Rudd Farms Artificial Recharge (AR) Limited License Application

Prepared For

Oregon Water Resources Department

Prepared by

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On Behalf of:

Rudd Farms

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Executive Summary

Rudd Farms is located about five miles northeast of La Grande, Oregon, and is a family farm that grows peppermint, grass seed, wheat, and alfalfa on about 3,000 acres.

In 2013, Rudd Farms constructed a 4,000 foot deep well completed in the Columbia River Basalt Group (CRBG) aquifer[1]. When originally tested in 2013, the well was highly productive[2]. Since 2013, the groundwater level in the well has fallen, which is a regional issue affecting several irrigation wells and municipal supply wells in La Grande (e.g., City of La Grande and City of Imbler). In addition, the yield of the Basalt Well has dropped[3].

Falling water levels in the CRBG aquifer are likely related to the hydraulic isolation of the aquifer. Specifically, the CRBG aquifer occurs at significant depths (about 3,450 feet below ground surface at in the Basalt Well) and is divided into compartments created by extensive faulting. Recharge to the CRBG aquifer is likely limited to areas where it crops out in the Blue Mountains and Wallowa Mountains, and it is uncertain how much of the recharge reaches the central part of the Grande Ronde Valley where the irrigation and public supply wells are located. While the hydraulic isolation of the CRBG aquifer likely contributes to its susceptibility to water level declines, it also makes the CRBG aquifer a desirable aquifer for Artificial Recharge (AR) because it can likely store relatively large quantities of water with limited risk of loss of stored water. In addition to maintaining sustainability of the Basalt Well, Rudd Farm's proposed AR project offers a public benefit to CRBG aquifer users because it will increase recharge to the CRBG aquifer, thereby contributing to its sustainability as a groundwater source.

Rudd Farms proposes to artificially recharge the CRBG aquifer during the winter with the objective of proactively mitigating future groundwater level declines, maintaining yield in the Basalt Well, and increasing the long-term reliability of groundwater supply. Rudd Farms proposes to recharge the Basalt Well using alluvial groundwater from an existing well during the winter (December to April), when the Oregon Water Resource Department's (OWRD) Water Availability Reporting System indicates that water is available for storage[4]. We estimate that Rudd Farm's AR project will store up to 54.4 million gallons (MG) per year, or up to 272 MG over the 5-year duration of the Limited License. Assuming AR pilot testing confirms that stored water is retained for recovery during the summer, then Rudd Farms may recover the water. A separate AR recovery Limited License would be requested based on observations from AR recharge testing to allow for recovery of stored water.

This AR Limited License Application meets or exceeds the requirements for AR applications in Oregon Administrative Rules (OAR) 690-350-0120. The application develops a pilot

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[1] UNIO 52415, permit G-17020

[2] The well produced 800 gallons per minute (gpm) based on a 12 hour aquifer test performed in August 2013.

[3] The yield of the well is currently about 500 gpm, based on a 24 hour aquifer test performed in October 2017.

[4] Grande Ronde R > Snake R – Above Willow Cr, 50% exceedance level

testing program based on local geology and hydrogeology, groundwater quality in the source and receiving aquifer, best practices for well operation, and requirements in Oregon Administrative Rules. The objective of the pilot testing is to determine the ultimate size and scope of the AR project.

1. Introduction

Rudd Farms is located about five miles northeast of La Grande, Oregon, and is a family farm that grows peppermint, grass seed, wheat, and alfalfa on about 3,000 acres. With an average annual precipitation of 16.5 inches, La Grande is arid, and agriculture is dependent on irrigation using surface water and groundwater (US Climate Data, 2018). Groundwater in the La Grande area is pumped primarily from two aquifers: (1) an alluvial aquifer and (2) the Columbia River Basalt Group (CRBG) aquifer that underlies the alluvial aquifer. The alluvial aquifer is by far the most widely-used source of groundwater in the La Grande area, but several highly-productive wells have been completed in the CRBG aquifer (Ferns et al., 2010; UGRRWP, 2018). Rudd Farms pumps groundwater from both the alluvial aquifer and the CRBG aquifer using five irrigation wells. The names and water rights for Rudd Farms' irrigation wells are presented in Table 1. Well locations are shown in Figure 1.

Table 1. Rudd Farms Irrigation Wells.

Well Name	OWRD ID	Application	Permit(s)	Certificate	Well Depth (feet bgs)	Aquifer
Well No. 1	UNIO 51770	G-16028	G-15541	90977	920	Alluvium
Well No. 2	UNIO 51478	G-16028	G-15541	90977	345	Alluvium
Well No. 3	UNIO 51938	G-16028	G-15541	90977	1,128	Alluvium
Schwepke Well	UNIO 50687	G-17637 G-13311 (sup) G-16999 (sup)	G-17361 G-12399 (sup) G-16509 (sup)	--	3,065	CRBG
Basalt Well	UNIO 52415	G-17558	G-17020	--	4,045	CRBG

NOTES:
bgs = below ground surface
sup = supplemental
CRBG = Columbia River Basalt Group

Regional CRBG Aquifer Observations

In 2013, Rudd Farms installed an irrigation well in the CRBG aquifer (UNIO 52415), which is referred to as the "Basalt Well" in this Limited License Application. The CRBG aquifer is hydraulically isolated from surface water, and using the CRBG aquifer for summer irrigation supply is therefore protective of fish habitat in the Grande Ronde River. However, due to this hydraulic isolation, groundwater in the CRBG aquifer is not rapidly replenished each winter and, therefore, is susceptible to groundwater level declines (UGRRWP, 2018). In fact, groundwater level declines in the CRBG aquifer near La Grande have been observed over the past forty years in several wells, as shown in the hydrographs of CRBG wells in Figure 2 (basalt well locations are shown in Figure 1). While water levels appear to be stable in some wells (e.g., UNIO 2046 and the Schwepke Well), other wells have experienced declines ranging from several feet (UNIO 50083) to over 100 feet (City of

La Grande public supply wells UNIO 940 and the UNIO 2098). Anecdotal information of water level declines in the CRBG aquifer has also been discussed in Union County planning documents [i.e., see discussion on Page 2-33 about the City of Imbler's public supply basalt well in UGRRWP (2018)]. These regional groundwater level declines are problematic because they typically result in reduced well yield from CRBG wells, and may indicate that the current level of water production from the CRBG aquifer is not sustainable[5]. Rudd Farms' proposed AR project offers a public benefit to CRBG aquifer users because it will increase recharge to the CRBG aquifer, thereby contributing to its sustainability as a groundwater resource.

1.1 Proposed Project to Artificially Recharge the CRBG

Rudd Farms proposes to artificially recharge (AR) the CRBG aquifer during the winter with the objective of proactively mitigating future groundwater level declines, maintaining yield of the Basalt Well, and increasing the long-term reliability of groundwater supply. While the hydraulic isolation of the CRBG aquifer may contribute to the susceptibility of the CRBG aquifer to water level declines, it also makes the CRBG aquifer a desirable aquifer for AR because it can likely store large quantities of water with limited risk of loss of stored water. This AR Limited License Application proposes to conduct pilot testing of AR in the CRBG aquifer. Depending on the results of pilot testing under the AR Limited License, Rudd Farms may apply for a permit for AR.

Source water for the recharge is alluvial groundwater from Rudd Farms Well No. 1 (UNIO 51770), and the CRBG aquifer will be recharged at the Rudd Farms Basalt Well (UNIO 52415), shown in Figure 1. If data collected during the project indicate that the recharged water is available for recovery, then Rudd Farms may apply to use some of the recharged water for irrigation purposes. Otherwise, the recharged water will be left in the CRBG aquifer to maintain a sustainable groundwater supply in the CRBG aquifer.

In 2018, GSI Water Solutions, Inc. (GSI) performed a fatal flaw level feasibility evaluation for recharging the CRBG aquifer (Appendix A) (GSI, 2018). Based on a 24 hour aquifer test of the Basalt Well, a 74 hour aquifer test of Well No. 1, and the number of days that source water is available each year, we estimate that the Basalt Well may be capable of storing up to 54.4 million gallons (MG) [167 acre-feet (ac-ft)] per year[6]. Based on the feasibility evaluation, the limiting factor on recharge capacity appears to be the rate that the Basalt Well can accept water (assuming recharge occurs with the water level below ground surface).

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[5] Longer-term water level monitoring, and an in depth evaluation of trends in recharge and pumping, need to be conducted to confirm that the water level declines indicate that the current groundwater pumping from the CRBG is not sustainable. For example, declines in groundwater levels also can be related to reduced recharge (i.e., short-term climate cycles).

[6] Assuming recharge from December 1 through April 14, an average recharge rate of 210 gallons per minute (gpm), and a long-term specific capacity of 1.6 gpm/foot of water level rise.

This report, prepared by GSI, is an AR Limited License application and includes all information required by Oregon Administrative Rules for AR applications, including the elements of the required Project Description Report and Hydrogeologic Feasibility Report[7]. The following index identifies where information required by the Oregon Administrative Rules for AR applications can be found in this document. The index was prepared to assist OWRD in reviewing Rudd Farms AR Limited License application.

OAR	Information Location in this Document
690-350-0120 (2) **Pre-Application Conference**	July 26, 2018
690-350-0120 (3) (a) **Minimum Perennial Stream Flow or Instream Water Right**	Not Applicable – Source water is not a stream
690-350-0120 (3)(b) **DEQ Water Quality Permit**	Not Applicable – Source water is not a wastewater
690-350-0120 (3)(c) **Purpose of Recharge**	Section 1 – Introduction AR Limited License Application Form (Appendix B)
690-350-0120 (3)(d) **Volume of Water Stored**	Section 3 – Pilot Testing Program AR Limited License Application Form (Appendix B)
690-350-0120 (3)(e) **Financial Capability**	Not Applicable – Recharge diversion is less than 5 cfs
690-350-0120 (3)(f) **Hydrogeologic Feasibility Report**	Section 2 – Hydrologic and Hydrogeologic Characterization
690-350-0120 (3)(g) **Project Description Report**	Section 2—Hydrologic and Hydrogeologic Characterization Section 3—AR Testing Program Section 4—System Operation and Wellhead Facility Design
690-350-0120 (3)(h) **Additional Information**	Not Applicable—Not requested at this time
690-350-0120 (4) **Recharge Permit Processing**	Not Applicable – Not a required element of an AR LL application
690-350-0120 (5)(a) **Maximum Rate and Volume**	Section 3—AR Testing Program
690-350-0120 (5)(b) **Meters**	Section 4 – System Operation and Wellhead Facility Design
690-350-0120 (5)(c) **Recordkeeping**	Section 3—AR Testing Program
690-350-0120 (5)(d) **Estimated Data**	Not Applicable – Not a required element of an AR LL application
690-350-0120 (5)(e)(A) **Monitoring Program**	Section 3—AR Testing Program
690-350-0120 (5)(e)(B) **Key Wells and Target Levels**	Section 3—AR Testing Program
690-350-0120 (5)(f) **Determination of Stored Recharge Water**	Section 3—AR Testing Program

[7] Requirements for AR applications are set forth in OAR 690-350-0120, OAR 690-310-0040, and OAR 340-040. The required elements of the Project Description Report are listed in OAR 690-350-0120(3)(g), and the required elements of the Hydrogeologic Feasibility Report are listed in OAR 690-350-0120(3)(f).

OAR	Information Location in this Document
690-350-0120 (5)(g) **Storage Account**	Not Applicable – Not a required element of an AR LL application
690-350-0120 (5)(h) **Annual Report**	Section 3—AR Testing Program
690-350-0120 (5)(i) **Allowable Use of Stored Recharge Water**	Section 4—System Operation and Wellhead Facility Design
690-350-0120 (5)(j) through (5)(m) **Permit Assignment** **Condition Changes** **Technical Oversight** **Other Conditions**	Not Applicable – Not a required element of an AR LL application, or recharge diversion is less than 5 cfs
340-040 **Antidegradation Evaluation**	Section 2.3—AR Feasibility Assessment
690-310-0040(1)(a) Application Form	Application for Limited Water Use License (Appendix B)
690-310-0040(1)(b) Additional Information Required for a Permit to Appropriate Groundwater	Section 2—Hydrologic and Hydrogeologic Characterization Section 4—System Operation and Wellhead Facility Design

Appendix B presents a completed Oregon Water Resources Department (OWRD) AR Limited License application form, Land Use Compatibility Statement, and the accompanying Limited License map for the proposed AR project. The application was completed in a manner that allows operational flexibility during the pilot testing period.

1.2 AR Pilot Testing Objectives

The purpose of AR pilot testing is to evaluate AR feasibility and capacity in the CRBG aquifer, and to develop design criteria for a full-scale operational AR program under an AR Permit. The pilot testing will be conducted in stages and in a controlled manner designed to provide the data necessary to develop an initial AR operational plan. The objectives of the pilot testing are to evaluate:

- Wellhead facility operation and response to AR
- Aquifer hydraulic response to AR
- Long-term performance of the AR well
- Optimal rate of recharge and volume of storage
- Potential for recovery
- Chemical compatibility of receiving aquifer water and source water (including an assessment of mixing, potential well clogging, and potential water quality changes)
- Quality of recovered water over time
- Frequency of redevelopment of the AR well necessary to maintain an acceptable and sustainable degree of well efficiency during AR operations

- Potential impacts of AR including loss of stored water (e.g., seeps, surface streams), water quality degradation, and interference with surrounding wells as a result of recharge and recovery operations.

The pilot testing described in this AR Limited License Application is designed to meet the objectives listed above and that can be used to apply for an AR permit.

1.3 Pilot Testing Study Area

The pilot test will be conducted by recharging the CRBG aquifer at the Rudd Farms Basalt Well, shown in Figure 1. Results from GSI's 2018 fatal flaw level feasibility evaluation (Appendix A) indicate that the Basalt Well has the following characteristics:

- Relatively high pumping capacity [production rate of 522 gallons per minute (gpm) during the 24 hour aquifer test].
- Estimated storage capacity of up to 54.4 MG in a single year.
- Low potential for adverse geochemical effects caused by mixing of receiving water and source water.
- Depth to water varies widely during the year, ranging from 88 feet below ground surface (bgs) (at the start of the irrigation season) to 175 feet bgs (at the end of the irrigation season).
- Low potential for loss of recharged water due to compartmentalization of the CRBG aquifer.

Additional geologic and hydrogeologic information about the CRBG aquifer is presented in Section 2.

1.4 Pilot Testing Schedule and Scope

Pilot Testing Schedule

Rudd Farms plans to begin pilot testing immediately following issuance of an AR Limited License by OWRD, and plans to recharge the CRBG aquifer each year from December through April 14. This recharge time period is based on GSI's assumption that OWRD will find a potential for substantial interference (PSI) between the Source Well and surface water. Specifically, review of surface water availability in the Grande Ronde Water Availability Basin[8] indicates that, at an 50% exceedance level, a Limited License to appropriate alluvial groundwater for AR storage with assumed PSI is available for

[8] Grande Ronde R>Snake R—AB Willow Creek

December, January, February, March, and April (OWRD, 2018a)[9]. Surface water is not available at the 50% exceedance level in November. Depending on the hydraulic response of the CRBG aquifer to AR, Rudd Farms may recover up to 85% of the AR water under a secondary permit during the irrigation season (May to October), which will be initially conducted under a Limited License for recovery pilot testing (an application will be submitted separately and will be based on AR recharge testing).

Pilot Testing Scope

Source water will be pumped from Rudd Farms' Well No. 1, and the CRBG aquifer will be recharged at the Basalt Well (shown in Figure 1). Source water will be treated by chlorination and filtration to reduce elevated concentrations of manganese in the source water. The recharge rate is highly depended on the amount of headspace in the Basalt Well (because Rudd Farms plans to conduct recharge at rates that maintain a water level below ground surface), but is anticipated to range from 140 gpm to 280 gpm. Note that Rudd Farms is requesting a maximum rate of 350 gpm on the Limited License application in Appendix B to account for potentially higher rates to evaluate possible short-term periods of higher recharge. We estimate that Rudd Farms' AR program will develop up to 54.4 MG of storage annually, based on testing of the Basalt Well in October 2017. The 54.4 MG storage volume equates to storing up to 272 MG of water over the 5 year term of the Limited License (assuming no recovery of stored water).

The first year of the pilot testing will consist of a shakedown test followed by a full recharge-storage-recovery cycle (a recovery Limited License to be applied for separately). The shakedown test will assess the performance of the piping, pumps, valves, and controls, and will last about one day. During this test, a relatively small volume of water will be recharged and recovered to evaluate initial system operations. The full AR cycle (i.e., Cycle 1) will more closely approximate an operational-scale AR cycle, and will be used to evaluate the aquifer response to AR.

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[9] Well No. 1 is located approximately 1.25 miles from the Grande Ronde River, and less than 0.5 miles from Canyon Creek/Wright Slough, which is a tributary to the Grande Ronde River.

2. Hydrologic and Hydrogeologic Characterization

This section characterizes the hydrology and hydrogeology in the Grande Ronde Valley, where Rudd Farms is located. The hydrologic and hydrogeologic information is used to evaluate the feasibility of AR, and to develop the AR testing program under this Limited License. This section is organized as follows:

- **Section 2.1:** Hydrology in the vicinity of Rudd Farms.
- **Section 2.2:** Geology and hydrogeology in the vicinity of Rudd Farms.
- **Section 2.3:** AR feasibility at Rudd Farms.

2.1 Hydrology

Grande Ronde River Basin Hydrology

Rudd Farms is situated in the Grande Ronde River Basin. With a drainage area of about 4,000 square miles and total length of about 212 miles, the Grande Ronde River is the largest surface water body in the basin, and drains the Wallowa Mountains to the southeast and the Blue Mountains to the west and northwest. The River flows into the Snake River at Hells Canyon (Kelly and White, 2016).

Surface Water Availability

As required by Oregon Administrative Rule (OAR) 690-009, OWRD considers groundwater wells in proximity to the Grande Ronde River to be hydraulically connected to the alluvial aquifer. Therefore, OWRD considers Well No. 1 to be hydraulically connected to the Grande Ronde River. A review of water availability in the Grande Ronde Water Availability Basin[10] indicates that, at an 50% exceedance level, a Limited License for pumping alluvial groundwater with assumed PSI is available for December, January, February, March and April (OWRD, 2018a)[11]. Water is not available for November at the 50% exceedance level. Results from OWRD's online Water Availability Analysis tool are provided in Appendix C.

2.2 Geology and Hydrogeology

The following discussion of the geologic and hydrogeologic setting at Rudd Farms is based on studies conducted by the Oregon Department of Geology and Mineral Industries

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[10] Grande Ronde R>Snake R—AB Willow Creek

[11] Well No. 1 is located approximately 1.25 miles from the Grande Ronde River, and less than 0.5 miles from Canyon Creek/Wright Slough, which is a tributary to the Grande Ronde River.

(DOGAMI) and United States Geological Survey (USGS) (DOGAMI, 2015; DOGAMI, 2016; Hampton and Brown, 1964), and data from the Oregon Water Resources Department (OWRD, 2017).

Geologic Setting

The Grande Ronde Valley is a fault-bounded graben that has been filled by over 2,400 feet of alluvial sediments. A map showing surficial geology in the vicinity of Rudd Farms is provided in Figure 3, and cross sections showing the occurrence, thickness and depths of geologic units are provided in Figure 4 and Figure 5. There are three geologic units at Rudd Farms, including (from youngest to oldest):

- **Valley-Fill Deposits.** The Valley-Fill Deposits are Neogene- and Quaternary-aged sediments deposited within the past 23 million years. The deposits are primarily composed of unconsolidated to weakly consolidated silts, sands, gravels, and tuffs of alluvial and/or volcaniclastic origin, ranging in thickness from 500 feet to more than 2,400 feet.

- **Volcanic Rocks.** The sides and bottom of the graben are comprised of volcanic rocks, including the Powder River Volcanic Field (PRVF) and the Columbia River Basalt Group (CRBG):

  - Powder River Volcanic Field. The PRVF underlies the Valley-Fill Deposits and originated from a sequence of lava flows in the Wallowa Mountains. Composed of volcaniclastic rocks including basalts, andesites, dacites, and tuff breccias, the PRVF extends across the Grande Ronde Valley, with thicknesses ranging from 200 feet to over 950 feet. The PRVF is surficially exposed at topographic highs including the Wallowa Mountains, and, to a lesser extent, the Blue Mountains.

  - Columbia River Basalt Group. Underlying the PRVF and originating from a sequence of extensive regional flood basalts that erupted in eastern Washington, the CRBG is composed of multiple individual basalt flows. The composition of each flow member generally includes a weathered flow top, a dense columnar interior, and a weathered flow bottom. The CRBG is the primary rock forming the bottom and sides of the graben, with thicknesses locally reaching over 3,000 feet. The CRBG is surficially exposed at topographic highs including the Blue Mountains and Wallowa Mountains.

Structurally, the Grande Ronde Valley is characterized by a high concentration of northwest trending faults and folds (see Figure 3). As shown in the Figure 4 and Figure 5 cross sections, displacements along the faults range from 1,200 feet to 1,800 feet. The primary structural components of the La Grande Valley include the Blue Mountain anticline to the west, the Grande Ronde Valley syncline, and the uplifted Wallowa Mountain dome to the east. These structures occurred following the emplacement of the CRBG and prior to deposition of the Valley-Fill Deposits.

