindane (BHC-gamma) (mg/L)	0.0002 (MCL)	0.004 (DEQ MML)							0.02	ND		0.02	ND		0.02	ND	
Malathinon (ug/L)															0.2	ND	
MCPA (ug/L)															0.2	ND	
Methiocarb (ug/L)															1	ND	
Methomyl (ug/L)															1	ND	
Methoxychlor (mg/L)	0.04 (MCL)	0.100 (DEQ MML)							0.2	ND		0.2	ND		0.2	ND	
Metolachlor (ug/L)															1	ND	
Metribuzin (ug/L)															0.2	ND	
Naphthalene (ug/L)															0.5	ND	
Naphthalene-d8 (ug/L)															0.5	ND	
Oxamyl (Vydate) (mg/L)	0.2 (MCL)								2	ND		2	ND		2	ND	
Parathion (ug/L)															0.2	ND	
Pendimethalin (ug/L)															0.2	ND	
Permethrin (ug/L)															0.2	ND	
Perylene-d12 (ug/L)																ND	
Phenanthrene (ug/L)															0.2	ND	
Phenanthrene-d10 (ug/L)																ND	
Prometon (ug/L)															0.2	ND	
Pronamide (ug/L)															0.2	ND	
Propachlor (ug/L)															0.1	ND	
Pyrene (ug/L)															0.2	ND	
Pentachlorophenol (mg/L)	0.001 (MCL)								0.04	ND		0.04	ND		0.04	ND	
Picloram (mg/L)	0.5 (MCL)								0.1	ND		0.1	ND		0.1	ND	
Propoxur (ug/L)															1	ND	
Aroclor 1016 (ug/L)	Regulated as total		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Aroclor 1221 (ug/L)	Regulated as total		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Aroclor 1232 (ug/L)	Regulated as total		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Aroclor 1242 (ug/L)	Regulated as total		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Aroclor 1248 (ug/L)	Regulated as total		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Aroclor 1254 (ug/L)	Regulated as total		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Aroclor 1260 (ug/L)	Regulated as total		0.5	ND		0.5	ND		0.5	ND		0.5	ND		0.5	ND	
Total Aroclors - (PCBs) (ug/L)	0.5 (MCL)									ND			ND		0.5	ND	
Simazene (mg/L)	0.004 (MCL)								0.07	ND		0.07	ND		0.07	ND	
Terbacil (ug/L)															0.2	ND	
Terphenyl-d14 (ug/L)																ND	
trans-Nonachlor (ug/L)															0.2	ND	
Triademefon (ug/L)															0.2	ND	
Trifluralin (ug/L)															0.2	ND	
Toxaphene (ug/L)	3 (MCL)	0.005 (DEQ MML)	2	ND		2	ND		2	ND		2	ND		1	ND	
RADIOLOGICALS																	