Hydrogeologic Setting

Groundwater resources of the Grande Ronde Valley primarily occur in two aquifers—the alluvial aquifer (which corresponds to the Valley-Fill Deposits geologic unit) and the CRBG aquifer (which corresponds to the Columbia River Basalt Group geologic unit). The PRVF geologic unit does not produce sufficient volumes of water for irrigation or municipal water supply purposes and, therefore, is not considered to be an aquifer. An overview of the hydrogeologic characteristics associated with each aquifer is provided below:

- **Alluvial Aquifer.** Groundwater in the alluvial aquifer occurs within permeable zones of the Valley-Fill Deposits geologic unit (i.e., gravels and sands) under unconfined to semi-confined conditions. In the area of Rudd Farms, the static water level of the alluvial aquifer is approximately 25 feet bgs, with the groundwater flow direction oriented towards surface water features. Recharge of the alluvial aquifer primarily occurs by infiltration of precipitation, irrigation return flow, and losses from surface water (Hampton and Brown, 1964).

- **CRBG Aquifer.** Groundwater in the CRBG aquifer occurs within the permeable interflow zones between basalt flows and exists under confined conditions. In the Grande Ronde Valley, the CRBG aquifer is generally artesian, with static water levels up to 90 feet above ground surface (based on a March 2018 water level measurement at UNIO 2098). The extensive faulting in the valley has likely compartmentalized the CRBG aquifer, and created hydraulically isolated compartments with variable water levels, groundwater gradients and flow directions. Recharge of the CRBG aquifer primarily occurs via precipitation on surficially exposed sections of the CRBG in the Wallowa and Blue Mountains; however, the amount of recharge that reaches the CRBG in the center of the valley may be limited due to aquifer compartmentalization.

Table 2 summarizes hydraulic properties of the alluvial aquifer and CRBG aquifer based on a pumping test of Well No. 1 and the Basalt Well conducted in October 2017, and USGS studies of the Grande Ronde Valley.

Table 2. Aquifer Properties.

Well ID	Transmissivity – Early Time (gpd/ft)	Transmissivity – Late Time (gpd/ft)	Horizontal Hydraulic Gradient [1] (ft/ft)	Storage [2] (dimensionless)
Alluvial Aquifer	5,248	2,333	0.0024	0.20
CRBG Aquifer	1,210	NA	No Data	0.00005

NOTES:
(1) Based on groundwater contours in Plate 5 and Plate 6 of Hampton and Brown (1964).
(2) Storage for the alluvial aquifer (Well No. 1) is from Driscoll (1986)—the midrange specific yield for a sand. Storage for the CRBG aquifer (Basalt Well) is from Golder (1996), based on estimates of storativity of the CRBG aquifer at wells operated by the City of Salem.
gpd/ft = gallons per day per foot
ft/ft = feet per foot
NA = No boundaries observed during aquifer test, so only one transmissivity is presented

Other Groundwater Users

GSI identified other groundwater wells in the vicinity of Rudd Farms using OWRD's online well log database (OWRD, 2017) and water right mapping system (OWRD, 2018b). We identified a total of 7 existing alluvial wells within 0.5 miles of Well No. 1, shown in Table 3. Five of the 7 alluvial wells could be precisely located based on property address, distance from section corner, or tax lot; these wells are denoted by the latitude and longitude in Table 4, and are shown in Figure 6. Some of the wells in Table 3 that could not be precisely located (i.e., wells without latitude or longitude) likely belong to the houses that are visible in the Figure 6 aerial photo; because no public water supply is available, these properties obtain water from wells. As shown in Table 3, Well No. 1 is producing groundwater from a deeper aquifer zone than most of the other alluvial wells.

Table 3. Alluvial Wells Within 0.5 Miles of Well No. 1.

Well ID	Water Right	Well Depth (feet bgs)	Latitude	Longitude	Distance to Well No. 1 (feet)
UNIO 51770 UNIO 51835 (Well No. 1)	90977	920	45.362485	-117.983947	0
UNIO 705 UNIO 707	--	260	45.358627°	-117.984087°	1,420
UNIO 709	--	350	--	--	--
UNIO 710	--	45	--	--	--
UNIO 2533 UNIO 52564	G-13146	272	45.357914°	-117.979119°	2,070
UNIO 50227	--	202	45.366627°	-117.992926°	2,757
UNIO 50450	G-13593	720	45.365797°	-117.992705°	2,550
UNIO 51734	--	83	45.362845°	-117.984210°	147

We identified 10 basalt wells within 5.0 miles of the Rudd Farms Basalt Well, shown in Table 4 and Figure 1. Nine of the 10 basalt wells could be precisely located based on information in the OWRD Groundwater Information System; these wells are denoted by the latitude and longitude in Table 4. The remaining well (UNIO 273) was located based on the quarter-quarter section listed on the driller's log for the well. As shown in Table 4, the Basalt Well is producing groundwater from a deeper aquifer zone than other wells completed in the CRBG aquifer.

Table 4. Basalt Wells Within 5.0 Miles of the Rudd Farms Basalt Well.

Well ID	Water Right Permit	Well Depth (feet bgs)	Latitude	Longitude	Distance From Basalt Well (feet)
UNIO 52415 (Basalt Well)	G-17020	4,045	45.380343	-117.971792	0
UNIO 50687	G-12399 G-16509 G-17361	3,065	45.409334	-117.968123	10,560
UNIO 50684	G-12738 G-15160 G-15504	3,138	45.398910	-118.006808	11,088
UNIO 271	G-10365 G-16933	1,191	45.442865	-117.978165	22,704
UNIO 273		1,300	45.442786	-117.978141	22,704
UNIO 2046	G-12359	1,802	45.433774	-117.964555	19,536
UNIO 50683	G-12382	2,507	45.434689	-117.933597	22,176
UNIO 325	G-2739	1,030	45.418584	-118.042919	23,232
UNIO 52334	G-16848	1,215	45.401000	-118.050380	21,648
UNIO 173	G-6870 G-15644 G-16963	1,394	45.438564	-118.009197	22,232
UNIO 174	G-2993	1,550	45.440591	-117.996698	22,704

NOTE:
bgs = below ground surface

Groundwater Quality

Groundwater resources of the Grande Ronde Valley aquifers are generally considered to be of good to excellent quality and suitable for municipal, irrigation, or domestic use with minimal pre-treatment being required (Hampton and Brown, 1964). In October of 2017, GSI collected groundwater samples from Rudd Farms' Well No. 1 and Basalt Well to characterize the quality of the alluvial aquifer and CRBG aquifer, respectively. Laboratory results of the groundwater samples from the alluvial aquifer and CRBG aquifer are summarized in Appendix D. Groundwater quality in each aquifer is summarized below:

- **Alluvial Aquifer:** All water quality constituents in Well No. 1 are below applicable maximum contaminant levels (MCLs) and secondary maximum contaminant levels (SMCLs) with the exception of manganese, which exceeded the SMCL of 0.05 milligrams per liter (mg/L) with a concentration of 0.14 mg/L. SMCLs are non-enforceable standards in drinking water that are guidelines to help public water systems in managing drinking water for aesthetic considerations such as color, odor and taste.

  In order to assess potential sources for the elevated manganese, Rudd Farms collected additional groundwater samples from Well No. 3 and from the Rudd domestic well, and found similarly high manganese concentrations (0.575 mg/L in the domestic well[12] and 0.0537 mg/L in Well No. 3[13]). Therefore, the high manganese in alluvial groundwater appears to be a regional issue related to naturally-occurring manganese in the alluvial aquifer.

- **Columbia River Basalt Group Aquifer:** While all water quality constituents in the Basalt Well were below applicable MCLs and SMCLs, the concentration of fluoride was over half of the MCL of 4 mg/L with a concentration of 3.1 mg/L.

2.3 AR Feasibility Assessment

The following sections assess the feasibility of Rudd Farms' proposed AR project from the perspectives of: (1) whether the volume of water than can be stored is likely to stabilize water levels in the CRBG aquifer, (2) whether AR can be conducted in conformance with the DEQ's antidegradation policy, (3) whether mixing between source water and native basalt groundwater will produce adverse effects, (4) whether appropriation of groundwater from Well No. 1 from December to April 14 will injure existing alluvial wells, and (5) whether recharging the Basalt Well will injure existing basalt wells.

Stabilization of CRBG Aquifer Water Levels

The objective of Rudd Farms' proposed AR project is to recharge the CRBG aquifer to proactively mitigate potential future groundwater level declines. To mitigate the impact of groundwater withdrawal and potentially stabilize groundwater levels in the CRBG aquifer, the volume that is artificially recharged is targeted to be the same order of magnitude as the annual volume of water that is pumped for irrigation. The volume of AR does not have to equal the amount that is pumped because the CRBG aquifer likely receives some amount of natural recharge.

We estimated the annual storage volume based on the following assumptions:

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[12] Sample collected on December 22, 2017

[13] Sample collected on August 16, 2018

- Recharge will occur from December 1 through April 14 (135 days).
- The amount of headspace in the Basalt Well ranges from 88 feet[14] to 175 feet[15], which is the depth to groundwater in the Basalt Well at different times of the year (i.e., seasonal high in the spring and seasonal low at the conclusion of the irrigation season).
- The specific capacity of the Basalt Well is 1.6 gpm/ft of water level buildup (see Appendix A for details).
- The Basalt Well can be recharged at a rate ranging from about 140 gpm to 280 gpm, depending on the amount of headspace available prior to the initiation of recharge and based on the specific capacity of 1.6 gpm/ft of drawup.

As shown on Table 5, we estimate that Rudd Farms' AR program will develop between 27.2 MG and 54.4 MG of storage annually based on the above assumptions. The annual and maximum storage volumes developed within Rudd Farms' AR project may be smaller due to local hydrogeologic conditions and the constraints of existing well construction, which will be determined during pilot testing. Rudd Farms currently plans to conduct recharge while maintaining water levels below ground surface. The storage volume could be increased by recharging the Basalt Well under pressure (i.e., recharging with the water level above ground surface), but recharging under pressure is not anticipated at this time.

Table 5. Estimated Storage Volumes.

Scenario	Recharge Rate (gpm)	Days of Recharge [1]	Annual Storage Volume (MG)	Maximum (5-Year) Storage Volume (MG)
Minimum Recharge Rate	140	135	27.2	136
Maximum Recharge Rate	280	135	54.4	272

NOTES:
(1) Recharge from December to April 14 each year
gpm = gallons per minute
MG = million gallons

Based on previous water use records for the Basalt Well from OWRD (2018c), the volume of water pumped during past irrigation seasons ranges from about 75 acre-feet (24.4 million gallons or MG) to 277 acre-feet (90 MG) (OWRD, 2017b)[16]. Therefore, the AR project appears to be capable of storing somewhere in the range of the volume of water

[14] Measured on March 23, 2016

[15] Measured on October 24, 2017

[16] Water use records from 2014, 2016 and 2017.

withdrawn in recent years, and is likely feasible from the perspective of water storage volume.

Conformance with Antidegradation Policy

Because the alluvial aquifer and CRBG aquifer are composed of different minerals, receive recharge from different sources, and contain groundwater with different residence times in the aquifer, the groundwater in the alluvial aquifer and CRBG aquifer have differences in geochemistry. As such, introducing alluvial groundwater into the CRBG aquifer will increase the concentration of some groundwater constituents in the CRBG aquifer, and will decrease the concentration of other groundwater constituents in the CRBG aquifer.

The AR rules require that Rudd Farms conduct AR in conformance with the Oregon Department of Environmental Quality (DEQ) groundwater protection rules, which require that "(a)ll groundwaters of the state shall be protected from pollution that could impair existing or potential beneficial uses." The groundwater protection rules further state that "domestic water supply is recognized as being the use that would usually require that highest level of water quality"[17].

Table 6 summarizes the 11 constituents with drinking water standards that were detected in the October 2017 groundwater samples from Well No. 1 or the Basalt Well (see Appendix D for all water quality data).

Table 6. Groundwater Quality.

Constituent	Drinking Water Standard	Standard (ug/L)	Well No. 1 (ug/L)	Basalt Well (ug/L)
Arsenic (Total)	MCL	10	1.5	2.4
Barium (Total)	MCL	2,000	79	15
Copper (Total)	MCL	1,300	3.6	< 2
Cyanide	MCL	200	45	66
Lead	MCL	15	0.87	< 0.5
Sulfate	SMCL	250,000	1,700	9,300
Total Dissolved Solids	SMCL	500,000	180,000	260,000
Chloride	SMCL	250,000	1,200	15,000
Fluoride	MCL	4,000	200	3,100
Iron (Total)	SMCL	300	160	< 0.02
Manganese	SMCL	50	140	4.6

NOTES:
MCL = Maximum Contaminant Level SMCL = Secondary MCL ug/L = micrograms per liter
ORANGE text indicates that constituent concentrations differ by at least an order of magnitude

[17] See OAR 340-040-0020(3).

Most of the detected constituents with drinking water standards (unbolded constituents in Table 6) have concentrations in source water and receiving water that are the same order of magnitude. In addition, these constituent concentrations are below drinking water standards. Therefore, mixing these contituents will meet Oregon's groundwater protection rules. Four of the 11 constituents—chloride, fluoride, iron, and manganese, shown in bold in Table 6—have concentrations in source water and receiving water that differ by at least an order of magnitude. AR will significantly decrease the concentrations of chloride and fluoride in the CRBG aquifer, which meets Oregon's groundwater protection rules.

AR will significantly increase the concentrations of iron and manganese in the CRBG aquifer. Iron concentrations in source water are below the drinking water standard (SMCL) and therefore will not impair the beneficial use of the CRBG aquifer groundwater for domestic drinking water purposes. However, manganese was detected above the drinking water standard (SMCL) of 50 ug/L in the alluvial aquifer, and was detected at very low concentrations in the CRBG aquifer (4.6 ug/L). Therefore, manganese could impair the beneficial use of groundwater in the CRBG aquifer for domestic purposes. Rudd Farms plans to treat alluvial groundwater to reduce manganese concentrations in source water to below the SMCL, thereby protecting groundwater quality to its highest beneficial use of domestic supply and conforming to DEQ's groundwater protection rules. Additional information about source water treatment for manganese removal is presented in Section 4.

Source and Receiving Water Geochemical Compatibility

Mixing groundwaters with different geochemistry has the potential to cause adverse effects on the aquifer or well (e.g., precipitation of minerals on the Basalt Well's screen, which reduces the injection capacity at the well). If mixing source water and receiving water do not produce adverse effects, then the waters are considered to be "geochemically compatible." S.S. Papadopulos & Associates, Inc. (SSPA) evaluated whether source water and receiving water were geochemically compatible using the USGS geochemical mixing model PHREEQC (Parkhurst and Appelo, 1999) and groundwater quality data collected from Well No. 1 and the Basalt Well in October 2017. The SSPA memorandum is provided in Appdendix A.

SSPA predicts that a mixture of source water and receiving water would be saturated or supersaturated in silica minerals (quartz and chalcedony), carbonate minerals (calcite, dolomite), and iron and manganese minerals (iron hydroxide, pyrolusite, bixbyite, and hausmannite), meaning that these minerals have a tendency to precipitate in the Basalt Well. However, SSPA's analysis indicates that it is unlikely that silica minerals and calcite minerals would precipitate because the precipitation kinetics of silica are extremely slow, and calcite precipitation requires a high nucleation energy. Iron and manganese precipitation is possible but, at the current concentrations, the amount of precipitate is likely to be negligible based on observations from existing Aquifer Storage and Recovery systems that are completed in the CRBG aquifer in Oregon and have similar concentrations of iron and manganese in source water. Additionally, the potential for iron and manganese precipitation will become less likely once the concentrations of iron and manganese are reduced after source water treatment.

We find that the potential for adverse effects to the Basalt Well (e.g., precipitation of minerals in the well) is unlikely to occur when receiving water and source water are mixed. Therefore, the AR project appears to be feasible from the perspective of mixing groundwaters with different geochemistries.

Injury to Existing Alluvial Wells

GSI used the Theis equation to evaluate potential injury to existing alluvial wells caused by pumping Well No. 1 for an additional 135 days (December 1 to April 14) (e.g., Driscoll, 1986):

$$s = \frac{114.6(Q)}{T} * W(u) \qquad u = \frac{1.87(r^2)(S)}{Tt} \qquad (1)$$

Where:

s = drawdown (feet)
Q = pumping rate rate (gallons per minute)
T = transmissivity (gallons per day per foot)
t = time (days)
r = radial distance from the well with a drawdown of s (feet)
S = storativity (dimensionless)

GSI used the Theis equation instead of the Cooper Jacob equation because "u" was greater than 0.01 over much of the radii of interest (the Cooper Jacob equation cannot be used when "u" is greater than 1). Specifically, the Theis equation was used to estimate the maximum amount of drawdown that will occur in vicinity alluvial wells (Table 3), under the following assumptions:

- Rudd Farms continuously recharges (ie. pumps at Well No. 1) from December 1 through April 14 (135 days).
- Well No. 1 pumps at a rate of 280 gpm. This rate is conservative because it is likely the maximum possible recharge rate based on available headroom in the Basalt Well, and is anticipated only to occur during the beginning of the recharge season. We estimate that the actual recharge rate will be between 140 gpm and 280 gpm (Appendix A). Recharging at a higher rate is conservative because it produces larger estimates of water level drawdown.
- The specific yield of the alluvial aquifer is 0.20, and the transmissivity is 2,333 gallons per day per foot (gpd/ft) (see Table 2). We are using a late-time transmissivity because it is representative of long-term AR operation.

Theis equation calculations are provided in Appendix E. The Theis equation indicates that the cone of depression (i.e., groundwater drawdown) from pumping Well No. 1 for 135 days will extend about 1,060 feet from the well (defining the cone of depression by the 1-foot drawdown contour). Only one well (UNIO 51734, an 83 feet deep domestic well that serves the Rudd Farms shop, about 150 feet north of Well No. 1) is located within the cone of depression. The Theis equation predicts that pumping Well No. 1 at 280 gpm for 135 days will cause about 42 feet of drawdown in UNIO 51734, which may significantly impair the ability of this well to produce sufficient water for domestic supply purposes. However, the Theis equation is based on multiple simplifying assumptions that result in over-prediction of drawdown in UNIO 51734. For example, the Theis equation assumes that Well No. 1 and UNIO 51734 are completed at the same depth horizon and draw water from the same water-bearing zone (in reality, UNIO 51734 is perforated from 40 to 80 feet bgs, and Well No. 1 is draws water from 180 feet bgs to 920 feet bgs). We do not anticipate that pumping Well No. 1 at 280 gpm will adversely affect UNIO 51734 because the wells pump groundwater from different depth horizons. To illustrate this, consider that Well No. 1 pumps at a significantly higher rate (about 800 gpm) during the irrigation season, and UNIO 51734 is able to produce sufficient water for domestic supply.

Because all other alluvial wells within 0.5 miles of Well No. 1 that could be accurately located are more than 1,060 feet from Well No. 1, we conclude that pumping Well No. 1 under this AR Limited License will not cause injury to existing alluvial wells.

Injury to Existing Basalt Wells

GSI used the Cooper Jacob equation to evaluate potential injury to existing basalt wells caused by recharging the basalt well (e.g., Fetter, 1988):

$$s = \frac{2.303(Q)}{4\pi T} * \log\left(\frac{2.25(T)(t)}{r^2 S}\right) \qquad (2)$$

Where:

s = drawdown (feet)
Q = pumping rate rate (cubic feet per day)
T = transmissivity (square feet per day)
t = time (days)
r = radial distance from the well with a drawdown of s (feet)
S = storativity (dimensionless)

The Cooper Jacob equation could be used because "u" was less than 0.01 for all radii of interest. The Cooper Jacob equation conservatively assumed that all existing basalt wells in the CRBG aquifer are hydraulically connected (which is unlikely due to compartmentalization of the CRBG aquifer), and was used to estimate the maximum amount of water level rise in these wells caused by recharging the Basalt Well, under the following assumptions:

- Rudd Farms continuously recharges from December 1 through April 14 (135 days).
- Water is recharged at a rate of 280 gpm (53,900 cubic feet per day). As was discussed previously, this is a conservatively high recharge rate.
- The storativity of the basalt aquifer is 0.00005, and the transmissivity is 27,089 gpd/ft (3,621 square feet per day)[18].

Cooper Jacob calculations are presented in Appendix E, and are summarized in Table 7. We estimate that the water level rise in basalt wells within 5.0 miles of Rudd Farms (all of which are artesian) will range from 4.0 feet to 6.3 feet of water (1.7 pounds per square inch to 2.7 pounds per square inch).

Table 7. Predicted Water Level Buildup in Basalt Wells Within 5.0 Miles of the Rudd Farms Basalt Well.

Well ID	Well Depth (feet bgs)	Distance From Well No. 1 (feet)	Buildup (feet)
UNIO 50687	3,065	10,560	6.3
UNIO 50684	3,138	11,088	6.2
UNIO 2046	1,802	19,536	4.8
UNIO 52334	1,215	21,648	4.6
UNIO 50683	2,507	22,176	4.5
UNIO 325	1,030	23,232	4.4
UNIO 173	1,394	22,232	4.4
UNIO 174	1,550	22,704	4.4
UNIO 271	1,191	22,704	4.5
UNIO 273	1,300	22,704	4.5

The predicted pressure increase at the basalt wells is minor, and can be accommodated by standard well seals. Recalling that artesian pressure in several basalt wells in the Grande Ronde Valley has declined over the past 30 years, the predicted artesian pressure at some

[18] The transmissivity at the Basalt Well based on a time-drawdown analysis is 1,210 gpd/ft (Appendix A). However, using this transmissivity for the CRBG aquifer in the Cooper Jacob equation results in a drawdown of 785 feet in the Basalt Well after 24 hours of pumping, which is unrealistic. The transmissivity calculated from the Basalt Well test is therefore biased low because of well inefficiencies. Razack and Huntley (1991) provides an equation for calculating transmissivity from specific capacity based on an empirical relationship between transmissivity and specific capacity derived from 215 wells. Using Razack and Huntley (1991), we find that the transmissivity of the Basalt Well is 27,089 gpd/ft. Using this value in the Cooper Jacob equation produces a drawdown of about 44 feet in the Basalt Well after 26 hours of pumping, which agrees reasonably well with the observed drawdown of 100 feet in October 2017 testing (assuming the Basalt Well is 44 percent efficient).

wells during AR is less than the pressure when the well was originally drilled (see historical artesian pressures at UNIO 2046 and UNIO 50683 in Figure 2). This indicates that the well seals can accommodate the pressure increases that occur as a result of AR. Therefore, it is likely that AR will be feasible from the perspective of impact to other basalt wells.

3. AR Pilot Testing Work Plan

This section presents a work plan for AR pilot testing. Pilot testing under the AR Limited License will be similar each year, except that Year 1 will include additional baseline testing and a shakedown test that are not part of Years 2 through 5. Therefore, the work plan for Year 1 is separated from the work plan for Years 2 through 5 in this section. This section is organized as follows:

- Section 3.1: An overview of the AR pilot test objectives, wells, recharge rates and volumes, schedule, backflushing requirements, pump to waste requirements, and contingencies for water disposal (applies to all years).
- Section 3.2: Year 1 AR pilot testing (baseline testing, shakedown testing, and a full AR cycle).
- Section 3.3: Year 2 to Year 5 AR pilot testing (full AR cycles).

3.1 Pilot Testing Overview

Under a Limited License, AR systems are pilot tested to determine the ultimate size and scope of the AR system (e.g., storage volume, recharge rate, etc.). Results from the pilot testing are used to provide long term operational characteristics for the project and inform the conditions of the AR permit.

Pilot Test Objectives

A cycle of AR consists of recharge, storage, and recovery. Data are collected during AR cycles to meet the following objectives:

- **Recharge.** Data collected during recharge are used to assess the extent and magnitude of head (i.e., pressure) buildup in the CRBG aquifer, potential for loss of stored water, well efficiency changes at the Basalt Well as a result of recharge, effectiveness of the manganese treatment system, and to verify that source water meets regulatory standards and does not violate DEQ's antidegradation policy.
- **Storage.** Data collected during storage are used to determine the degree to which the head buildup in the CRBG aquifer is maintained and any changes to stored water quality during storage.
- **Recovery.** Data collected during recovery are used to determine if the quality of the stored water changes during storage, to evaluate loss of stored water during storage, and to identify changes in well performance over several cycles of recharge.

Pilot Testing Scope (Wells, Schedule and Storage Volume)

The Rudd Farms AR System is composed of the following wells, which are listed in Table 1 and shown in Figure 1:

- The Source Well (Well No. 1)
- The AR Well (Basalt Well)
- An observation well (Schwepke Well), which is an existing basalt irrigation well. Historically, the Schwepke Well has been inactive from November through March[19], so the well can be used to monitor water level response to AR during most of the recharge period

The following bullets summarize the anticipated operational schedule and storage volumes of the AR System, which may change based on irrigation needs, results from each year of AR pilot testing, and unforeseen factors (equipment failure, well maintenance, staffing needs, etc.):

- Recharge from December 1 through April 14
- Recharge rates that vary from 140 gpm to 280 gpm, and may peak at 350 gpm for short durations
- Annual storage volume of between 27.2 MG to 54.4 MG
- Maximum (5 Year) storage volume of 136 MG to 272 MG

No system losses (i.e., conveyance losses) are anticipated when water is conveyed between Well No. 1 and the Basalt Well, however, this will be verified by comparing flow totalizer measurements collected at the source well and the Basalt Well during AR pilot testing.

Recovery of AR Water

Depending on the hydraulic response of the CRBG aquifer to AR, Rudd Farms may apply to recover up to 85% of the recharged water during the first five years of AR. During subsequent years of recharge, Rudd Farms may apply to recover more that 85% (if data support less potential for loss of stored water)[20]. If Rudd Farms plans to recover recharged water under an AR recovery Limited License, then it will submit an application to OWRD after or near completion of recharge pilot testing, approximately one month before the proposed start date of recovery of AR water. Rudd Farms understands that, for accounting purposes, withdraws of water under an AR Recovery Limited License must occur before any withdraws of water under the Basalt Well's water right.

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[19] Based on OWRD Water Use Reporting data from 2011 through 2017, available online at: https://apps.wrd.state.or.us/apps/wr/wateruse_query/wr_wur_entity_report.aspx?directory_id=106947&start_year=&end_year= .

[20] See OAR 390-350-0130(3)

Monitoring (Water Quality, Water Level, Water Quantity)

Rudd Farms will monitor water quality, water quantity, and groundwater levels during each AR Cycle. The specific AR monitoring program is described in Section 3.2 (Year 1) and Section 3.3 (Year 2 through Year 5).

Duration of Limited License

To implement Rudd Farms' AR project, Rudd Farms is requesting an AR Limited License with a duration of five years, with the option to extend the AR Limited License by 5-year periods to allow for potential modifications of and continued operation of the AR system.

Backflushing

Backflushing of the Basalt Well is conducted to remove fine material (rust or fine silts/sands) that is entrained in water from Well No. 1 and enters the Basalt Well during recharge. Backflushing frequency typically depends on a number of well-specific factors. As a starting point, the Basalt Well will be backflushed every two weeks during recharge. Backflushing frequency for the Basalt Well may be modified in the future based on changes in specific capacity over time during recharge. Backflushing will consist of pumping the basalt well at a rate of about 130% of the recharge rate (i.e., backflushing will occur at a rate of at least 375 gpm). The reason for pumping to waste at a rate that is higher than the recharge rate is to remove fine material from the basalt aquifer by imparting more energy on the well than occurs during recharge. Backflushing will consist of two cycles of pumping that last 20 minutes each, with a 20 minute rest in between each cycle.

Pump to Waste Before Recharge

Prior to injecting any water into the Basalt Well, Well No. 1 will be turned on and pumped to waste at the Basalt Well wellhead, where it will infiltrate into surficial soils. Pumping to waste before injection flushes particulate material from the conveyance piping. Water will be pumped to waste until it is visually clear, and then will be injected into the Basalt Well.

Water Disposal Contingency Plan

It is highly unlikely that quality of the recharged water will become impaired during storage, based on the water quality analysis and geochemical mixing evaluation (Appendix A) and GSI's experience with AR systems in CRBG aquifers. However, in the unlikely event that the quality of the recharge water becomes impaired or the recovered water is unacceptable, all of the water recharged into the aquifer will be recovered and pumped to waste (discharged to ground and allowed to infiltrate near wellhead) or managed in accordance with DEQ permits for disposal (if necessary).

3.2 Year 1 AR Testing

The first year of AR testing will consist of baseline testing and a shakedown test (Section 3.2.1) in addition to performing one cycle of AR operations (Section 3.2.2).

3.2.1 Baseline AR Testing and Shakedown Testing

Baseline testing is performed to establish conditions in the aquifer and wells prior to AR, and to ensure proper functioning of equipment (i.e., valves, flow totalizers, etc.). Baseline testing and shakedown testing are discussed in the following sections.

Baseline Testing

Baseline testing includes water quality monitoring, water level monitoring, and well performance testing.

- **Baseline Water Quality.** Baseline water quality monitoring at Well No. 1 and the Basalt Well has already been completed (samples collected in October 2017). Groundwater quality samples were analyzed for all water quality standards set forth in Oregon's Aquifer Storage and Recovery (ASR) rules[21]. Results of the baseline water quality monitoring are provided in Appendix A, and were discussed in Section 2.3.

- **Baseline Water Level.** Baseline water level monitoring will be performed at Well No. 1, the Basalt Well, and Schwepke Well at least one month prior to the beginning of recharge. Water levels will be recorded hourly with a down hole pressure transducer and data logger, and will be measured manually when the pressure transducer is installed.

- **Baseline Well Performance.** A performance test will be conducted at the Basalt Well in Spring 2020 to assess the baseline (pre-AR) performance of the well. The baseline performance test will be compared to future performance tests to assess the performance of the Basalt Well after each recharge cycle. The performance test will consist of the following steps:

[21] OAR 690-350-0020. At the time the samples were collected, Rudd Farms anticipated permitting this project under the ASR rules. Water quality sampling requirements under the ASR rules (OAR 690-350-0020) is more extensive than water quality sampling under the AR rules (OAR 690-350-120).

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- Measure the static water level.
- Pump the Basalt Well at the full rate for two (2) hours and measure the pumping water level.
- Turn off the pump.
- Calculate specific capacity (i.e., pumping rate divided by drawdown).

Shakedown Test

Before initiating the first cycle of AR operations, a shakedown test will be performed that will consist of:

- **Recharge Test.** The Basalt Well will be recharged with source water from Well No. 1 for about four hours to test and confirm proper functioning of pipes, valves, flow totalizers, and wells during recharge. Adjustments will be made as required.

- **Recovery Test.** After the recharge, the Basalt Well will be pumped to confirm proper functioning of pipes, valves, flow totalizers, and wells during recovery. All recharged water will be recovered. Recovered water from the shakedown test will be pumped-to-waste (discharged to ground near wellhead and allowed to infiltrate) or will be distributed into Rudd Farms' irrigation system.

The shakedown test is anticipated to last approximately one or two days.

3.2.2 Cycle 1 AR Testing

Following the completion of baseline monitoring and the shakedown testing, the first cycle of AR operations will be performed (Cycle 1). The duration of Cycle 1 will be dependent on climate, irrigation needs, and unforeseen equipment failure. For planning purposes, we are proposing an anticipated schedule that involves conducting 135 days of recharge (i.e., December 1 through April 14) and 30 days of storage (April 15 through May 15). Recovery would begin on May 16 under the water right for the Basalt Well.

Cycle 1 AR Water Quality Testing

Water quality testing will involve collecting water quality samples at Well No. 1, the Basalt Well, and the Schwepke Well. The Cycle 1 water quality testing program consists of three analyte groups designated as Group A, Group B, and Group C, as shown on Table 8 (which is attached to the end of the report text). Each analyte group provides information on a different aspect of AR (e.g., manganese treatment, tracking loss of stored water, etc.). A general description of each analyte group is provided below:

- **Group A.** A comprehensive list to ensure that AR is meeting the requirements of Oregon's Groundwater Protection Rules. Includes most contaminants regulated under OAR 340-040 and OAR 333-061.
- **Group B.** A list of general geochemical parameters and metals to evaluate the response of the CRBG aquifer to recharge. Specifically, these parameters are required to make piper plots and stiff diagrams, or are parameters that are significantly different in CRBG groundwater and alluvial groundwater (see Table 6).
- **Group C.** A targeted list of constituents with elevated background concentrations (ie. manganese) and disinfection byproducts to evaluate treatment effectiveness.

Cycle 1 water quality testing will be performed in accordance with the water quality testing schedule presented on Table 9. The frequency of water quality testing and suite of analyzed constituents may be altered if data indicates that changes to water quality testing are warranted. For samples collected during recharge and storage, sample collection times are denoted in terms of days since recharge or storage began. Samples will only be collected if that day of recharge or storage is reached. For example, if recharge only lasts 90 days, the "Day 120" sample of recharged water will not be collected.

Table 9. Cycle1 Water Quality Monitoring.

AR Stage	Time	Well No. 1 (Source Well)	Basalt Well (AR Well)	Schwepke Well (Observation Well)
Recharge	Day 1 (At Startup)	Group C	--	Group B [1]
	Day 30 (~Jan 1)	Mn	--	Group B
	Day 60 (~Feb 1)	Group B & Mn	--	Group B
	Day 90 (~March 1)	Mn	--	Group B
	Day 120 (~April 1)	Mn	--	Group B
Storage	Day 14	--	Group B	Group B
Recovery	Day 1	--	Group A	Group B
	50% of Recovery Volume	--	Group B	Group B
	100% of Recovery Volume	--	Group B	Group B

NOTES:
(1) Collect sample before injection starts
Mn = Manganese
Group A, Group B, and Group C analyte suites are shown in Table 8, which is attached to the end of the report text.

Cycle 1 AR Water Level Monitoring

Water level monitoring will be performed at Well No. 1, the Basalt Well, and the Schwepke Well. Water levels will be monitored hourly with a down-hole pressure transducer and data logger. In addition to transducer measurements, water levels will be measured manually twice each year. The purpose of manual water level measurements is to confirm that transducer measurements are accurate. The first manual water level measurement will occur in March (to correspond with water level monitoring required by Rudd Farms' water rights). The second manual water level measurement will occur during a summer month during recovery (to correspond with water quality sampling during recovery).

Basalt Well Performance Test

A well performance test will be performed at the Basalt Well at the start of the recovery phase that will be structured to match the baseline performance test completed at the Basalt Well prior to AR. Results of the performance test will be compared to the baseline performance test to assess changes in well efficiency following the completion of one AR cycle. The performance test will consist of the following steps:

- Measure the static water level.
- Pump the Basalt Well at the full rate for two (2) hours and measure the pumping water level.
- Turn off the pump.
- Calculate specific capacity (i.e., pumping rate divided by drawdown).

3.3 Cycle 2 through Cycle 5 AR Operations

The results of the Cycle 1 of AR will be evaluated and used to optimize and fine-tune Rudd Farms' AR project in subsequent cycles. The objective of AR operations during Year 2 through Year 5 is to develop larger storage volumes in support of stabilizing groundwater levels of the CRBG aquifer and improve the overall efficiency of Rudd Farms' AR system. The anticipated AR operations plan for a subsequent year will be included with each AR annual report submitted to OWRD. Any modifications to the water level or water quality monitoring plan as outlined in this work plan will be submitted to OWRD for review and approval.

Cycle 2 to Cycle 5 Water Quality Testing

Water quality testing during Cycle 2 through Cycle 5 is shown in Table 10. If data collected during pilot testing indicate that changes to the water quality testing program in Table 10 are necessary, Rudd Farms will communicate the changes to OWRD in the Annual Report that is submitted prior to the change taking effect (or by email, if notification is necessary prior to the Annual Report due date).

Table 10. Cycle 2 to Cycle 5 Water Quality Monitoring.

AR Stage	Time	Well No. 1 (Source Well)	Basalt Well (AR Well)	Schwepke Well (Observation Well)
Baseline	Day 1 (At Startup)	Group A	Group A [1]	Group B [1]
Recharge	Day 30 (~Jan 1)	Mn	--	--
	Day 60 (~Feb 1)	Group B & Mn	--	Group B
	Day 90 (~March 1)	Mn	--	--
	Day 120 (~April 1)	Mn	--	Group B
Storage	Day 14	--	Group B	Group B
Recovery	Day 1	--	Group A	Group B
	50% of Recovery Volume	--	Group B	Group B
	100% of Recovery Volume	--	Group B	Group B

NOTES:
(1) Collect sample before injection starts
Mn = Manganese
Group A, Group B, and Group C analyte suites are shown in Table 8, which is attached to the end of this report text.

Cycle 2 to Cycle 5 Water Level Monitoring

Water level monitoring during Cycle 2 through Cycle 5 is planned to be identical to that of Cycle 1. If data collected during pilot testing indicate that changes to the water level monitoring program are necessary, Rudd Farms will communicate the changes to OWRD in the Annual Report that is submitted prior to the change taking effect (or by email, if notification is necessary prior to the Annual Report due date).

3.3 Determination of Stored Water Available for Recovery

AR projects typically use water level changes in "key wells" to determine the amount of stored water that is available for recovery. However, it is not economically feasible for Rudd Farms to install multiple key wells in the CRBG aquifer, at depths exceeding 4,000 feet bgs. In addition, key wells are not technically required to assess water availability for recovery because the CRBG aquifer is likely compartmentalized, and there is not a potential for loss of stored water. Data collected during pilot testing will be used to evaluate compartmentalization of the CRBG aquifer.

If data collected during recharge and storage indicates that the CRBG aquifer is compartmentalized (and that there is no loss of stored water), Rudd Farms' AR project proposes a formula that relies on quantities of recharge metered at the Basalt Well's flow totalizer. Specifically, 85% of water that is metered recharging the Basalt Well will be available for recovery, per OAR-690-350-0120 (5)(f), during the first five years of the

Limited License. Additional analysis of potential loss of stored water will be evaluated through pilot testing, and a higher recovery percentage may be requested during subsequent recharge permits if data support it (see OAR-690-350-0130).

3.4 Reporting

As required by OAR-690-350-0120 (5)(c), Rudd Farms' AR project will maintain records of metered quantities of water, water levels, water quality, and other pertinent information. Recordkeeping will conform to the standards and protocol of the quality assurance and quality control plan outlined in Section 7 and the recordkeeping form included in Appendix F.

At the end of each year, Rudd Farms will compile records and submit an annual report to OWRD and any other applicable regulatory agencies (ie. DEQ) in fulfillment of OAR-690-350-0120(5)(h) that includes the following report structure and components, at a minimum:

1. Executive Summary
2. Project Description
   - Introduction
   - Existing Site Conditions
3. Pilot Test Results
   - AR Recharge and Recovery Rates and Volumes (stored water and native groundwater)
   - AR Well Performance during Recharge and Recovery
4. Water Quality Monitoring
   - Data Collection
   - Recharge Water Quality
   - Recovered Water Quality (All recovery-related data will also be provided as part of a secondary Limited License for use of artificially recharged waters, if one is submitted).
   - Chemical Reactions
5. Water Level Monitoring and Aquifer Response
   - Data Collection
   - Results
6. Conclusions
7. Proposed ASR Operations Plan for the Subsequent Year

Annual reports will be submitted at the end of each water year (November), before the initiation of the subsequent year's AR operations.

4. AR System Operation and Wellhead Facility Design

This section details aspects related to the design and operation of Rudd Farms' AR system, including the existing water supply infrastructure for use in an AR system; proposed infrastructure modifications and associated cost estimates; and plans for project construction. This section is organized as follows:

- **Section 4.1:** The existing water supply infrastructure for use in an AR system.
- **Section 4.2:** Proposed infrastructure modifications.
- **Section 4.3:** Plans for constructing and implementing water supply infrastructure for use in an AR system.

4.1 Existing AR System Construction and Capacity

The design and operation of Rudd Farms' AR system will follow the rules outlined in OAR 690 Division 350 (Artificial Groundwater Recharge) and Division 250 (Well Construction Standards). The following subsections provide an overview of the design and operation of AR infrastructure for Rudd Farms' proposed AR system.

4.1.1 Source Well

Rudd Farms' AR project proposes to use alluvial groundwater from Well No. 1 as source water for recharge. Well No. 1 is located approximately 2,589 feet west and 44 feet north of the west quarter corner of Township 2 South, Range 39 East, Section 29 (see Figure 6).

Existing Construction

Well No. 1 is 920 feet deep. The construction of Well No. 1 (well log and as-built diagram) are included in Appendix G.

Well No. 1 must meet current well construction standards in the Oregon Administrative Rules to be authorized by OWRD for AR use. GSI reviewed the construction of Well No. 1 (as reported on well log UNIO 51770/51835) to evaluate whether existing well construction meets Oregon Administrative Rule requirements:

- **Well Seal.** Well No. 1 is sealed to a depth of 110 feet bgs with cement and bentonite, in between the 24-inch diameter outer casing and 36-inch diameter borehole wall (i.e., seal thickness exceeds the 4-inch minimum thickness and depth requirements of OAR 690-210-140).
- **Well Casing.** Well No. 1 casing consists of:
  - 16-inch diameter, 0.250-inch gauge steel to 210 feet bgs,

- 16-inch diameter, 0.375-inch gauge steel from 220 feet bgs to 510 feet bgs, and
- 10-inch diameter, 0.250-inch gauge steel from 520 feet bgs to 880 feet bgs.

These casing gauges meet the requirements of OAR 690-210-0190(3) for steel casing.

In summary, the existing construction of Well No. 1 meets current Oregon Administrative Rules water well construction standards and is sufficient for use as an AR extraction well.

Well No. 1 Production Capacity

Well No. 1 is capable of meeting the recharge rate target of up to 280 gpm described in this Limited License. This conclusion is based on a 74 hour constant rate pumping test that GSI performed at Well No. 1 in October 2017. During the test, the pumping rate was 795 gpm (Appendix A). GSI extrapolated the specific capacity vs. time data from the test to estimate a long-term (135 day) specific capacity of 2 gpm/ft at Well No. 1. The 135 day specific capacity was selected to be representative of a 135 day recharge cycle. Assuming a static groundwater level of 15 feet bgs and a well screen depth of 180 feet bgs, Well No. 1 is able to produce 360 gpm when pumping 24 hours per day for 135 days without unsaturating the well screen.

4.1.2 Basalt Well

Rudd Farms' AR project proposes to artificially recharge the CRBG aquifer using the Basalt Well. The Basalt Well is located approximately 510 ft east and 1,430 feet south of the northwest corner of Township 2 South, Range 39 East, Section 20 (see Figure 1).

Existing Construction and Capacity

The Basalt Well is 4,045 feet deep. Construction specifications associated with the Basalt Well (well log and as-built diagram) are included in Appendix G.

The Basalt Well must meet current well construction standards in the OARs to be authorized by OWRD for AR use. GSI reviewed the construction of the Basalt Well (as reported on well log UNIO 52415) to evaluate whether existing well construction meets OAR requirements:

- **Well Seal.** The 22-inch diameter lower borehole is more than four inches in diameter greater than the 16-inch diameter permanent well casing, and is constructed at least 5 feet into bedrock. The annular space between the 16-inch casing and 22-inch borehole is filled with grout. This meets the requirements of OAR 690-210-150.
- **Well Casing.** The Basalt Well casing consists of:

- 24-inch diameter, 0.375-inch gauge steel to 116 feet bgs, and
- 16-inch diameter, 0.375-inch gauge steel from 116 feet bgs to 2,504 feet bgs.

These casing gauges meet the requirements of OAR 690-210-0190(3) for steel casing.