	Wanapum Groundwater														
	I-WELL 5			Inland Well 5			Inland Well 1			Inland Well 2			Inland Well 3		
Sample Date:	8/16/2016			6/21/2017			11/28/2012			1/31/2013			5/3/2013		
Lab ID:	160817045-001			170622027-001											
Analyte	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q
Diazinon (ug/L)				0.2	ND		0.2			0.2			0.2		
Bis-(2-Ethylhexyl) adipate (mg/L)	0.2	ND		0.2	ND		0.2			0.2			0.2		
Bis-(2-Ethylhexyl) phathalate (mg/L)	0.6	ND		0.6	ND		0.6			0.6			0.6		
Dibromochloropropane (DBCP) (mg/L)	0.02	ND		0.02	ND		0.02			0.02			0.02		
Dibenz(a,h)anthracene (ug/L)				0.2	ND		0.2			0.2			0.2		
Diethylphthalate (ug/L)				0.4	ND		0.4			0.4			0.4		
Dimethylphthalate (ug/L)				0.4	ND		0.4			0.4			0.4		
Di-n-butylphthalate (ug/L)				0.1	ND		0.1			0.1			0.1		
Dinoseb (mg/L)	0.2	ND		0.2	ND		0.2			0.2			0.2		
Dioxin (2,3,7,8-TCDD) (mg/L)					NA										
Diquat (mg/L)	0.4	ND		0.4	ND		0.4			0.4			0.4		
Endothall (mg/L)	9	ND		9	ND		9			9			9		
Endrin (ug/L)	0.02	ND		0.02	ND		0.02			0.02			0.02		
EPTC (ug/L)				0.3	ND		0.3			0.3			0.3		
Ethylene dibromide (EDB) (ug/L)	0.001	ND		0.01	ND		0.01			0.01			0.01		
Ethyl Parathion (ug/L)				0.2	ND		0.2			0.2			0.2		
Fluoranthene (ug/L)				0.2	ND		0.2			0.2			0.2		
Fluorene (ug/L)				0.2	ND		0.2			0.2			0.2		
Glyphosate (mg/L)	5	ND		5	ND		5			5			5		
g-Chlordane (ug/L)				0.2	ND		0.2			0.2			0.2		
Heptachlor (mg/L)	0.04	ND		0.04	ND		0.04			0.04			0.04		
Dieldrin (ug/L)	0.2	ND		0.2	ND		0.2			0.2			0.2		
Heptachlor epoxide (ug/L)	0.04	ND		0.04	ND		0.04			0.04			0.04		
Hexachlorobenzene (ug/L)	0.2	ND		0.2	ND		0.2			0.2			0.2		
Hexachlorocyclopentadiene (mg/L)	0.1	ND		0.1	ND		0.1			0.1			0.1		
Indeno(1,2,3-cd)pyrene (ug/L)				0.2	ND		0.2			0.2			0.2		
Lindane (BHC-gamma) (mg/L)	0.02	ND		0.02	ND		0.02			0.02			0.02		
Malathinon (ug/L)				0.2	ND		0.2			0.2			0.2		
MCPA (ug/L)				0.2	ND		0.2			0.2			0.2		
Methiocarb (ug/L)				1	ND		1			1			1		
Methomyl (ug/L)				1	ND		1			1			1		
Methoxychlor (mg/L)	0.2	ND		0.2	ND		0.2			0.2			0.2		
Metolachlor (ug/L)				1	ND		1			1			1		
Metribuzin (ug/L)				0.2	ND		0.2			0.2			0.2		
Naphthalene (ug/L)				0.5	ND		0.5			0.5			0.5		
Naphthalene-d8 (ug/L)				0.5	ND		0.5			0.5			0.5		
Oxamyl (Vydate) (mg/L)	2	ND		2	ND		2			2			2		
Parathion (ug/L)				0.2	ND		0.2			0.2			0.2		
Pendimethalin (ug/L)				0.2	ND		0.2			0.2			0.2		
Permethrin (ug/L)				0.2	ND		0.2			0.2			0.2		
Perylene-d12 (ug/L)					ND										
Phenanthrene (ug/L)				0.2	ND		0.2			0.2			0.2		
Phenanthrene-d10 (ug/L)					ND										
Prometon (ug/L)				0.2	ND		0.2			0.2			0.2		
Pronamide (ug/L)				0.2	ND		0.2			0.2			0.2		
Propachlor (ug/L)				0.1	ND		0.1			0.1			0.1		
Pyrene (ug/L)				0.2	ND		0.2			0.2			0.2		
Pentachlorophenol (mg/L)	0.04	ND		0.04	ND		0.04			0.04			0.04		
Picloram (mg/L)	0.1	ND		0.1	ND		0.1			0.1			0.1		
Propoxur (ug/L)				1	ND		1			1			1		
Aroclor 1016 (ug/L)	0.5	ND		0.5	ND		0.5			0.5			0.5		
Aroclor 1221 (ug/L)	0.5	ND		0.5	ND		0.5			0.5			0.5		
Aroclor 1232 (ug/L)	0.5	ND		0.5	ND		0.5			0.5			0.5		
Aroclor 1242 (ug/L)	0.5	ND		0.5	ND		0.5			0.5			0.5		
Aroclor 1248 (ug/L)	0.5	ND		0.5	ND		0.5			0.5			0.5		
Aroclor 1254 (ug/L)	0.5	ND		0.5	ND		0.5			0.5			0.5		
Aroclor 1260 (ug/L)	0.5	ND		0.5	ND		0.5			0.5			0.5		
Total Aroclors - (PCBs) (ug/L)		ND		0.5	ND		0.5			0.5			0.5		
Simazene (mg/L)	0.07	ND		0.07	ND		0.07			0.07			0.07		
Terbacil (ug/L)				0.2	ND		0.2			0.2			0.2		
Terphenyl-d14 (ug/L)					ND										
trans-Nonachlor (ug/L)				0.2	ND		0.2			0.2			0.2		
Triademefon (ug/L)				0.2	ND		0.2			0.2			0.2		
Trifluralin (ug/L)				0.2	ND		0.2			0.2			0.2		
Toxaphene (ug/L)	2	ND		1	ND		1			1			1		
RADIOLOGICALS															