- **Well Liner Pipe.** The Basalt Well is lined from 2,504 to 4,025 feet bgs with 12-inch diameter, 0.250-inch gauge, 0.188-inch slot steel perforated liner, which extends about 33 feet into the permanent casing. This meets the requirements of OAR 690-210-0290.

In summary, the existing construction of the Basalt Well meets current OAR water well construction standards and is sufficient for use as an AR recharge well.

Basalt Well Recharge Capacity

The Basalt Well is capable of meeting a recharge rate target of up to 280 gpm described in this Limited License. This conclusion is based on a 24 hour constant rate pumping test conducted at the Basalt Well in October 2017. The pumping test was conducted at a rate of 522 gpm (Appendix A). GSI extrapolated the specific capacity vs. time data to estimate a long-term (135 day) specific capacity for the Basalt Well of 1.6 gpm/ft. The 135 day specific capacity was chosen to be representative of a 135 day recharge cycle. Assuming a static depth to groundwater ranging between 88 feet bgs[22] and 175 feet bgs[23], the basalt well will accommodate recharge rates ranging from about 140 gpm to 280 gpm when recharging 24 hours a day for 135 days without resulting in a rise in water level above ground surface (assuming that specific capacity during pumping is the same as specific capacity during recharge).

4.2 Proposed AR System Modifications

Before pilot testing, each wellhead will be retrofit for AR operation. The retrofit allows the well to supply water during the summer and to recharge water into the aquifer during the winter. The well is equipped with system controls that allow automatic and manual operation. The wellheads will be situated within a pump house and wellhead facility. A conceptual schematic diagram showing the proposed wellhead assembly and piping for Well No. 1 and the Basalt Well is provided in Appendix H. The retrofits include the following:

- A manganese treatment system, including a reservoir for chlorine, metering pump, injection line, and bag filters to remove precipitated manganese.

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[22] Measured on March 23, 2016

[23] Measured on October 24, 2017

- Piping valves that allow for flushing the distribution system water lines to remove particulates prior to the start of recharge or recovery.
- Piping valves that allow for pump-to-waste during periodic back flushing events.
- Totalizing flow meters that can provide real-time volumetric recharge and recovery data during recharge and recovery.
- Dedicated downhole water level transducers in Well No. 1 and in the Basalt Well so that the performance of the well can be monitored.
- An access port and sounding pipe for manual water level measurements in the Basalt Well and Well No. 1.
- Sampling ports on piping to facilitate collection of water samples during recharge, storage, and recovery, from either the Basalt Well or Well No. 1. The sampling ports will allow sampling of raw source water (pre-manganese treatment) and treated source water (post-manganese treatment).
- Recharge through the existing, vertical lineshaft pump using a non-reverse ratchet to prevent backspin. Flows will be throttled back through the pump bowls to keep the pump column full, to maintain back pressure, and to regulate the recharge rate.

4.3 Plans for Project Construction

Conceptual plans for project construction, including upgrades to Well No. 1, the Basalt Well, and subgrade piping between the wells are provided in Appendix H.

5. Permits and Authorizations

This section identifies the permits and approvals necessary to conduct AR pilot testing and provides documentation that the necessary permits and approvals have either been obtained, requested, or will be obtained before AR pilot testing begins.

5.1 Groundwater Rights

This section provides an overview of the water right permits and limited licensees necessary to extract and recover groundwater for Rudd Farms' proposed AR project.

- **Extraction of Source Water.** The proposed recharge period of Rudd Farms' AR project is from December 1 through April 14. The extraction of source water at Well No. 1 will be authorized by this AR Limited License.

  In no case will the appropriation of groundwater at Well No. 1 for the use of recharge exceed the volume permitted by the AR Limited License. The appropriation of groundwater at Well No. 1 for other permitted uses (i.e. irrigation) outside of the proposed recharge period will comply with the provisions of water right certificate 90977. Rudd Farms' existing groundwater right for Well No. 1 and the alluvial aquifer are provided in Appendix I.

- **Recovery of Recharge Water.** Rudd Farms currently holds a water right permit (G-17020) to pump water at the Basalt Well. This permit will be used to authorize any pumping of the Basalt Well. If Rudd Farms would like to pump water from the Basalt Well beyond the permitted rates and duty as allowed in water rights permit G-17020, Rudd Farms will apply for a Limited License for AR Recovery (and eventually a secondary groundwater permit to recover recharged water) at least one month prior to beginning recovery.

  In no case will Rudd Farms' appropriation and use of groundwater exceed the cumulative rates and dutypermitted by a recovery permit and existing groundwater right (G-17020). Rudd Farms' existing groundwater right for the Basalt Well and CRBG aquifer are provided in Appendix I.

5.2 Underground Injection Control (UIC) Registration

Because Rudd Farms is proposing to conduct AR using a well to conduct recharge, operation and testing requires registration under the DEQ's Underground Injection Control (UIC) program. Appendix J contains a draft UIC registration form. The UIC form will be submitted to DEQ for review and approval after this AR Limited License application is assigned a number by OWRD.

5.3 Land Use Approval

AR operation and testing requires evidence that land use and development approval from the local government is sought, obtained, or unnecessary. Appendix B contains a completed Land Use Information Form for the proposed AR project, including the locations of the extraction/injection wells and the place of use for recharged water. The AR project area is located outside city limits, therefore land use approval is need only from the Union County Planning Department.

6. Monitoring Procedures and QA/QC Plan

This section details the quality assurance and quality control (QA/QC) plan for monitoring that will be performed throughout Rudd Farms' AR project. The objective of this QA/QC plan is to collect water level and water quality data that are valid representations of the conditions at each sampling location.

6.1 General

This section outlines QA/QC procedures that are required for all types of monitoring being performed (i.e., water level or water quality).

Personnel Qualifications

Only personnel that have prior water level/water quality sampling experience or site-specific training in the standards and procedures of this QA/QC plan shall collect monitoring data. GSI will review collected data for completeness and compliance with this plan.

Recordkeeping

The sampling technician will document field observations and measurements on the field form provided in Appendix F. The following information will be recorded on the form for each sampling location:

- Name of person(s) performing monitoring activities
- Date and time of monitoring activities
- Location of monitoring activities
- Description of methodology for performing monitoring activities and any deviations from this QA/QC plan

The field form may be modified in the future to incorporate additional information, or to make the form more user-friendly.

6.2 Manual Water Level Monitoring

Manual Water Level Monitoring Equipment List

The following general list of equipment and materials is required for all monitoring activities, at a minimum:

- Field form (Appendix F)
- Water level meter

- Personal protective equipment (PPE) (i.e., gloves)
- Chlorine bleach solution, spray bottle, and paper towels (to prevent cross-contamination between wells)

To prevent cross-contamination between wells, water level meters will be disinfected in between wells using a chlorine bleach solution.

Manual Water Level Monitoring Procedures

Procedures for water level monitoring at each location will proceed as follows:

1. Don nitrile gloves
2. Record flow rate (instantaneous flow rate and totalizer reading) on the monitoring form in Appendix F
3. Disinfect water level meter using chlorine bleach solution, spray bottle, and paper towels
4. Lower the water level meter tape down the PVC access tube, and measure water level from the top of the tube to the nearest 0.1 foot. Record water level and measurement time on the monitoring form in Appendix F
5. Copy the field forms and send to GSI

6.3 Water Quality Monitoring

Water quality samples will be collected according to the schedule in Table 9 (Cycle 1 of AR) or Table 10 (Cycle 2 to Cycle 5 of AR).

Water Quality Monitoring Equipment List

The following general list of equipment and materials is required for all monitoring activities, at a minimum:

- Water sample containers, coolers, and chain-of-custody (COC) forms
- Field form (Appendix F)
- Ice
- Meters for measuring temperature, conductivity, pH, dissolved oxygen (DO), oxidation reduction potential (ORP), and turbidity
- New tubing
- Personal protective equipment (PPE) (i.e., gloves)
- Distilled water in a spray bottle

To prevent cross-contamination between wells, only new tubing will be used during sampling. Gloves shall be replaced after handling equipment/samples from each location. Water quality meters will be cleaned with distilled water.

Water Quality Monitoring Procedure

The following procedure for water quality monitoring assumes that all sampling will occur in one day:

1. Order bottles from the lab, and find out how many days after sampling that the lab needs the bottles (to meet EPA holding times). Label the bottles before sampling (see "Sample Names" section below).
2. Calibrate meters that will be used during the day's sampling.
3. Turn on pumps in each well for the following durations at the following rates, to ensure that three well volumes of water are removed from the well prior to sampling:
    a. Basalt Well at 500 gpm for 240 minutes (4 hours).
    b. Schwepke Well at 1,100 gpm for 90 minutes (1.5 hours).
    c. Well No. 1 at 800 gpm for 60 minutes (1 hour).
4. After the well has been pumped for the durations in Step 3, collect samples from each well using the following methods:
    a. Record flow rate (instantaneous flow rate and totalizer reading) on the monitoring form in Appendix F.
    b. Measure field parameters [temperature, conductivity, pH, dissolved oxygen (DO), oxidation reduction potential (ORP), and turbidity].
    c. Don nitrile gloves.
    d. Attach new tubing to the well sampling port and fill bottles. Transfer bottles to cooler after filling. Take care to ensure there are no bubbles larger than a pea in 40 milliliter (mL) vials.
    e. Transfer ice into Ziploc bags, ensuring that ice is double-bagged. Place ice in cooler.
    f. Turn off well and dispose of tubing.
5. Complete the chain of custody and send samples to analytical laboratory for analysis. Make sure the laboratory receives the samples by the required date.
6. Copy the field forms and send to GSI.

Sample Names

Samples will be assigned unique names to indicate where and when the sample was collected. The sample name will include the following information:

a. **Well ID:** ID of well being sampled:

Location	Well ID
Well No. 1	W1
Basalt Well	BW
Schwepke Well	SW

b. **Cycle ID:** The current cycle of the AR project:

Cycle	Cycle ID
1	C1
2	C2
3	C3
4	C4
5	C5

c. **Monitoring Date:** The date of the monitoring (month, day, year).

For example, a sample collected from Well No. 1, during Cycle 1, on February 1, 2020, will be "W1-C1-02.01.2020."

Laboratory QA/QC

Samples collected during the pilot testing program will be analyzed by an analytical laboratory certified by the Oregon Environmental Laboratory Accreditation Program (ORELAP).

With respect to water quality monitoring, no duplicate samples will be collected in the field. If laboratory testing results indicate that a parameter has an unexpectedly high concentration approaching applicable regulatory standards (i.e., federal MCL), recharge or recovery will be stopped and the location will be resampled as soon as possible according to the procedures outlined above.

Analytical data will be assessed by GSI to ensure that the specified QA/QC objectives have been met, which includes a review of; COC documentation, holding times, and matrix spikes.

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Figures

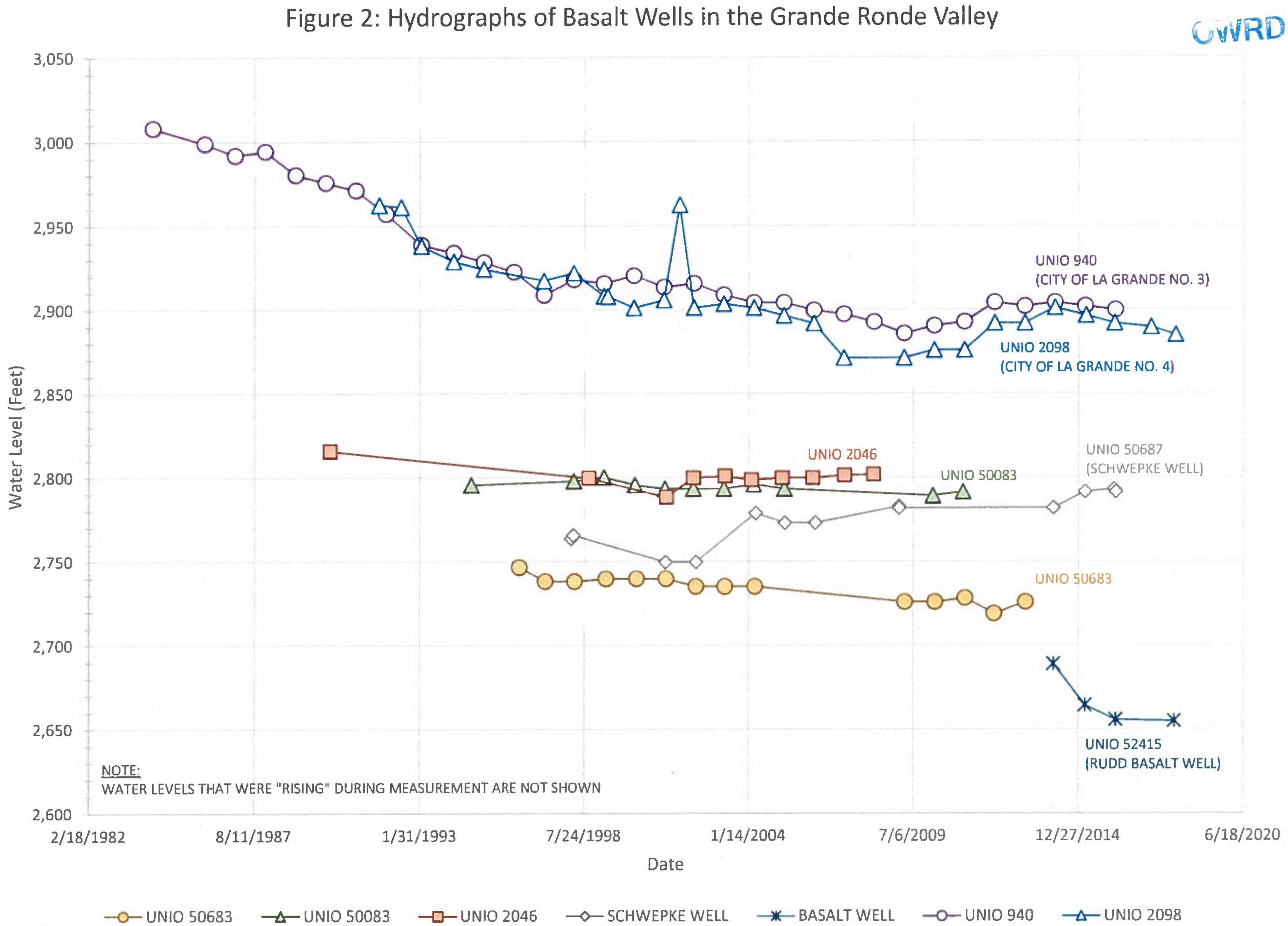

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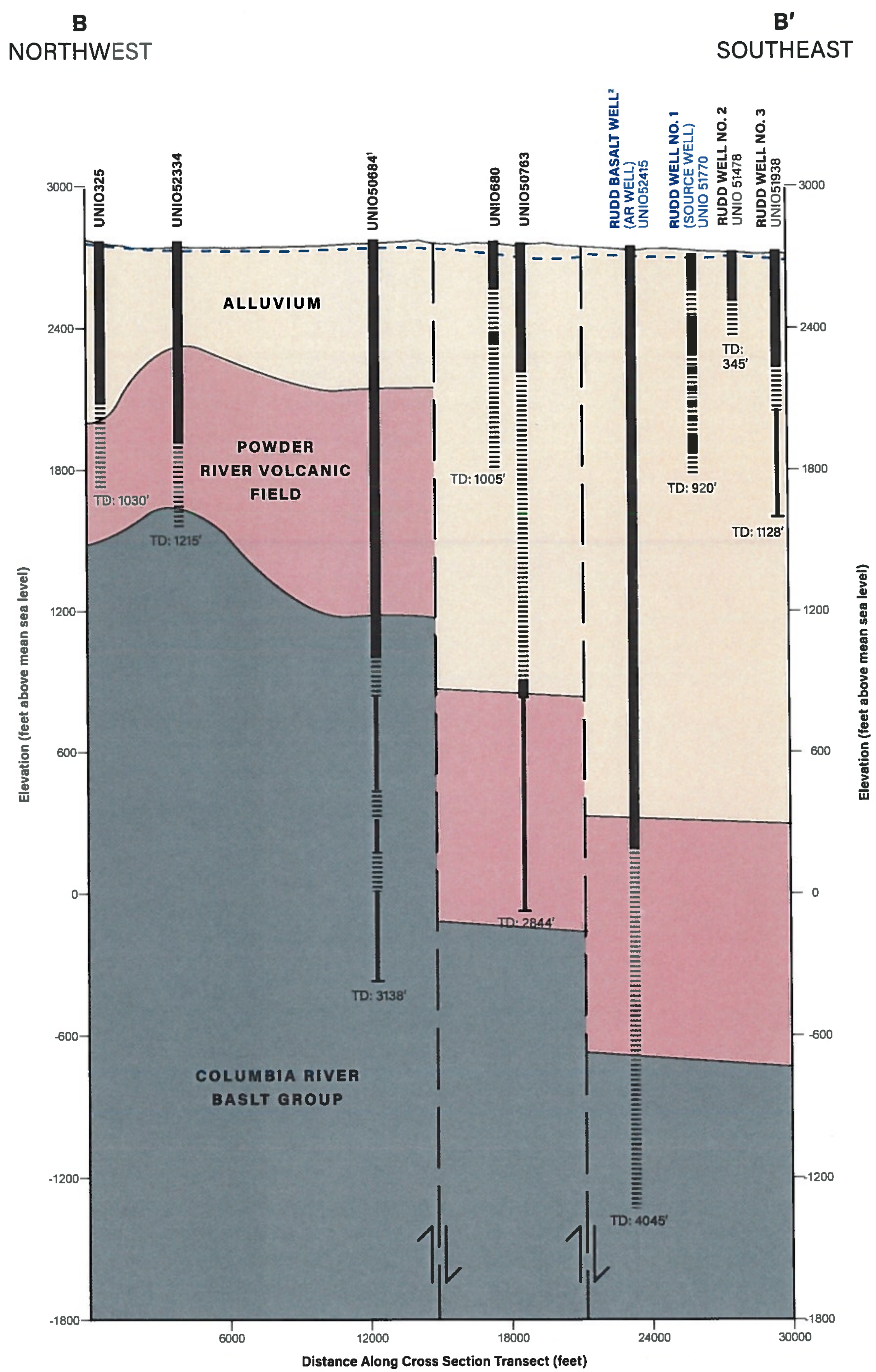
FIGURE 5

Cross Section B-B'

Rudd Farms
AR Limited License Application



LEGEND

- Surface Elevation
- Static Water Level
- Inferred Fault

Well Details

- UNIO Log ID
- Seal
- Perforations/Screen
- Open Borehole
- TD Total Depth

Surficial Geology

Valley-Fill Deposits

- Neogene Sedimentary Rocks and Quaternary Surficial Deposits

Volcanic Rocks

- Powder River Volcanic Field
- Columbia River Basalt Group

NOTES:

Fault(s) between UNIO50684 and UNIO52415 inferred by Ferns E. Al (2017)

1. Lithology contact locations and depths provided by DOGAMI Bulletin 107 (2016)
2. Lithology contact locations and depths provided by Ferns et. al (2017)

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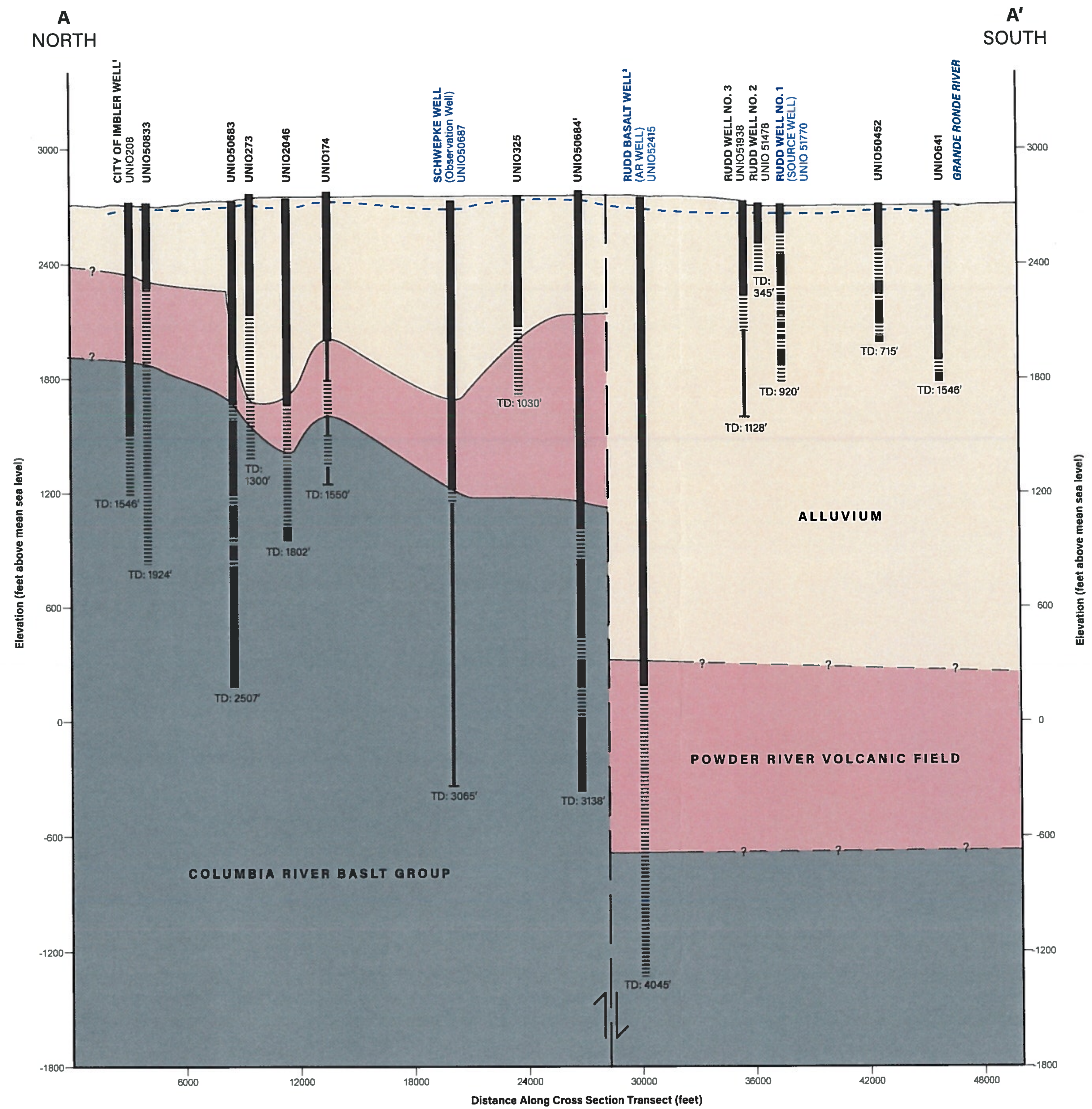