AR LIMITED LICENSE WATER QUALITY TEST RESULTS

			WILLOW CREEK/COLUMBIA RIVER SOURCE WATER					
			PRE-FILTER			POST-FILTER		
		Sample Date:	10/10/2013			10/10/2013		
		Lab ID:	131011061-001			131011061-002		
Analyte	OHA DW Standards	Oregon DEQ Standards	MRL	Result	Q	MRL	Result	Q
Gross Alpha (pCi/L)	15 (MCL)	15 (DEQ MML)						
Gross Beta (pCi/L)	4 mrem/year (official) 50 pCi/L (trigger)	50 pCi/L (DEQ MML)						
Radium 226 (pCi/L)								
Radium 228 (pCi/L)								
Radium 226/228 (pCi/L)	5 (MCL)							
Uranium Activity (piCi/L)	30 (MCL)							
Radon (pCi/L)	300 (Advisory)							

	WILLOW CREEK/COLUMBIA RIVER SOURCE WATER								
	PRE FILTER			POST FILTER			INLAND BOOSTER		
Sample Date:	8/15/2016			8/15/2016			6/20/2017		
Lab ID:	160816027-001			160816027-002			170621069-001		
Analyte	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q
Gross Alpha (pCi/L)	1	1.19 ± 0.738		1	0.401 ± 0.499		1	2.11+/-0.869	
Gross Beta (pCi/L)	1	1.48 ± 0.742		1	0.696 ± 0.461		1	0.95+/-0.5	
Radium 226 (pCi/L)	1	0.025 ± 0.074		1	0.098 ± 0.126		1	0.191+/-0.295	
Radium 228 (pCi/L)	1	0.754 ± 0.649		1	-0.068 ± 0.327		1	0.489+/-0.185	
Radium 226/228 (pCi/L)	1	0.0332		1	-1.441		1		
Uranium Activity (piCi/L)	0.67	ND		0.67	ND		0.67	1.27	
Radon (pCi/L)		6.69 ± 24			-9.99 ± 23				

				Wanapum Groundwater					
	I-WELL 5			Inland Well 5			Inland Well 1		
Sample Date:	8/16/2016			6/21/2017			11/28/2012		
Lab ID:	160817045-001			170622027-001					
Analyte	MRL	Result	Q	MRL	Result	Q	MRL	Result	Q
Gross Alpha (pCi/L)	1	0.604 ± 1.56		1	0.553+/-1.03		1		
Gross Beta (pCi/L)	1	2.59 ± 1.69		1	6.9+/-1.67		1		
Radium 226 (pCi/L)	1	0.049 ± 0.105		1	0.296+/-0.352		1		
Radium 228 (pCi/L)	1	0.844 ± 0.358		1	0.838+/-0.201		1		
Radium 226/228 (pCi/L)	1	0.0581		1			1		
Uranium Activity (piCi/L)	0.67	ND		0.67	ND		0.67		
Radon (pCi/L)		183 ± 30							

	Wanapum Groundwater					
	Inland Well 2			Inland Well 3		
Sample Date:	1/31/2013			5/3/2013		
Lab ID:						
Analyte	MRL	Result	Q	MRL	Result	Q
Gross Alpha (pCi/L)	1			1		
Gross Beta (pCi/L)	1			1		
Radium 226 (pCi/L)	1			1		
Radium 228 (pCi/L)	1			1		
Radium 226/228 (pCi/L)	1			1		
Uranium Activity (piCi/L)	0.67			0.67		
Radon (pCi/L)						

[Yellow]: Exceeds DEQ water quality standard
[Orange]: Greater than 50% of DEQ water quality standard

#: Copper has an Action Level of 1.3 and a SMCL of 1.0
**: MCL being re-evaluated by EPA
†: Corrosivity analysis by Langelier Index
††: Proposed standard
MCL: Maximum Contaminant Level
MRL: Method Reporting Limit

SMCL: Secondary Maximum Contaminant Level
Q: Laboratory data qualifier
NA: Not Applicable
ND: Non Detect
NR: Not Reported
µg/L: Micrograms per liter
µS/cm: Micro-Siemens per centimeter
mg/L: Milligrams per liter

ATTACHMENT F

Threemile Canyon Farms – Inland Project Limited License Application for Aquifer Recharge: Quality Assurance and Quality Control Plan

Attachment F
Threemile Canyon Farms - AR Quality Assurance and Control Plan

INTRODUCTION AND BACKGROUND

Threemile Canyon Farms (TMCF) is requesting an Aquifer Recharge (AR) Limited License for water storage during the spring and fall, which will be recovered in the summer months when agricultural demand is high. This document provides quality assurance and quality control (QA/QC) procedures that will be performed to ensure data collected during pilot testing are valid, accurate, and representative of aquifer conditions. The AR Pilot Testing Program (Attachment C) describes the planned approach; pilot testing system, operations, and monitoring plans (objective and timing of data collection) for AR pilot testing. The data collected during the initial cycle testing under the Limited License will confirm the feasibility of AR at the Site and help develop design criteria and testing procedures for potential additional AR wells at TMCF.

MONITORING PROCEDURES

Monitoring will consist of collecting water quality samples for laboratory analysis, field parameter measurements, flow rate measurements, water level measurements, and making field observations. Monitoring procedures required for collecting this data are described in the following sections.

Water Quality Sampling for Laboratory Analysis

The water quality parameters list for each analytical suite are presented in Table C-4 of the Pilot Testing Program (Attachment C). These parameters were selected to evaluate the chemical compatibility of native and source water and identify potential water quality changes associated with mixing or chemical reactions within the aquifer. The parameters were also selected to comply with Oregon Department of Environmental Quality (DEQ) criteria. Additionally, disinfection byproducts will also be samples for regularly to evaluate the potential for their attenuation in the storage aquifer during pilot testing.

Water quality samples will be collected from a dedicated port at the AR Well (Inland Well #1) which will be installed along the conveyance system. Samples will be collected after the field water quality parameters have stabilized. Water quality samples collected during testing under the Limited License will be submitted to an Oregon Environmental Laboratory Accreditation Program (ORELAP) laboratory. The contracted laboratory will be responsible for ensuring the appropriate sample bottles and preservatives are provided ahead of field sampling. Field staff will cross check the bottle list and preservatives before sampling.

Sample Identification and Labeling

A unique number will be given to each sample. The sample ID will reflect the following:

- Location
- Cycle
- Period
- Number

Table F-1 presents the sample ID components. For example, the first sample collected during Phase 1 recharge would be assigned the unique sample ID "AR-P1C1-RCH-1". Sample labels will be secured to each container with an assigned field sample identification number applied to each sample as it is collected.

Table F-1. Water Quality Sample ID Abbreviations		
Location	**Cycle**	**Period**
AR = AR Well	P1C1 = Phase 1, Cycle 1	Recharge = RCH
OBS = Observation Well	P1C2 = Phase 1, Cycle 2	Storage = STO
		Recovery = REC

Chain of Custody

A chain of custody (COC) form will be used to track possession of each sample and will be completed for each sample shipment. The COC will ensure the traceability of analytical results to the original sample through analytical methods referenced on the COC. The COC will accompany all samples from the field to the laboratory and a copy will be retained in the project file.