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FIGURE 4

Cross Section A-A'

Rudd Farms
AR Limited License Application

LEGEND

- Surface Elevation
- Static Water Level
- Inferred Fault

Well Details

- Log ID
- Seal
- Perforations/Screen
- Open Borehole
- TD Total Depth

Surficial Geology

Valley-Fill Deposits

- Neogene Sedimentary Rocks and Quaternary Surficial Deposits

Volcanic Rocks

- Powder River Volcanic Field
- Columbia River Basalt Group

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Fault(s) between UNIO50684 and UNIO52415 inferred by Ferns E. Al (2017)

1. Lithology contact locations and depths provided by DOGAMI Bulletin 107 (2016)
2. Lithology contact locations and depths provided by Ferns et. al (2017)

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Tables

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Table 8. Water Qality Monitoring Analyte List

Rudd Farms AR Limited License Application

Analyte	**Full Suite** (Group A) *Start of Recharge*	**Mixing Indicators** (Group B) *End of Recharge* *Middle of Recharge*	**Treatment Effectiveness** (Group C) *Monthly During Recharge*
Geochemical			
Bicarbonate as $CaCO_3$	X	X	
Calcium	X	X	
Carbonate as $CaCO_3$	X	X	
Chloride	X	X	
Cyanide (Total)	X		
Fluoride	X	X	
Hardness (as $CaCO_3$)	X		
Langelier Saturation Index	X		
Magnesium	X	X	
Nitrite as N	X		
Nitrate as N	X		
Potassium	X	X	
Silica	X		
Sodium (Total)	X	X	
Sulfate	X	X	
Total Alkalinity	X		
Total Organic Carbon	X		
Total Suspended Solids	X		
Metals			
Antimony (Total)	X		
Aluminum (Total	X		
Arsenic (Total)	X		
Barium (Total)	X	X	
Beryllium (Total)	X		
Cadmium (Total)	X		
Chromium (Total)	X		
Copper (Total)	X		
Iron (Total)	X	X	
Lead (Total)	X		
Manganese (Total)	X	X	X
Mercury (Total)	X		
Nickel (Total)	X		
Selenium (Total)	X		
Silver (Total)	X		
Thallium (Total)	X		
Zinc (Total)	X		
Disinfection By-Products			
Chloroform (Trichloromethane)	X		X
Bromodichloromethane	X		X
Bromoform (Tribromomethane)	X		X
Dibromochloromethane	X		X
Total Trihalomethanes	X		X
Bromochloroacetic Acid	X		X
Dibromoacetic Acid	X		X
Dichloroacetic Acid	X		X
Monobromoacetic Acid	X		X
Monochloroacetic Acid	X		X
Trichloroacetic Acid	X		X
Total Haloacetic Acids	X		X
Synthetic Organic Compounds (SOCs)			
2, 4-D	X		
2, 4, 5-TP (Silvex)	X		
Alachlor (Alanex)	X		
Atrazine	X		
Benzo(a)Pyrene	X		
BHC-gamma (Lindane)	X		
Carbofuran	X		
Chlordane	X		
Dalapon	X		
Di(2-ethylhexyl)adipate *(adipates)*	X		
Di(2-ethylhexyl)phthalate *(phthalates)*	X		
Dibromochloropropane (DBCP)	X		
Dinoseb	X		

Analyte	Full Suite (Group A) *Start of Recharge*	Mixing Indicators (Group B) *End of Recharge Middle of Recharge*	Treatment Effectiveness (Group C) *Monthly During Recharge*
Diquat	X		
Ethylene Dibromide (EDB)	X		
Endothall	X		
Endrin	X		
Glyphosate	X		
Heptachlor	X		
Heptachlor Epoxide	X		
Hexachlorobenzene (HCB)	X		
Hexachlorocyclopentadiene	X		
Methoxychlor	X		
Pentachlorophenol	X		
Picloram	X		
Simazine	X		
Total Polychlorinated Biphenyls (PCBs)	X		
Toxaphene	X		
Vydate (Oxamyl)	X		
Volatile Organic Compounds (VOCs)			
1, 1-Dichloroethylene	X		
1, 2-Dichloroethane (EDC)	X		
1, 2-Dichloropropane	X		
1, 2 ,4-Trichlorobenzene	X		
1, 1, 1-Trichloroethane	X		
1, 1, 2-Trichloroethane	X		
Benzene	X		
Chlorobenzene (monochlorobenzene)	X		
cis-1,2-Dichloroethylene	X		
Ethylbenzene	X		
Methylene Chloride	X		
Styrene	X		
Tetrachloroethylene (PCE)	X		
Toluene	X		
Total Xylenes	X		
trans-1,2-Dichloroethylene	X		
Trichloroethylene (TCE)	X		
Vinyl chloride	X		
Radionuclides			
Alpa, Gross	X		
Beta, Gross	X		
Radium 226	X		
Radium 228	X		
Uranium	X		

GSI Water Solutions, Inc.

Appendix A: GSI Technical Memorandum: Phase II ASR Fatal Flaws Analysis and Next Steps

Water Solutions, Inc.

Technical Memorandum

To: Brett Rudd / Rudd Farms

From: Matt Kohlbecker, RG / GSI Water Solutions, Inc.
Jason Melady, RG / GSI Water Solutions, Inc.

Date: March 16, 2018

Re: **Phase II ASR Fatal Flaws Analysis and Next Steps**

Executive Summary

Rudd Farms is evaluating whether Aquifer Storage and Recovery (ASR) can be used to supplement natural recharge to the basalt aquifer and stabilize the groundwater level in the Farm's 4,045 foot deep basalt well (called the "Basalt Well" in this memo). The ASR concept at Rudd Farms involves using groundwater from the alluvial aquifer to recharge the Basalt Well during the winter (December through March), and recovering the water in the summer for irrigation. Rudd Farms retained GSI Water Solutions, Inc. (GSI) to evaluate whether there are any fatal flaws to using ASR.

The fatal flaws analysis consists of two phases. In Phase I of the fatal flaws analysis, GSI met with the Oregon Water Resources Department (OWRD) and did not find any fatal flaws from the perspective of water rights permitting (that is, Rudd Farms should be able to obtain a winter time groundwater right to pump alluvial groundwater from Well No. 1, Well No. 2, and Well No. 3[1]). This technical memorandum documents Phase II of the fatal flaws analysis, which involves determining if there are any fatal flaws to ASR from the perspectives of groundwater quality, the volume of water that can be stored in the basalt aquifer, interference with other wells (i.e., unacceptable water level rise in the basalt aquifer during recharge), and adverse effects caused by mixing source water from alluvial wells with native groundwater in the Basalt Well. We did not find any fatal flaws to ASR during the Phase II analysis. However, we did identify some challenges that may have significant implications for cost, and thus overall feasibility. Specifically, because manganese concentrations in alluvial groundwater exceed ASR standards, the alluvial groundwater will need to be treated prior to recharging the Basalt Well. We estimate that Rudd Farms can begin recharge in January 2020, assuming OWRD processes the required permits by August 2019.

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[1] See GSI (2017)

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The following sections provide an overview of the Phase II ASR fatal flaws analysis. Detailed technical information about is presented in Attachment A through Attachment E.

Background

Rudd Farms currently operates four irrigation wells at its properties in La Grande, Oregon. A fifth well (Well No. 2) is not currently used for irrigation purposes but may be modified and used for irrigation in the future. Table 1 summarizes information about each well, including the well name, well depth, water rights, and the aquifer in which each well is completed.

Table 1. Rudd Farms Groundwater Wells.

Well Name	Well Depth (feet bgs)	Water Right(s)	Aquifer
Well No. 1 (UNIO 51770/51835)	920	90977	Quaternary-Late Tertiary Sediment Aquifers [1]
Well No. 2 (UNIO 51478)	345	90977	Quaternary-Late Tertiary Sediment Aquifers [1]
Well No. 3 (UNIO 51938)	1,128	90977	Quaternary-Late Tertiary Sediment Aquifers [1]
Schwepke Well (UNIO 50687)	3,065	Permit G-17361 Permit G-16509 (sup) Permit G-12399 (sup)	CRBG - Grande Ronde Basalt [1]
Basalt Well (UNIO 52415)	4,045	Permit G-17020	Powder River Volcanics [2] CRBG - Wanapum Basalt [2] CRBG - Grande Ronde Basalt [2]

NOTE:
bgs = below ground surface   CRBG = Columbia River Basalt Group   sup = supplemental
(1) From OWRD (2017a)
(2) From McClaughry and Van Tassell (2013)

Since the Basalt Well was drilled in 2014, it has experienced declines in groundwater levels and groundwater production. Specifically, the depth to groundwater in the spring of 2014 was 55 feet below ground surface (bgs), and the well produced 800 gallons per minute (gpm)[2]. By spring of 2016, the depth to groundwater had declined to 88 feet bgs[3], and the well production had declined to 500 gpm[4]. Per the conditions of the water right permit for the Basalt Well, the falling water levels may trigger a reduction in rate or volume withdrawn from the well, or may result in use of the well being discontinued by OWRD.

The declining water levels in the Basalt Well indicate that natural recharge may not be sufficient to fully replenish the basalt aquifer after irrigation season pumping. Rudd Farms is considering using ASR to supplement natural recharge and stabilize water levels so that the Basalt Well can serve as a long-term sustainable groundwater supply source. The ASR concept at Rudd Farms involves pumping groundwater from alluvial wells (Well No. 1, a modified Well No. 2, or Well No.

2 See the well log for UNIO 52415.
3 Water level measurement on March 23, 2016, available online from the OWRD Groundwater Site Information System (OWRD, 2017a).
4 Based on communications with Brett Rudd in June 2017.

3) and using it to recharge the Basalt Well during the winter (December through March). During the summer, the water will be recovered from the Basalt Well for irrigation purposes. In this memo, alluvial groundwater from Well No. 1, Well No. 2, and Well No. 3 is called "source water," groundwater in the Basalt Well is called "native groundwater," and the basalt well is called the "ASR Well."

Fatal Flaws Analysis

There are several criteria for a successful ASR project. The source water and native groundwater must be geochemically compatible and must meet water quality standards set by OWRD and the Department of Environmental Quality (DEQ). In addition, the receiving aquifer must be capable of storing enough water, and recharge cannot adversely impact other wells by causing an unacceptable amount of water level rise. If a proposed ASR project does not meet these criteria, then we consider the ASR project to be fatally flawed. Therefore, the first step when considering ASR is to conduct a fatal flaws analysis. This memo presents an evaluation of the following potential fatal flaws to ASR, including:

- **Source Water Quality.** Source water must meet water quality standards set forth in Oregon's ASR rules[5], and must not degrade groundwater quality[6]. Source water quality is a potential fatal flaw to ASR because if the source water cannot meet ASR water quality standards or would degrade groundwater, then the groundwater must be treated prior to recharge, which may be technologically infeasible or cost-prohibitive. In this memo, we compare source water quality data to ASR standards and native groundwater quality data in order to determine if source water quality meets the applicable water quality standards, and does not degrade native groundwater.

- **Storage Volume.** The volume of water that can be stored in an ASR well is a function of the time available for recharge, headroom available for water level buildup in the ASR Well, the specific capacity of the ASR Well (amount of water level rise per gallon per minute of water that is recharged), and the ASR well's production rate. Storage volume is a potential fatal flaw to ASR because the Basalt Well must be able to store enough groundwater during recharge to meet the project objective of stabilizing groundwater levels in the Basalt Well. In this memo, we estimate the volume of water that can be recharged during the winter, and compare it to the volume of water that has been pumped from the Basalt Well during past irrigation seasons in order to assess whether enough water can be stored in the Basalt Well to stabilize water levels.

- **Geochemical Compatibility Source Water and Native Groundwater.** Mixing between different waters (source water and native groundwater) may produce adverse effects (for example, precipitation of minerals that could clog the ASR well). In this memo, we used a geochemical mixing model (PHREEQC) to predict whether mixing alluvial groundwater and native groundwater is likely to produce adverse effects.

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[5] See Oregon Administrative Rules 690-350-0020
[6] See Oregon Administrative Rules 340-040

- **Interference With Other Wells.** Recharging the Basalt Well will cause groundwater levels in the basalt aquifer to rise. The water level rise in the basalt aquifer may cause water levels in other basalt wells to rise. If the water level rise in other wells is too large, then the water level rise could be a fatal flaw to ASR. In this memo, we located other basalt wells within five miles of Rudd Farms and used an analytical equation (the Cooper Jacob equation) to predict the amount of water level rise that recharge will cause in the wells.

In October 2017, GSI collected groundwater quality and well performance data from Well No. 1 and the Basalt Well with the objective of evaluating these potential fatal flaws to ASR. Technical details about the data collection in October 2017 are provided in Attachment A. The following sections present an overview of GSI's fatal flaws evaluation.

Source Water Quality

Analysis

GSI collected a native groundwater sample from the Basalt Well on October 17, 2017, and collected a source water quality sample from Well No. 1 on October 18, 2017. The samples were submitted to Eurofins Laboratories (Monrovia, California) for analysis of constituents with ASR standards and common groundwater contaminants. Laboratory results, and the regulatory standards that source water quality must meet, are provided in Table 1. Red text in Table 1 indicates that a constituent in source water exceeds a regulatory standard. We make two conclusions from these water quality analyses:

- **Source Water Treatment Will Be Required Due to Manganese.** With the exception of manganese, all water quality constituents in source water are below ASR standards. Manganese was detected at a concentration of 0.14 milligrams per liter (mg/L), which is above the ASR standard of 0.05 mg/L. In addition, the manganese concentration in source water is higher than the manganese concentration in native groundwater (0.0046 mg/L). In order to determine if the high manganese concentration at Well No. 1 was a local phenomenon, Brett Rudd collected a second water quality sample on December 21, 2017, from his alluvial domestic well and submitted it to Anatek Labs (Moscow, Idaho) for analysis. Manganese was detected in the alluvial domestic well at a concentration of 0.575 mg/L. Based on the detections of manganese in multiple alluvial wells, we conclude that the alluvial aquifer at Rudd Farms (and likely in the La Grande Valley) is characterized by high manganese concentrations.

  High levels of manganese are not a fatal flaw to ASR because source water can be treated to remove manganese. In typical ASR projects, manganese treatment involves aeration of the water to precipitate the manganese, and/or chlorination. We have obtained a cost estimate from Anderson Perry Engineers (La Grande, Oregon) to conduct a pilot test to determine the feasibility and costs of manganese treatment, and included it in Attachment B. Anderson Perry estimates a cost for the pilot study of $10,000 to $15,000, excluding direct reimbursable expenses.

- **Source Water Will Not Degrade Groundwater.** With the exception of manganese, constituent concentrations in source water are either less than, or about the same as, constituents in native groundwater.

Conclusion

In summary, there are no fatal flaws to ASR from the perspective of source water quality. However, manganese concentrations in source water pose a challenge to ASR at Rudd Farms because the manganese will need to be removed prior to injection.

Storage Volume

Analysis

If the ASR project is to achieve the goal of stabilizing water level declines in the basalt well, then the volume of water that can be stored in the Basalt Well during the winter should be the same order of magnitude as the volume of water that is pumped from the Basalt Well during the summer. We evaluated whether the storage volume is a fatal flaw to ASR by comparing the volume of water that has been pumped from the Basalt Well during past irrigation seasons to the volume of water that we anticipate can be stored in the Basalt Well during the winter. Detailed calculations for the analysis are presented in Attachment C. Our analysis finds that:

- The volume of water pumped from the Basalt Well during past irrigation seasons ranges from about 75 acre-feet (24.4 million gallons or MG) to 277 acre-feet (90 MG) (OWRD, 2017b)[7].

- The volume of water that we estimate can be stored in the basalt well during the winter is about 113 acre-feet (36.8 MG). This volume assumes recharge from December 1 through March 31, an average recharge rate of 210 gallons per minute (gpm), and a Basalt Well specific capacity of 1.6 gpm/ft.

Conclusion

Because the volume of the water that can be stored in the Basalt Well during the winter is the same order of magnitude as the volume of water pumped from the Basalt Well during past irrigation seasons, we find that storage volume is not a fatal flaw to ASR at Rudd Farms.

Mixing Between Source Water and Native Groundwater

Analysis

S.S. Papadopulos & Associates, Inc. (SSPA) evaluated the potential for mixing between source water and native groundwater to cause adverse effects like mineral precipitation that could clog the Basalt Well. The evaluation was based on the PHREEQC geochemical mixing model. The SSPA memorandum is provided in Attachment D. SSPA predicts that a mixture of source water and native groundwater would be saturated or supersaturated in silica minerals (quartz and chalcedony), carbonate minerals (calcite, dolomite), and iron and manganese minerals (iron hydroxide, pyrolusite, bixbyite, and hausmannite). This means that these minerals have a

[7] During the 2017 water year, 75 ac-ft was pumped from the Basalt Well; during the 2014 water year, 277 ac-ft was pumped from the Basalt Well.

tendency to precipitate. However, SSPA believes it is unlikely that silica minerals and calcite minerals would precipitate because precipitation kinetics of silica are extremely slow, and calcite precipitation requires a high nucleation energy. Iron and manganese precipitation is possible but will become less likely once the concentrations of iron and manganese are reduced due to treatment of manganese in source water. Additionally, at the current concentrations, the amount of precipitate is likely to be small based on iron and manganese concentrations at other ASR systems.

Conclusion

We find that the potential for adverse affects to the Basalt Well (e.g., precipitation of minerals in the well) is unlikely to occur when native basalt groundwater and source water are mixed. Therefore, there are no fatal flaws to ASR from the perspective of mixing between native basalt groundwater and source water.

Interference With Other Wells

Analysis

Basalt wells within about five miles of Rudd Farms' Basalt Well were identified using OWRD's online well log database (OWRD, 2018), and are shown in Table 2. With the exception of UNIO 50763, other wells completed in the basalt aquifer are artesian. The artesian pressures range from 20.98 to 59.83 feet of water (about 9.1 to 25.9 psi). Artesian wells are likely hydraulically isolated from the Basalt Well (because the Basalt Well is not artesian).

Table 2. Basalt Wells Within About 5 Miles of Rudd Farms

Well ID	Well Depth (feet bgs)	Distance From Basalt Well (miles)	Water Level[1] (feet bgs)	Measurement Date	Location[2]		Aquifer
					Latitude	Longitude	
UNIO 50687	3,065	2.0	-53.13	3/23/2016	45.409334	-117.968123	CRBG-GR
UNIO 50684	3,138	2.1	-30.03	3/24/2008	45.398910	-118.006808	
UNIO 50763	2,844	1.1	59*	1/31/1994	45.383124	-117.994035	
UNIO 208	1,546	5.3	-87.78*	12/12/1987	45.457511	-117.963722	CRBG-GR
UNIO 271	1,191	4.3	-28.41	3/7/2017	45.442865	-117.978165	CRBG-GR
UNIO 273	1,300	4.3	-16.17*	7/12/1977	45.442786	-117.978141	
UNIO 2046	1,802	3.7	-59.83	3/10/2008	45.433774	-117.964555	CRBG-GR
UNIO 50683	2,507	4.2	-20.98	3/28/2013	45.434689	-117.933597	CRBG
UNIO 50833	1,924	5.3	-50.51	3/10/2017	45.456536	-117.970202	CRBG-GR
UNIO 325	1,030	4.4	Artesian*	12/10/1964	45.418584	-118.042919	
UNIO 52334	1,215	4.1	-49.51	3/23/2017	45.401000	-118.050380	
UNIO 173	1,394	4.4	-55.46	4/5/2016	45.438564	-118.009197	CRBG
UNIO 174	1,550	4.3	-36.96	11/25/1965	45.440591	-117.996698	

NOTES:

(1) Water levels are from permit-required monitoring as documented on the OWRD Groundwater Site Information System, except for water levels marked with "*", which were measured at the time of well installation by the driller.

(2) From OWRD Groundwater Site Information System, except for UNIO 273, UNIO 325, which is based on PLSS and aerial photographs (if the well could be identified on an aerial photograph).

CRBG – GR = Columbia River Basalt Group – Grande Ronde Formation

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We conservatively assume the worst-case condition that the Rudd Farms Basalt Well is hydraulically connected to all basalt wells within 5 miles of Rudd Farms, and used the Cooper

Jacob equation to predict the maximum amount of water level rise in these wells caused by recharging the Basalt Well, under the following assumptions:

- Rudd Farms continuously recharges from December 1 through March 31 (121 days).
- Water is recharged at a rate of 280 gpm. This is likely the maximum possible recharge rate; we estimate that the average recharge rate will be closer to 140 gpm, see Attachment C. Recharging at a higher rate is conservative because it produces larger estimates of water level rise.
- The storativity of the basalt aquifer is 0.00005[8], and the transmissivity is 27,089 gpd/ft[9].

Cooper Jacob Equation calculations are provided in Attachment E. We predict that the maximum buildup in response to ASR (about 7.6 feet) occurs at UNIO 50763 (which is not artesian). We predict that the artesian wells will experience an additional buildup in response to ASR of 1.7 to 2.7 psi (i.e., about 3.9 to 6.2 feet of water).

Conclusion

Because the groundwater level at UNIO 50763 is 59 feet below ground surface, the predicted 7.6 feet of buildup will not cause the adverse affect of groundwater levels rising above ground surface at the well. The pressure increase at artesian basalt wells within 5 miles of Rudd Farms is slight, and we anticipate that the well seals are built to accommodate this slight pressure increase. Therefore, the potential for adverse impacts to other basalt wells does not pose a fatal flaw to ASR at Rudd Farms.

Conclusions and Recommendations

We did not identify any fatal flaws to ASR as a part of this Phase II evaluation. However, we did identify some challenges to ASR that will need to be overcome to successfully implement ASR. We recommend the following next steps to implement ASR at Rudd Farms, in the following order and according to the following schedule, with the objective of beginning recharge during the winter of 2020:

- **Water Rights Permitting (Currently Ongoing).** OWRD requires that Rudd Farms obtain a winter time (December to February) water rights permit for Well No. 1, Well No. 2 and Well No. 3. OWRD processes groundwater permit applications in approximately 12 to 18 months. Assuming Rudd Farms applies for a groundwater permit in March 2018, the water right will be issued by August 2019.

[8] Storativity of the Columbia River Basalt Group in Salem, Oregon (see Golder, 1996).

[9] The transmissivity at the Basalt Well based on a time-drawdown analysis is 1,210 gpd/ft (Attachment A). However, using this transmissivity for the CRBG aquifer in the Cooper Jacob equation results in a drawdown of 785 feet in the Basalt Well after 24 hours of pumping, which is unrealistic. The transmissivity calculated from the Basalt Well test is therefore biased low because of well inefficiencies. Razack and Huntley (1991) provides an equation for calculating transmissivity from specific capacity based on an empirical relationship between transmissivity and specific capacity derived from 215 wells. Using Razack and Huntley (1991), we find that the transmissivity of the Basalt Well is 27,089 gpd/ft. Using this value in the Cooper Jacob equation produces a drawdown of about 44 feet in the Basalt Well after 26 hours of pumping, which agrees reasonably well with the observed drawdown of 100 feet (assuming the Basalt Well is 44 percent efficient).

- **Manganese Removal Pilot Test (May 2018).** The first step for designing a manganese treatment system is to conduct a pilot test to determine the feasibility of treatment and a planning level cost for full-system implementation.

- **Additional Groundwater Sampling (May 2018).** We recommend that Rudd Farms sample Well No. 3 for manganese, and Well No. 1 for bacteriological parameters. The manganese results from Well No. 3 will inform the potential of using Well No. 3 as source water, and the bacteriological analysis of Well No. 1 will inform the ASR system engineering design (e.g., chlorine treatment to manage bacterial populations). This sampling can be done at the same time as the Manganese Removal Pilot test.

- **ASR Limited License (June to August, 2018).** OWRD requires an ASR Limited License to inject water into the Basalt Well. OWRD processes ASR Limited License applications in 12 months (i.e., issue in August 2019). We recommend applying for an ASR Limited License if the manganese treatment pilot test indicates manganese removal is feasible and cost effective.

- **Engineering Design (Summer 2019 to December 2019).** If OWRD issue the ASR Limited License and water rights, Rudd Farms can begin the engineering design and construction of the ASR system. The engineering design would begin in Summer 2019 and would involve wellhead modifications for backflushing, full-scale manganese treatment system, bi-directional flowmeters, the need for a down-hole flow control valve, etc.). Wellhead modifications would occur in October to December of 2019 (after the 2019 irrigation season) and involve pulling the pump to assess well integrity and remove drip oil (which can be a food source for bacteria during injection), and constructing pump-to-waste facilities.

- **Cycle 1 of ASR (January 2020 to October 2020).** Cycle 1 of ASR involves recharge during the winter, storage, and recovery during the irrigation season. The ASR Limited License will require sampling of native groundwater, source water, and stored water, and Rudd Farms will track water levels in the basalt well closely during recharge for any signs of adverse affects like clogging.

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Table 1
Laboratory Analytical Results
Rudd Farms - Phase II ASR Evaluation

Sample Location / *Lab*	Rudd Farms / Eaton Analytical			**Source Water** Well No. 1 10/18/2017	**Native Groundwater** Basalt Well 10/17/2017
	Standard	**Criteria**	**Unit**		
Geochemical and Inorganic Constituents					
Alkalinity			mg/L	120	140
Antimony (Dissolved)			mg/L	< 0.01	< 0.001
Antimony (Total)	0.006	MCL	mg/L	< 0.01	< 0.001
Aluminum (Dissolved)			mg/L	< 0.02	< 0.02
Aluminum (Total	0.05 - 0.2	SMCL	mg/L	< 0.02	< 0.02
Arsenic (Dissolved)			mg/L	0.0015	0.0026
Arsenic (Total)	0.01	MCL	mg/L	0.0015	0.0024
Barium (Dissolved)			mg/L	0.077	0.015
Barium (Total)	2	MCL	mg/L	0.079	0.015
Beryllium (Dissolved)			mg/L	< 0.001	< 0.001
Beryllium (Total)	0.004	MCL	mg/L	< 0.001	< 0.001
Bicarbonate as $CaCO_3$			mg/L	140	160
Cadmium (Dissolved)			mg/L	< 0.0005	< 0.0005
Cadmium (Total)	0.005	MCL	mg/L	< 0.0005	< 0.0005
Calcium (Dissolved)			mg/L	17	< 1
Calcium (Total)			mg/L	18	< 1
Carbonate as $CaCO_3$			mg/L	< 2	6.6
Chloride	250	SMCL	mg/L	1.2	15
Chromium (Dissolved)			mg/L	< 0.001	< 0.001
Chromium (Total)	0.1	MCL	mg/L	< 0.001	< 0.001
Copper (Dissolved)			mg/L	< 0.002	< 0.002
Copper (Total)	1.3	MCL	mg/L	0.0036	< 0.002
Cyanide (Total)	0.2	MCL	mg/L	0.045	0.066
Fluoride (Total)	2	MCL, MML, SMCL	mg/L	0.2	3.1
Hardness (as $CaCO_3$)			mg/L	73	< 3
Iron (Dissolved)			mg/L	0.13	< 0.02
Iron (Total)	0.3	SMCL	mg/L	0.16	< 0.02
Langelier Index - 25 degree				0.18	-0.76
Lead (Dissolved)			mg/L	< 0.0005	< 0.0005
Lead (Total)	0.015	MCL	mg/L	0.00087	< 0.0005
Magnesium (Dissolved)			mg/L	6.9	< 0.1
Magnesium (Total)			mg/L	6.9	< 0.1
Manganese (Dissolved)			mg/L	0.15	0.0046
Manganese (Total)	0.05	SMCL	mg/L	**0.14**	0.0046
Mercury (Dissolved)			mg/L	< 0.0002	< 0.0002
Mercury (Total)			mg/L	< 0.0002	< 0.0002
Nitrite as N	1	MCL	mg/L	< 0.05	< 0.05
Nitrate as N	10	MCL	mg/L	< 0.1	< 0.1
Nickel (Dissolved)			mg/L	< 0.005	< 0.005
Nickel (Total)			mg/L	< 0.005	< 0.005
pH of CaCO3 saturation			--	8.03	8.65
Potassium (Dissolved)			mg/L	4	4.5
Potassium (Total)			mg/L	4	4.7
Selenium (Dissolved)			mg/L	< 0.005	< 0.005
Selenium (Total)			mg/L	< 0.005	< 0.005
Silica (Dissolved)			mg/L	60	110
Silica (Total)			mg/L	53	110
Silver (Dissolved)			mg/L	< 0.0005	< 0.0005
Silver (Total)			mg/L	< 0.0005	< 0.0005
Sodium (Dissolved)			mg/L	20	74
Sodium (Total)			mg/L	20	77
Sulfate	250	SMCL	mg/L	1.7	9.3
Total Nitrate-Nitrite			mg/L	< 0.1	< 0.1
Thallium (Dissolved)			mg/L	< 0.001	< 0.001
Thallium (Total)	0.002	MCL	mg/L	< 0.001	< 0.001
Total Dissolved Solids	500	SMCL	mg/L	180	260
Total Hardness			mg/L	73	< 3
Total Organic Carbon			mg/L	0.5	0.97
Total Suspended Solids			mg/L	< 10	< 10
Zinc (Dissolved)			mg/L	< 0.02	< 0.02
Zinc (Total)	5	SMCL	mg/L	< 0.02	< 0.02

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Sample Location / Lab	Rudd Farms / Eaton Analytical Standard	Criteria	Unit	Source Water Well No. 1 10/18/2017	Native Groundwater Basalt Well 10/17/2017
Disinfection By-Products					
Chloroform (Trichloromethane)			ug/L	< 0.5	< 0.5
Bromodichloromethane			ug/L	< 0.5	< 0.5
Bromoform (Tribromomethane)			ug/L	< 0.5	< 0.5
Dibromochloromethane			ug/L	--	--
Total Trihalomethanes	80	MCL, MML	ug/L	--	--
Bromochloroacetic Acid	*	*	ug/L	--	--
Dibromoacetic Acid			ug/L	--	--
Dichloroacetic Acid			ug/L	--	--
Monobromoacetic Acid			ug/L	--	--
Monochloroacetic Acid			ug/L	--	--
Trichloroacetic Acid			ug/L	--	--
Total Haloacetic Acids	60	MCL	ug/L	--	--
Synthetic Organic Compounds (SOCs)					
2, 4-D	70	MCL, MML	ug/L	< 0.1	< 0.1
2, 4-DB			ug/L	< 2	< 2
2, 4, 5-T			ug/L	< 0.2	< 0.2
2, 4, 5-TP (Silvex)	10	MCL, MML	ug/L	< 0.2	< 0.2
3, 5-Dichlorobenzoic acid			ug/L	< 0.5	< 0.5
3-Hydroxycarbofuran			ug/L	< 0.5	< 0.5
Acifluorfen			ug/L	< 0.2	< 0.2
Alachlor (Alanex)	2	MCL	ug/L	< 0.1	< 0.1
Aldicarb (temik)			ug/L	< 0.5	< 0.5
Aldicarb sulfone			ug/L	< 0.5	< 0.5
Aldicarb sulfoxide			ug/L	< 0.5	< 0.5
Aldrin			ug/L	< 0.01	< 0.01
Atrazine	3	MCL	ug/L	< 0.05	< 0.05
Baygon			ug/L	< 0.5	< 0.5
Bentazon			ug/L	< 0.5	< 0.5
Benzo(a)Pyrene	0.2	MCL	ug/L	< 0.02	< 0.02
BHC-gamma (Lindane)	0.2	MCL, MML	ug/L	< 0.01	< 0.01
Carbaryl			ug/L	< 0.5	< 0.5
Carbofuran	40	MCL	ug/L	< 0.5	< 0.5
Chlordane	2	MCL	ug/L	< 0.1	< 0.1
Dalapon	200	MCL	ug/L	< 1	< 1
Di(2-ethylhexyl)adipate *(adipates)*	400	MCL	ug/L	< 0.6	< 0.6
Di(2-ethylhexyl)phthalate *(phthalates)*	6	MCL	ug/L	2.4	**7.6**
Dibromochloropropane (DBCP)	0.02	MCL	ug/L	< 0.01	< 0.01
Dicamba			ug/L	< 0.1	< 0.1
Dichlorprop			ug/L	< 0.5	< 0.5
Dieldrin			ug/L	< 0.01	< 0.01
Dinoseb	7	MCL	ug/L	< 0.2	< 0.2
Diquat	20	MCL	ug/L	< 0.4	< 0.4
Ethylene Dibromide (EDB)	0.05	MCL	ug/L	< 0.01	< 0.01
Endothall	100	MCL	ug/L	< 5	< 5
Endrin	0.2	MCL, MML	ug/L	< 0.01	< 0.01
Glyphosate	700	MCL	ug/L	< 6	< 6
Heptachlor	0.4	MCL	ug/L	< 0.01	< 0.01
Heptachlor Epoxide	0.2	MCL	ug/L	< 0.01	< 0.01
Hexachlorobenzene (HCB)	1	MCL	ug/L	< 0.05	< 0.05
Hexachlorocyclopentadiene	50	MCL	ug/L	< 0.05	< 0.05
Methomyl			ug/L	< 0.5	< 0.5
Methoxychlor	40	MCL, MML	ug/L	< 0.05	< 0.05
Methiocarb			ug/L	< 0.5	< 0.5
Molinate			ug/L	< 0.1	< 0.1
Paraquat			ug/L	< 2	< 2
Pentachlorophenol	1	MCL	ug/L	< 0.04	< 0.04
Picloram	500	MCL	ug/L	< 0.1	< 0.1
Simazine	4	MCL	ug/L	< 0.05	< 0.05
Thiobencarb (ELAP)			ug/L	< 0.2	< 0.2
Total Polychlorinated Biphenyls (PCBs)	0.5	MCL	ug/L	< 0.1	< 0.1
Toxaphene	3	MCL, MML	ug/L	< 0.5	< 0.5
Vydate (Oxamyl)	200	MCL	ug/L	< 0.5	< 0.5

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Sample Location / Lab	Rudd Farms / Eaton Analytical			Source Water	Native Groundwater
				Well No. 1	Basalt Well
				10/18/2017	10/17/2017
	Standard	Criteria	Unit		
Volatile Organic Compounds (VOCs)					
1, 1-Dichloroethane			ug/L	< 0.5	< 0.5
1, 1-Chloroethylene			ug/L	< 0.5	< 0.5
1, 1-Dichloroethylene	7	MCL, MML	ug/L	< 0.5	< 0.5
1, 1-Dichloropropene			ug/L	< 0.5	< 0.5
1, 2-Dichloroethane (EDC)	5	MCL, MML	ug/L	< 0.5	< 0.5
1, 2-Dichloropropane	5	MCL	ug/L	< 0.5	< 0.5
1, 3-Dichloropropane			ug/L	< 0.5	< 0.5
2, 2-Dichloropropane			ug/L	< 0.5	< 0.5
1, 2, 3-Trichlorobenzene			ug/L	< 0.5	< 0.5
1, 2, 3-Trichloropropane			ug/L	< 0.5	< 0.5
1, 2 ,4-Trichlorobenzene	70	MCL	ug/L	< 0.5	< 0.5
1, 2, 4,-Trimethylbenzene			ug/L	< 0.5	< 0.5
1, 3, 5-Trimethylbenzene			ug/L	< 0.5	< 0.5
1, 1, 1,2-Tetrachloroethane			ug/L	< 0.5	< 0.5
1, 1, 2, 2-Tetrachloroethane			ug/L	< 0.5	< 0.5
1, 1, 1-Trichloroethane	200	MCL, MML	ug/L	< 0.5	< 0.5
1, 1, 2-Trichloroethane	5	MCL	ug/L	< 0.5	< 0.5
2-Butanone (MEK)			ug/L	< 5	< 5
4-Methyl-2-Pentanone			ug/L	< 5	< 5
Benzene	5	MCL, MML	ug/L	< 0.5	< 0.5
Bromobenzene			ug/L	< 0.5	< 0.5
Bromochloromethane			ug/L	< 0.5	< 0.5
Bromoethane			ug/L	< 0.5	< 0.5
Bromomethane (Methyl Bromide)			ug/L	< 0.5	< 0.5
Chlorobenzene (monochlorobenzene)	100	MCL	ug/L	< 0.5	< 0.5
Carbon Disulfide			ug/L	< 0.5	< 0.5
Carbon Tetrachloride			ug/L	< 0.5	< 0.5
Chlorodibromomethane			ug/L	< 0.5	< 0.5
Chloroethane			ug/L	< 0.5	< 0.5
Chloromethane (Methyl Chloride)			ug/L	< 0.5	< 0.5
cis-1,2-Dichloroethylene	70	MCL	ug/L	< 0.5	< 0.5
cis-1, 3-Dichloropropene			ug/L	< 0.5	< 0.5
Dibromomethane			ug/L	< 0.5	< 0.5
Dichloromethane			ug/L	< 0.5	< 0.5
Dichlorodifluoromethane			ug/L	< 0.5	< 0.5
Di-isopropyl ether			ug/L	< 3	< 3
Ethylbenzene	700	MCL	ug/L	< 0.5	< 0.5
Hexachlorobutadiene			ug/L	< 0.5	< 0.5
Isopropylbenzene			ug/L	< 0.5	< 0.5
m, p-Xylenes			ug/L	< 0.5	< 0.5
m-Dichlorobenzene (1, 3-DCB)			ug/L	< 0.5	< 0.5
Methylene Chloride	0.005	MCL	ug/l	< 0.5	< 0.5
Methyl Tert-butyl ether (MTBE)			ug/L	< 0.5	< 0.5
Napthalene			ug/L	< 0.5	< 0.5
n-Butylbenzene			ug/L	< 0.5	< 0.5
n-Propylbenzene			ug/L	< 0.5	< 0.5
o-Chlorotoluene			ug/L	< 0.5	< 0.5
o-Dichlorobenzene (1, 2-DCB)			ug/L	< 0.5	< 0.5
o-Xylene			ug/L	< 0.5	< 0.5
p-Chlorotoluene			ug/L	< 0.5	< 0.5
p-Dichlorobenzene (1, 4-DCB)			ug/L	< 0.5	< 0.5
p-Isopropyltoluene			ug/L	< 0.5	< 0.5
sec-Buytlbenzene			ug/L	< 0.5	< 0.5
Styrene	100	MCL	ug/L	< 0.5	< 0.5
tert-amyl Methyl Ether			ug/L	< 3	< 3
tert-Butyl Ethyl Ether			ug/L	< 3	< 3
tert-Butylbenzene			ug/L	< 0.5	< 0.5
Tetrachloroethylene (PCE)	5	MCL	ug/L	< 0.5	< 0.5
Toluene	1000	MCL	ug/L	< 0.5	< 0.5
Total Xylenes	10000	MCL	ug/L	< 0.5	< 0.5
Total 1,3-Dichloropropene			ug/L	< 0.5	< 0.5
Total THM			ug/L	< 0.5	< 0.5
trans-1,2-Dichloroethylene	100	MCL	ug/L	< 0.5	< 0.5
trans-1, 3-Dichloropropene			ug/L	< 0.5	< 0.5
Trichloroethylene (TCE)	5	MCL, MML	ug/L	< 0.5	< 0.5
Trichlorofluoromethane			ug/L	< 0.5	< 0.5
Trichlorotrifluoroethane (Freon 113)			ug/L	< 0.5	< 0.5
Vinyl chloride	2	MCL, MML	ug/L	< 0.3	< 0.3

Sample Location / Lab	Rudd Farms / Eaton Analytical			Source Water Well No. 1 10/18/2017	Native Groundwater Basalt Well 10/17/2017
	Standard	Criteria	Unit		
Radionuclides					
Alpa, Gross			pCi/L	< 3	< 3
Alpha, Min Detectable Activity			pCi/L	1.8	2.8
Alpha, Two Sigma Error			pCi/L	0.64	0.7
Beta, Gross			pCi/L	5.1	< 3.0
Beta, Min Detectable Activity			pCi/L	1.5	1.4
Beta, Two Sigma Error			pCi/L	0.6	0.5
Radium 226			pCi/L	< 1	< 1
Radium 226 Min. Detect Activity			pCi/L	0.42	0.38
Radium 226 Two Sigma Error			pCi/L	< 1	< 1
Radium 228			pCi/L	< 1	< 1
Radium 228 Min Detect Activity			pCi/L	0.82	0.65
Radium 228 Two Sigma error			pCi/L	< 1	< 1
Radium 226, 228 Combined			pCi/L	< 2	< 2
Radon 222			pCi/L	300	140
Radon 222, Two Sigma Error			pCi/L	15	9.5
Uranium			ug/L	< 1	< 1
Microbial					
E. Coli Bacteria			MPN/100 mL	< 1	<1
Total Coliform Bacteria			MPN/100 mL	2	<1
Total Coliform Bacteria (P/A)				P	A
E.Coli Bacteria (P/A)				A	A

Notes

ASR Injection Standards = Lowest value within MCL/2, MML/2, or SMCL except disinfection by-products.

ASR Injection Standards for disinfection by-products = Lowest value within MCL, MML, or SMCL.

ASR = aquifer storage and recovery

MCL = maximum contaminant level for drinking water

-- = not tested

GSI Water Solutions, Inc.

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Attachment A – October 2017 Data Collection

In October 2017, GSI Water Solutions, Inc. (GSI) collected the following data at Rudd Farms in La Grande, Oregon, to inform an analysis of fatal flaws to Aquifer Storage and Recovery (ASR):

- Constant rate pumping test at the Basalt Well (about 26 hours of pumping followed by 7 days of recovery monitoring).
- Constant rate pumping test at Well No. 1 (about 73 hours of pumping followed by 23 hours of recovery monitoring).
- Groundwater quality samples from Well No. 1 and the Basalt Well.

The following sections provide detailed documentation of the methods and results of the data collection.

Basalt Well Pumping Test

The Basalt Well is sealed to 2,537 feet bgs, and is completed in the Powder River Basalts (beginning at 2,502 feet bgs) and Columbia River Basalt Group (beginning at 2,919 feet bgs). The static depth to groundwater in the Basalt Well (55 feet below ground surface[1]) is above the top of the basalts; therefore, the Basalt Well is completed in a confined aquifer.