Field Parameter Measurements

Field parameter measurements are conducted to measure constituents that cannot be measured reliably after transport to the laboratory. These include:

- Electrical conductivity
- Dissolved oxygen
- pH
- Temperature
- Oxidation-Reduction potential

These will be measured with a portable multiparameter instrument such as a YSI Professional Plus or similar. Additional constituents such as chlorine residual or turbidity may also be measured with Hach™ testing kits real-time during testing. These values will be recorded in the field notebook and data provided during the reporting phase. All instrumentation will be calibrated with reference solutions that meet the standards of the instrument user's manual.

Water Level Measurements

Manual water level measurements will be collected via automated pressure transducers which are currently installed in the planned AR well (Inland Well #1) and all planned observation wells to collect high frequency water level data which are outlined in the Pilot Testing Program. Transducer downloads will be named to reflect the location, date (mm-dd-yyyy) and time of the download. Transducer data will also be tracked by the TMCF staff through their supervisory control and data acquisition system (SCADA).

Manual water level measurements will be collected at the start of AR testing at all the observations wells, and the AR well. Water level sounders will be used to obtain manual measurements at the Inland Wells (Inland Well #1, Inland Well #2 Inland Well #3, Inland Well #4, Inland Well #5 and the Inland OBS Well).

Water levels in the Dairy Wells (Willow Creek Well #1, Shop Well, Well 7, Jersey Well, Well #5 and the Holstein Well) will be collected at the start of AR via airline as there is no access for a water level sounder. Additional water level measurements may be collected if a transducer shows signs of malfunction, and periodically to assess for drift.

Flow Rate Measurements

Flow rate measurements will be based on visual observations of flowmeters installed on recharge and discharge piping. Two flow meters will be installed on both recharge and discharge piping (four total) for accuracy and redundancy in case of failure. We will require flow meters to be factory calibrated to within +/- 5% accuracy, and installed according to manufacturer's recommendations with respect to distance between the meters and upstream/downstream interruptions in uniform horizontal flow. Instantaneous and totalizing flow measurements will be made as frequently as practicable, and an in-line pressure transducer will be installed to create a high-density data set if flow-normalization corrections become necessary during data analysis. Visual observations will be recorded on field data sheets and transducer downloads will be named to reflect the location, date (mm-dd-yyyy) and time of the download.

Calibration Requirements

Equipment used to collect water quality field parameters will be field calibrated each time a sample is collected to ensure accurate and precise measurements. Instruments will be calibrated with reference solutions and methods conforming to the instrument user's manual. Calibration information will be recorded in the field logbook to document instrument performance. If measurements appear anomalous, the field staff will document and recalibrate if necessary.

Transducers will be factory calibrated prior to pilot testing. Documentation of the calibration can be made available to OWRD upon request.

Field Log and Observations

All observations related to pilot testing will be documented on field data forms or in the field notebook. Field observations that will be recorded include, but are not limited to, the following:

- Project or site name
- Date and time of data entry
- Description of work being formed
- Person performing the work
- Names and affiliations of personnel onsite
- Weather conditions
- Location of sampling point
- Field parameter values
- Collecting time and date
- Types and location of samples
- Requested analysis
- Filtration and preservatives
- Depth to groundwater and purging time/volume

QUALITY CONTROL

Field Quality Control

Field notes will be reviewed periodically by the Project Manager to ensure they are complete, consistent, and free of errors. All test equipment will be subject to preventative maintenance to minimize equipment down time and ensure accuracy. All field equipment will be calibrated to the standards set in the user manuals. All non-conforming conditions will be identified, documented and resolved.

Laboratory Quality Control

The analytical laboratory will use trip blanks, method blanks, spikes, duplicates, surrogates and control samples in each batch containing AR sampling for analysis. Data quality indicators will be used where data does not meet standard laboratory quality checks in accordance with the EPA Contract Laboratory Program or specified analytical method. Method detection limits will be presented to OWRD once the laboratory has been selected and contracted.

Data will be examined for data errors, omissions and compliance with applicable criteria. Results will be verified by the project manager to ensure that data are consistent, correct and complete. Data qualifiers are assigned where necessary and that sample methods and protocols consisted with this plan were obtained. Data validation will also be performed to ensure the laboratory has met all data quality objectives. The results from these procedures will be reviewed by the project team and accompany the report.