Methods

A constant rate pumping test was conducted at the Basalt Well in October 2017. The purpose of the test was to measure aquifer properties (i.e., transmissivity) and well performance (i.e., specific capacity) in order to inform ASR storage volume, baseline well performance, and well interference evaluation.

Prior to pumping, water levels in the Basalt Well were monitored for about 7 hours[2]. The pumping test consisted of pumping the Basalt Well from October 16 to October 17 (about 26 hours of pumping) at an average rate of 522 gallons per minute (gpm), followed by seven days of recovery monitoring. Water levels were monitored in the Basalt Well (pumping well), Well No. 1 (observation well), and Well No. 3 (observation well) both manually[3] and automatically[4]. During the test, groundwater from the Basalt Well was conveyed to a pivot located approximately 0.5 miles southwest of the well. Flow totals were recorded using a totalizing flow meter at the wellhead.

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[1] UNIO 52415, measured July 20, 2013.

[2] A pressure transducer was installed in the Basalt Well on October 13, 2017, for the purpose of monitoring background water levels for about three days. However, the water level in the well was deeper than the transducer when the transducer was installed, so water levels were not recorded until the early morning of October 16, when water levels rose above the transducer.

[3] Using a Powers Electric Well Sounder.

[4] Using an Instrumentation Northwest (INW) vented PT2X pressure transducer. A 300 psi transducer was used in the Basalt Well, and 100 psi transducers were used in Well No. 1 and Well No. 3.

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Results

Water levels in the Basalt Well during the pumping test are shown in Figure A.1. The maximum drawdown in the Basalt Well at a pumping rate of about 522 gpm was about 93 feet (26-hour specific capacity of 5.6 gpm/ft).

There are two anomalies in the water levels during the pumping test. The first anomaly occurs at the beginning of the test and is a rapid, short-term decline in the water level to about 300 feet below the reference point (see Figure A.1). The anomaly is related to a change in pumping rate at the beginning of the test. Specifically, the Basalt Well pumped at approximately 1,200 gpm for the first three minutes of the test; after the first three minutes of the test the pumping rate was reduced to about 500 gpm. The change in pumping rate was likely caused by some combination of the well discharging into empty distribution piping at the beginning of the test (i.e., no piping head loss and no backpressure from the irrigation pivot) and the shallow water levels in the well at the outset of the test (i.e., less lift). The second anomaly occurs at the end of the test and is a rapid rise in the water level to about 260 feet below the reference point immediately after the pump was turned off. This rapid increase in water level likely occurred when water from the distribution piping and riser pipe drained back into the well when the pump was shut off (the pump is not equipped with a backflow preventer check valve).

A semi-logarithmic plot of water-level drawdown in the Basalt Well versus time during the pumping portion of the aquifer test is shown in Figure A.2. Based on this plot, we estimate that transmissivity of the aquifer that the Basalt Well pumps from is 1,210 gallons per day per foot (gpd/ft). It is important to note that this transmissivity estimate is likely biased low due to turbulent head loss in the pumping well during the test. The transmissivity and specific capacity at the Basalt Well are summarized in Table A.1. Because specific capacity is a time-dependent variable that decreases over time, we calculated both a short term specific capacity (based on drawdown after 26 hours of pumping) and a long-term specific capacity (based on extrapolating the drawdown line to 120 days of pumping, which is the anticipated length of the injection period from December through March).

Table A.1. Aquifer Parameters and Well Performance.

Well	Transmissivity (gpd/ft)	Specific Capacity (gpm/ft)	
		Short-Term	Long-Term
Basalt Well	1,210	5.6 [1]	1.6 [2]

NOTES:
(1) Pumping for 26 hours at 522.5 gpm, drawdown of 94 feet.
(2) Pumping for 120 days, drawdown of 325 feet (the extrapolated drawdown line is shown in Figure A.2).

Water level recovery is shown in Figure A.3. Residual drawdown is plotted on the y-axis, and time is shown on the x-axis (time is plotted as the ratio of time since pumping started to time since pumping stopped). When residual drawdown is zero, the time ratio is greater than one. This means that the Basalt Well was recharged during the aquifer test. The recharge is likely related to the Basalt Well being pumped shortly before the constant rate test began and recovering from earlier pumping during the test (during the seven hours of background monitoring, water levels in the Basalt Well rose 2.7 feet, indicating that the Basalt Well was still recovering from the pumping). Due to the fact that the Basalt Well was recovering from earlier pumping, we could not calculate a transmissivity from the recovery data.

Water levels in the observation wells (Well No. 1 and Well No. 3) did not exhibit any response to pumping in the Basalt Well (see Figure A.1). This is an expected result because the pumping well and observation wells are completed in different aquifers.

Basalt Well Sampling

Groundwater samples were collected from the Basalt Well from a ¾-inch ball valve at the wellhead at the end of the pumping test. The samples were shipped under chain of custody procedures to Eurofins Laboratories (Monrovia, California), where they were analyzed for the parameters in Table 1. GSI measured field parameters using a Yellow Springs Instruments (YSI) meter and flow through cell. Prior to measuring parameters, the YSI meter was calibrated to dissolved oxygen, pH (3 point), conductivity, and oxidation reduction potential (ORP). GSI monitored field parameters at the Basalt Well for 86 minutes. At that time, the parameters were basically unchanged during the final measurement period (14 minutes) except for ORP which changed from -158.9 to -168.1 millivolts (mV).

Well No. 1 Pumping Test

Well No. 1 is completed in sands and gravels that underlie an approximately 170 feet thick clay unit. The static depth to groundwater in Well No. 1 (15 feet below ground surface[5]) is above the top of the sands and gravels; therefore, Well No. 1 is completed in a confined aquifer.

Methods

A constant rate pumping test was conducted at Well No. 1 in October 2017. The purpose of the test was to measure well performance (i.e., specific capacity) in order to inform whether Well No. 1 is a limiting factor on ASR storage volume.

Prior to pumping, water levels in Well No. 1 were monitored for about eight days. The pumping test consisted of pumping Well No. 1 from October 18 to October 21 (about 74 hours of pumping) at an average rate of 795 gpm, followed by one day of recovery monitoring. Water levels were monitored in Well No. 1 (pumping well), Well No. 3 (observation well), and the Basalt Well (observation well) both manually[6] and automatically[7]. During the test, groundwater from Well No. 1 was conveyed to a pivot located approximately one third of a mile northeast of the well. Flow totals were recorded using a totalizing flow meter at the wellhead.

Results

Water levels in Well No. 1 during the pumping test are shown in Figure A.4. The water levels in Well No. 1 prior to pumping ranged from about 85 feet below the reference point to 66 feet

[5] UNIO 51835, measured in 2005

[6] Using a Powers Electric Well Sounder.

[7] Using an Instrumentation Northwest (INW) vented PT2X pressure transducer. A 300 psi transducer was used in the Basalt Well, and 100 psi transducers were used in Well No. 1 and Well No. 3.

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below the reference point and exhibited a rising trend, indicating that water levels in the alluvial aquifer were still recovering from irrigation season pumping prior to the test. The maximum drawdown in the Well No. 1 at a pumping rate of about 795 gpm was about 225 feet (74-hour specific capacity of 3.53 gpm/ft).

A semi-logarithmic plot of water-level drawdown in Well No. 1 versus time during the pumping portion of the aquifer test is shown in Figure A.5. A negative boundary was encountered about 100 minutes after pumping started. Negative boundaries occur when the rate of drawdown increases with time, and indicate a barrier to groundwater flow. At about 2,000 minutes after pumping started, the drawdown curve levels off, indicating either a positive boundary or leakage from above and below the sand and gravel aquifer. Based on this plot, we estimate that transmissivity of the aquifer that Well No. 1 pumps from ranges from 5,248 gpd/ft (early-time) to 2,333 gpd/ft (late-time). It is important to note that this transmissivity estimate is likely biased low due to turbulent head loss in the pumping well during the test. The transmissivity and specific capacity at Well No. 1 are summarized in Table A.2.

Table A.2. Aquifer Parameters.

Well	Transmissivity (gpd/ft)		Short-Term Specific Capacity (gpm/ft)	Long-Term Specific Capacity (gpm/ft)
	Early-Time	Late-Time		
Well No. 1 Drawdown	5,248	2,333	3.5 [1]	2.0 [2]
Well No. 1 Recovery	5,674	3,180	NA	NA

NOTES:
(1) Pumping for 74 hours at 795 gpm, drawdown of 225 feet.
(2) Pumping for 120 days, drawdown of 325 feet (the extrapolated drawdown line is shown in Figure A.2).

Water level recovery at Well No. 1 is shown in Figure A.6. Residual drawdown is plotted on the y-axis, and time is shown on the x-axis (time is plotted as the ratio of time since pumping started to time since pumping stopped). When residual drawdown is zero, the time ratio is greater than one. This means that the Well No. 1 was recharged during the aquifer test. The recharge is likely related to the alluvial aquifer continuing to recover from irrigation-season pumping (during the 8 days of background monitoring, water levels in Well No. 1 rose about 20 feet, indicating that the alluvial aquifer was recovering from the pumping during the irrigation season). Based on Figure A.6, we estimate that transmissivity of the aquifer that Well No. 1 pumps from ranges from 5,674 gpd/ft (early-time) to 3,180 gpd/ft (late-time). Transmissivity estimates from recovery data are generally more reliable because water levels in the well are not affected by fluctuations in pumping rate. The transmissivity at Well No. 1 is summarized in Table A.2.

Figure A.7 shows water levels in Well No. 1 and the well screen in the well. During the pumping test (conducted at 795 gpm), the water level in the well was drawn down below the top of the well screen. Lowering the water level into the screened increases oxygenation in both the water column and the aquifer near the well, which may enhance biological activity in the vicinity of the well. Injecting water that contains a large amount of biological activity Basalt Well may create

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well clogging problems in the Basalt Well (if bacterial populations are not managed with chlorination). We recommend collecting a bacteriological sample from Well No. 1 in order to assess whether a bacterial population has become established in the well, and whether additional chlorination may be necessary to control bacterial populations prior to injection.

Also shown in Figure A.7 are the early-time and late-time extrapolated drawdown lines when Well No. 1 pumps at 795 gpm. Because injection will be limited to 280 gpm based on the capacity of the Basalt Well to accommodate water level rise (see Attachment C), the early-time and late-time drawdown lines at 795 gpm are not representative of drawdown in Well No. 1 during recharge. We estimated the early-time and late-time drawdown lines when Well No. 1 pumps at 280 gpm using the following equation relating transmissivity, drawdown, and pumping rate:

$$\Delta s = \frac{264(Q)}{T} \qquad (1)$$

Where Δs is drawdown over one log cycle of time (feet), *Q* is the pumping rate (gpm), and *T* is transmissivity (gpd/ft). We solved Equation (1) for drawdown over one log cycle of time assuming a pumping rate of 280 gpm and a transmissivity of 5,248 gpd/ft (early-time) or 2,333 gpd/ft (late-time), and plotted the resulting lines on Figure A.7. After about 40,000 minutes (28 days) of pumping Well No. 1 continuously at 280 gpm, the water levels in Well No. 1 are predicted to fall below the top of the well screen. However, this prediction does not account for the fact that water levels in the well appear to stabilize when the well has been pumping for about 2,000 minutes (see "Positive Boundary or Leakage" in Figure A.7). We recommend monitoring water levels in Well No. 1 during injection to confirm that Well No. 1 can be pumped at 280 gpm without drawing the water level below the top of the screen. It may be necessary to rest Well No. 1 occasionally to prevent the water levels from falling below the top of the screen during recharge.

Water levels in the observation wells (the Basalt Well and Well No. 3) did not exhibit any response to pumping in Well No. 1. Water levels in the Basalt Well are shown in Figure A.1, and water levels in Well No. 3 are shown in Figure A.8. This indicates that pumping Well No. 1 does not cause interference in Well No. 3, for the 74 hour period that we observed water levels.

Well No. 1 Sampling

Groundwater samples were collected from Well No. 1 at a ¾-inch ball valve at the wellhead after the well had pumped for about 90 minutes. The samples were shipped under chain of custody procedures to Eurofins Laboratories (Monrovia, California), where they were analyzed for the parameters in Table 1. GSI measured field parameters using a Yellow Springs Instruments (YSI) meter and flow through cell. Prior to measuring parameters, the YSI meter was calibrated to dissolved oxygen, pH (3 point), conductivity, and ORP. GSI monitored the field parameters at Well No. 1 for 42 minutes. At the time that the field parameters were measured, the parameters were basically unchanged during the final measurement period, except for DO which changed from 0.93 milligrams per liter (mg/L) to 0.82 mg/L (4 minutes between readings).

Figure A.1. Water Levels in the Basalt Well

Rudd Farms Basalt Well Pumping Test

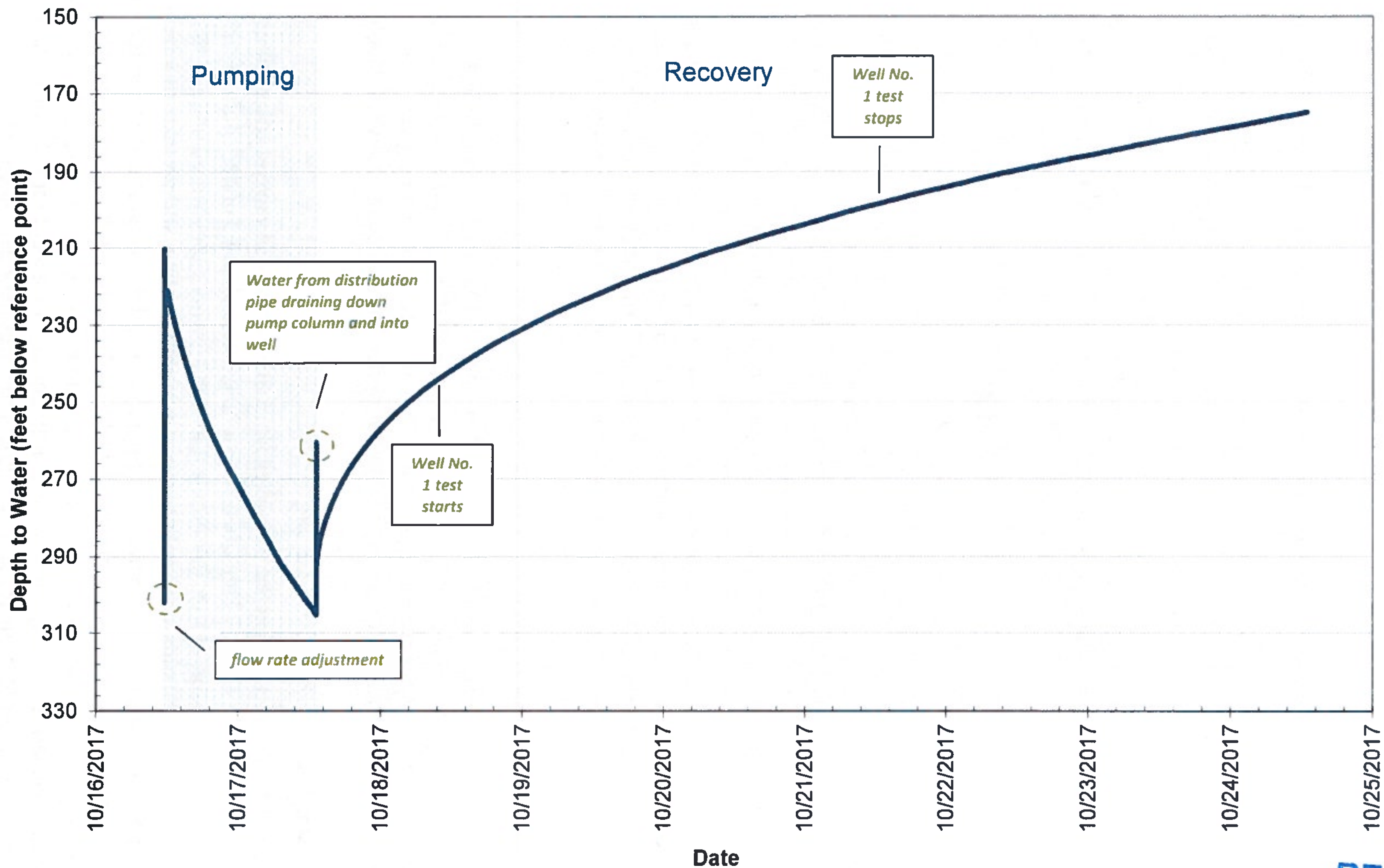

Figure A.2. Drawdown in the Basalt Well

Rudd Farms Basalt Well Pumping Test

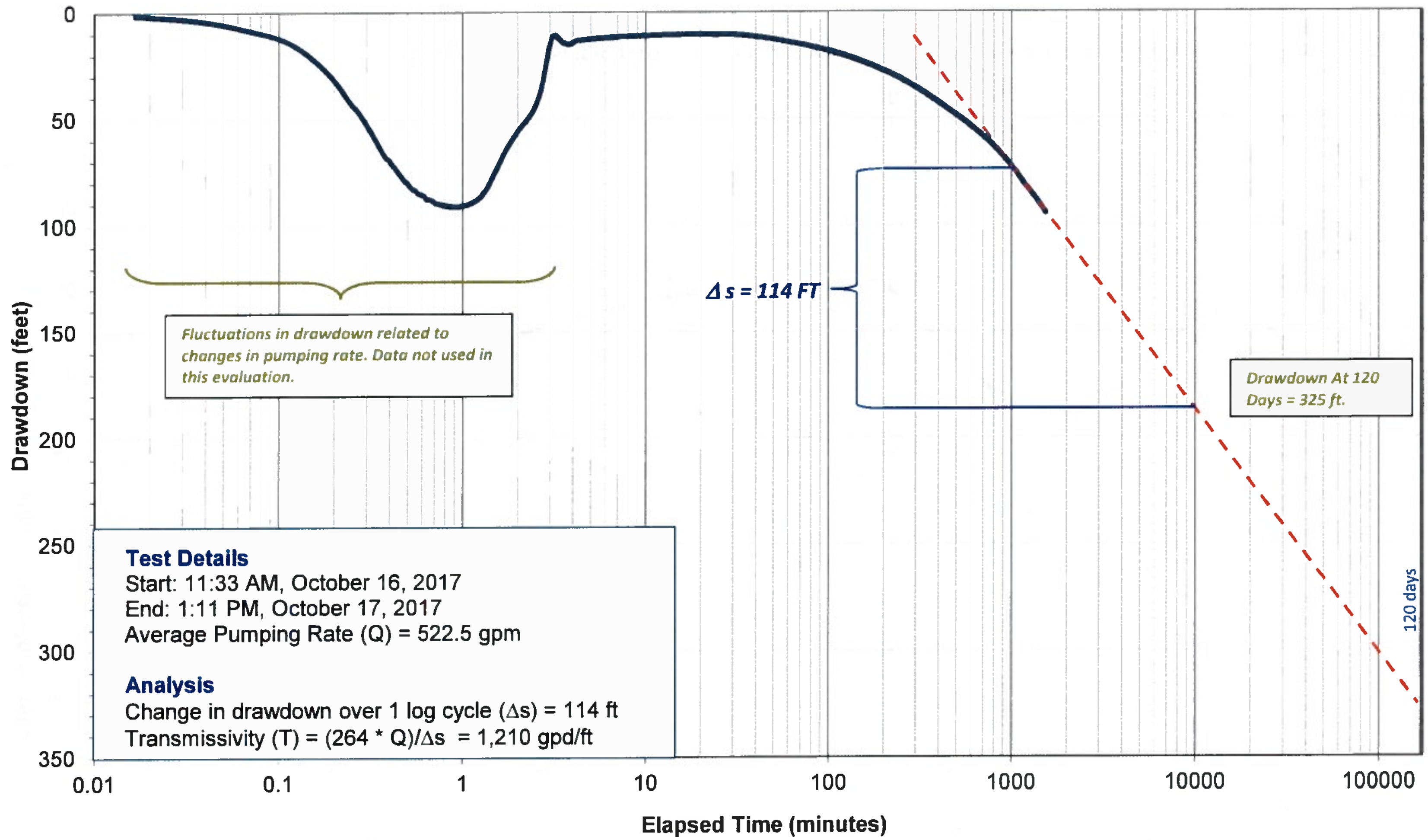

Figure A.3. Residual Drawdown in Basalt Well
Rudd Farms Basalt Well Pumping Test

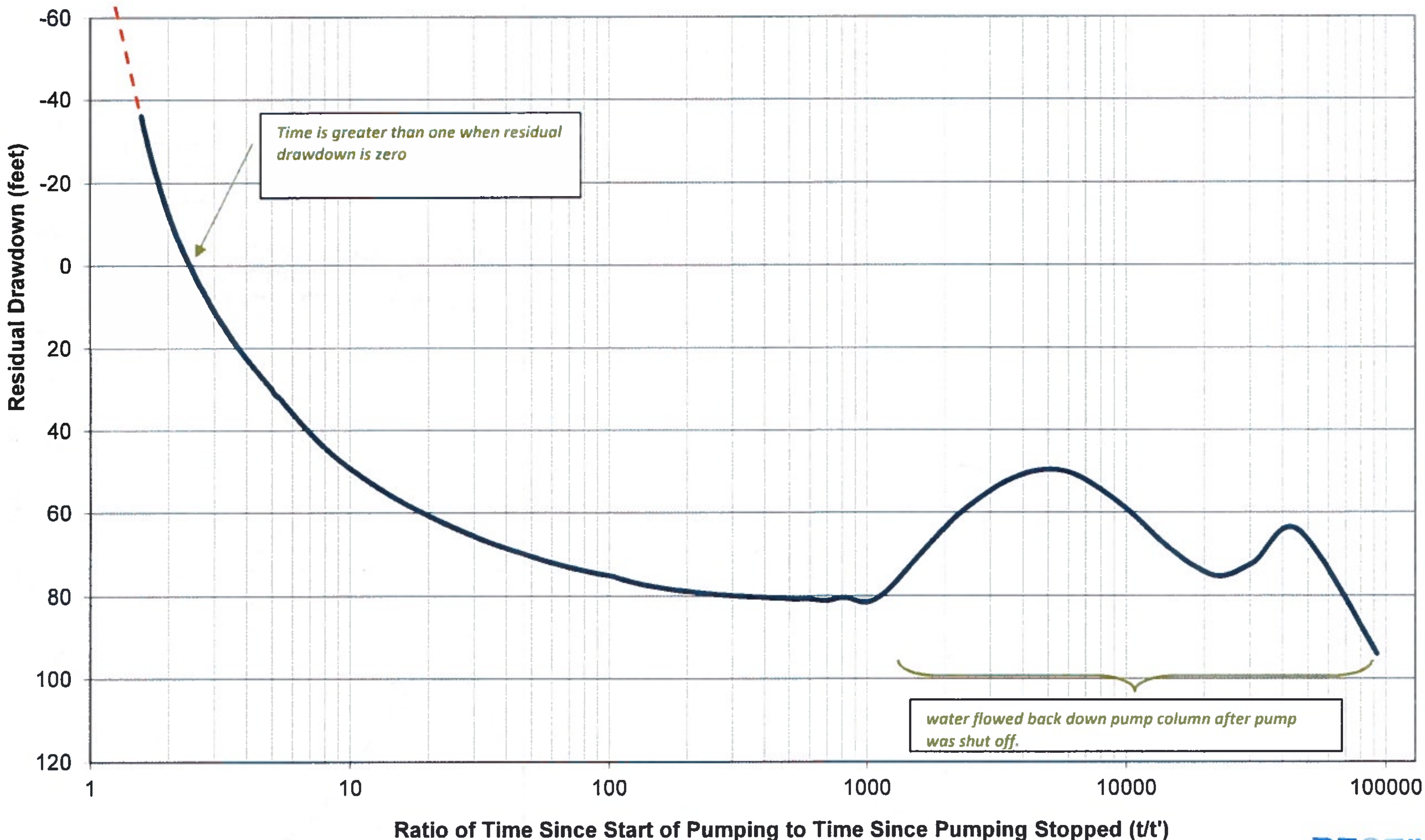

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Figure A.4. Water Levels in Well No. 1
Rudd Farms Well No. 1 Pumping Test

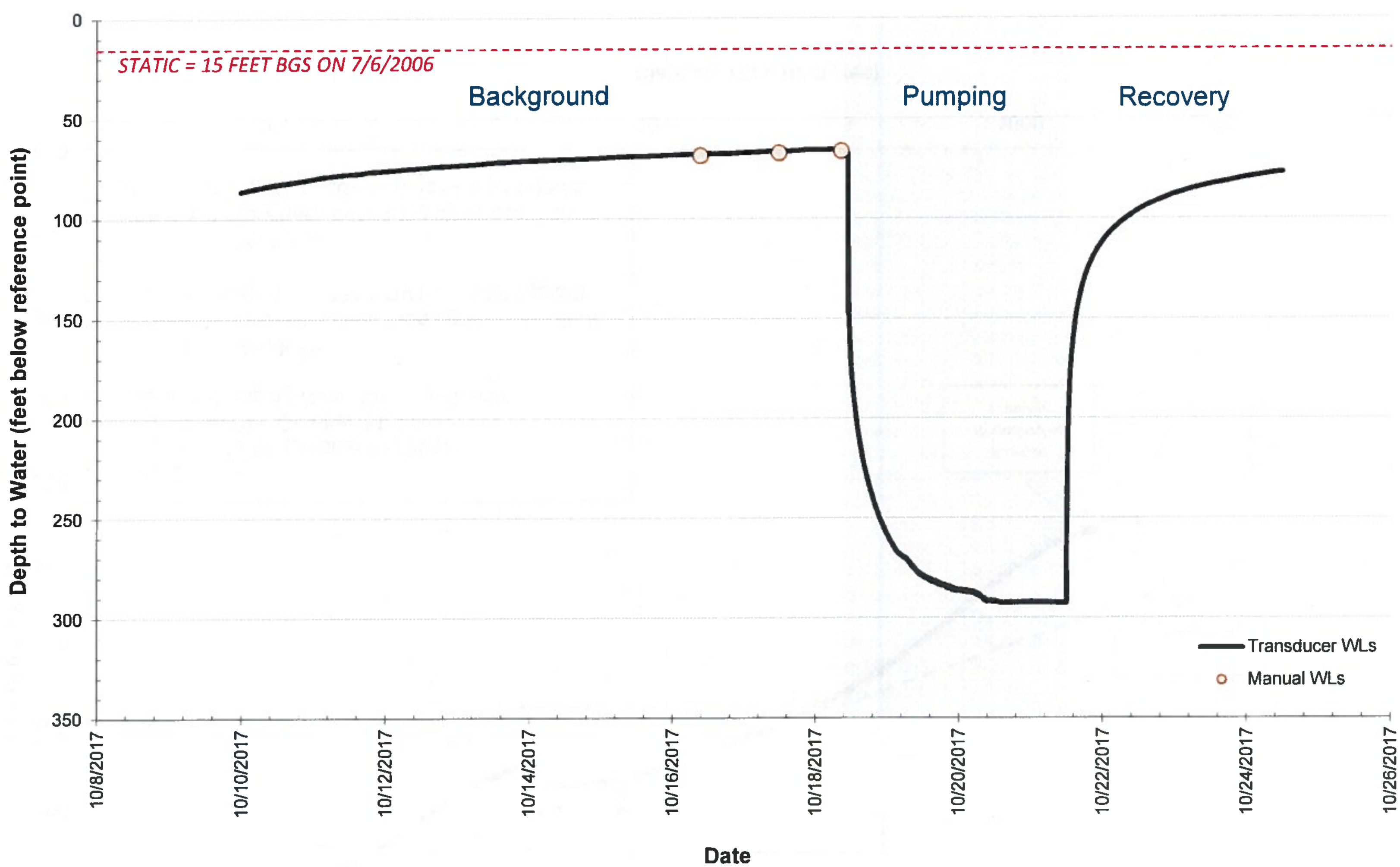

Figure A.5. Drawdown in Well No. 1
Rudd Farms Well No. 1 Pumping Test

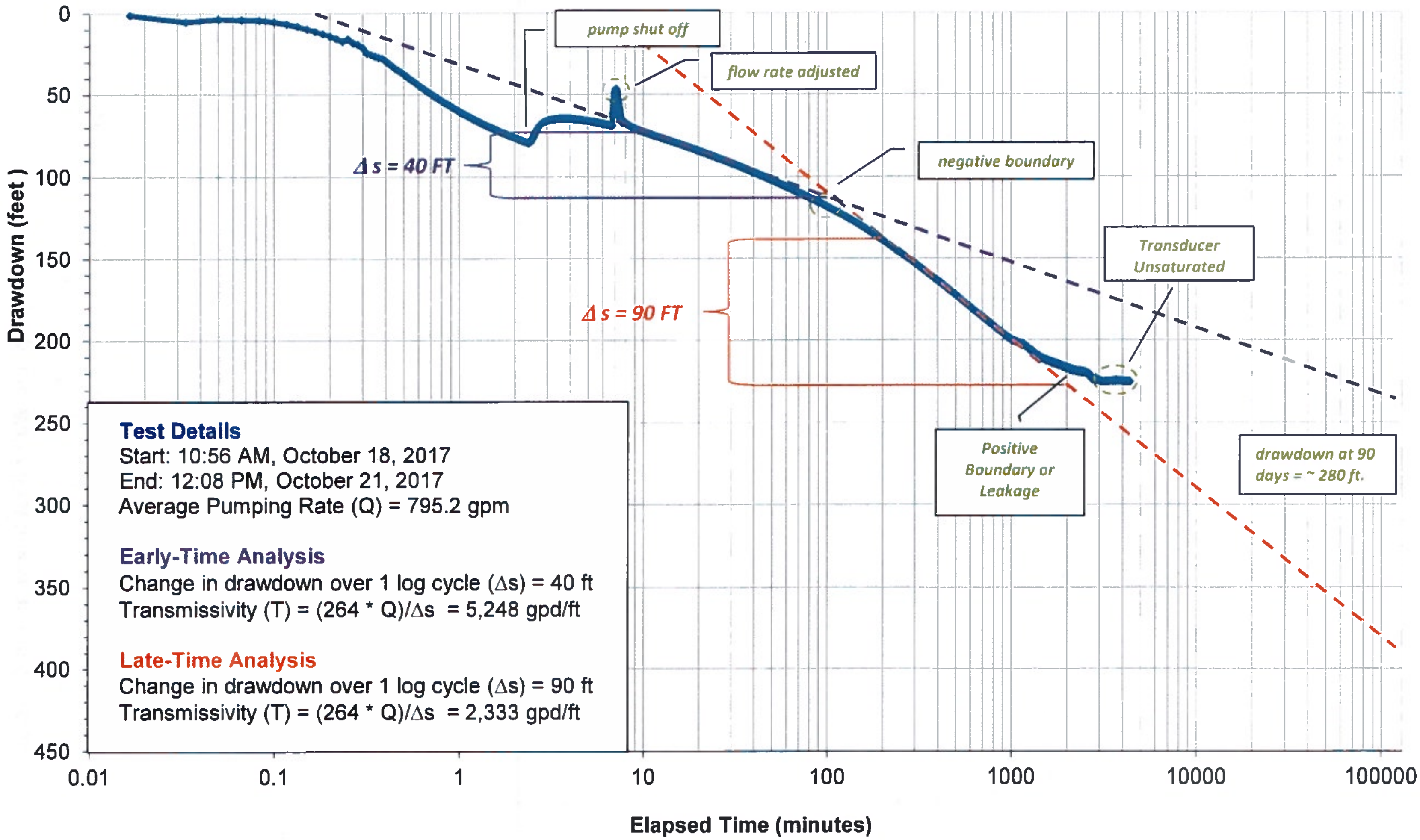

Figure A.6. Residual Drawdown in Well No. 1
Rudd Farms Well No. 1 Pumping Test

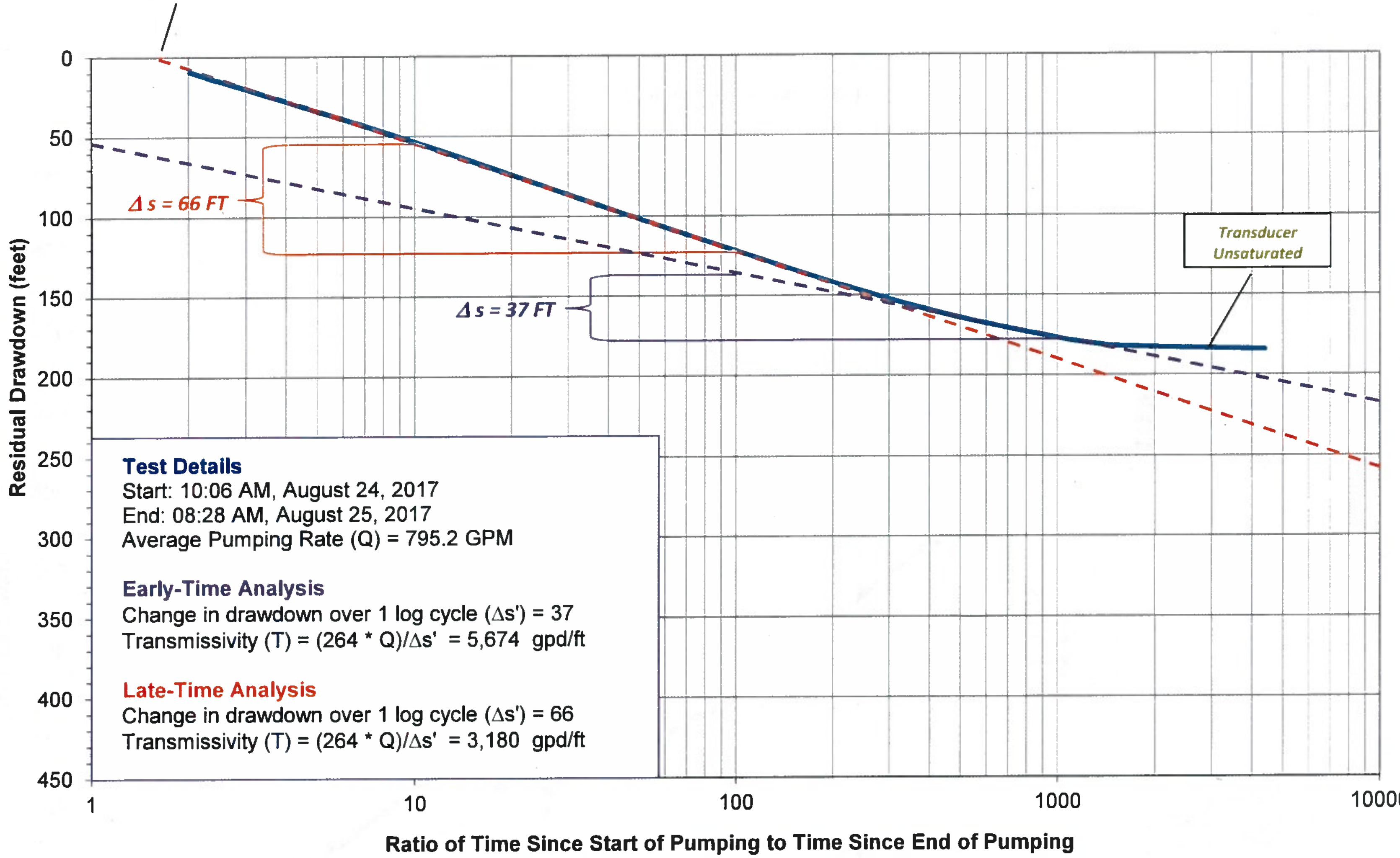

Figure A.7. Drawdown in Well No. 1
Rudd Farms Well No. 1 Pumping Test

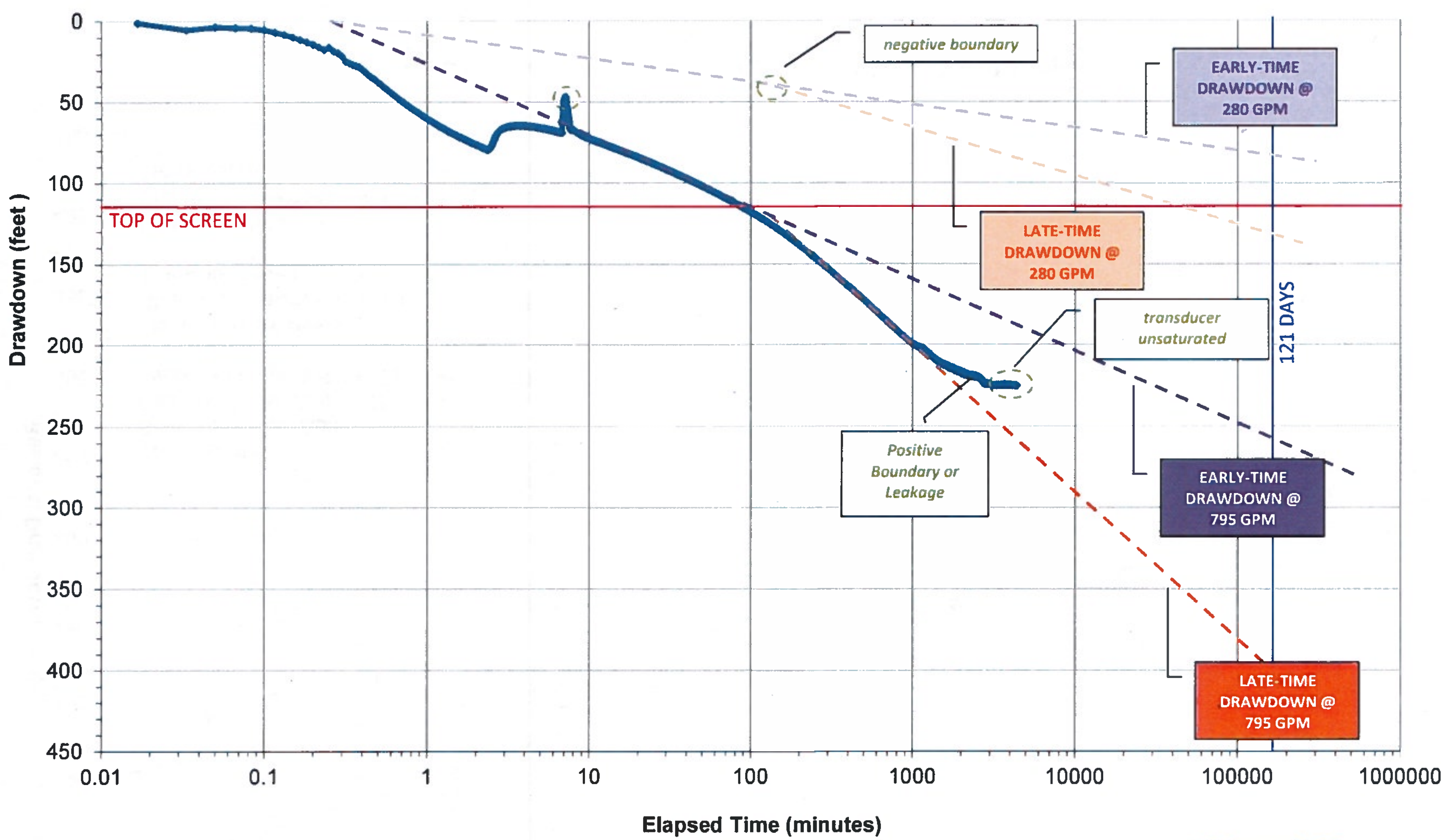

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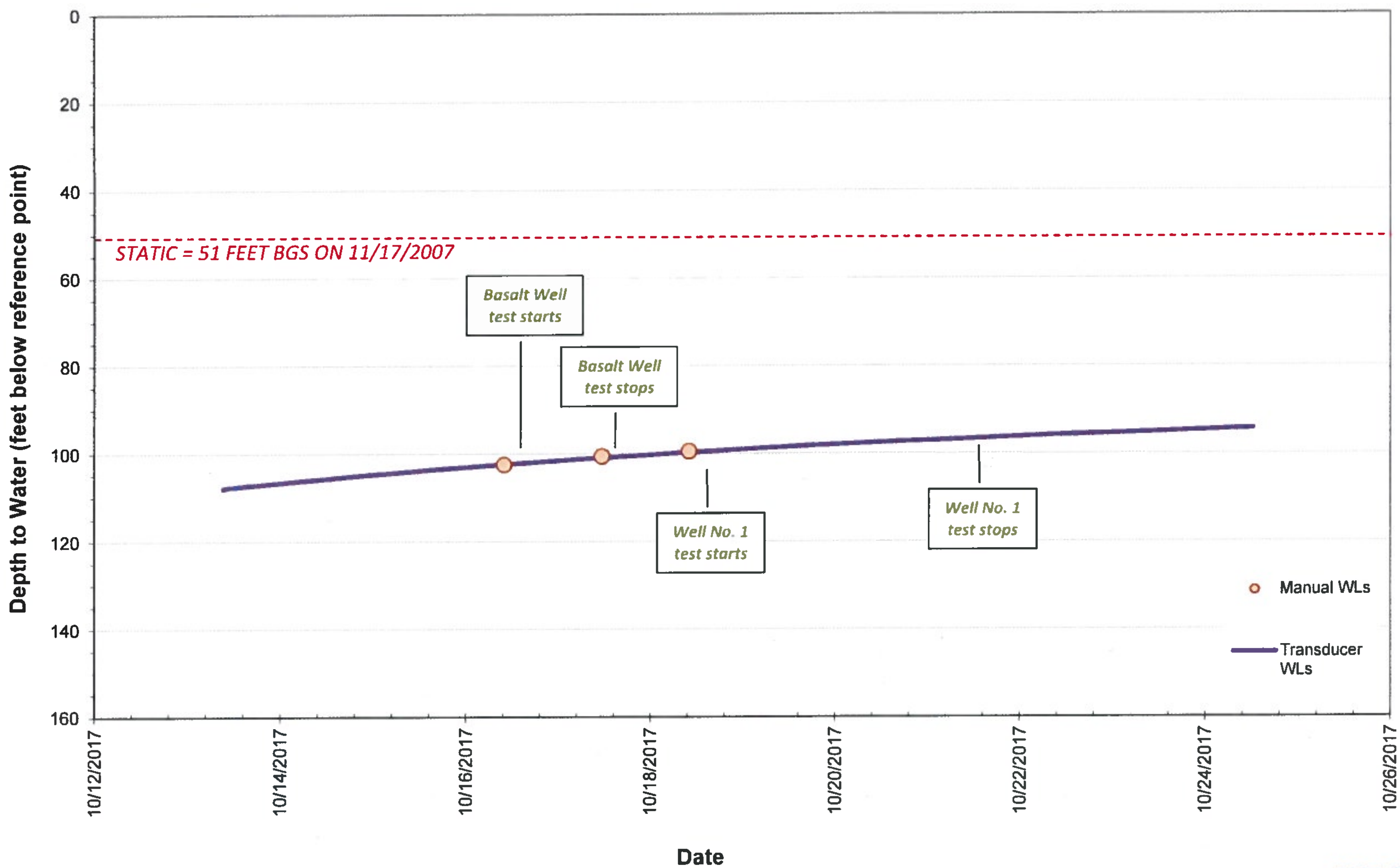
Figure A.8. Water Levels in Well No. 3

Rudd Farms Basalt Well and Well No. 1 Pumping Test



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Attachment B – Manganese Removal Pilot Test Scope and Fee Estimate

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SCOPE OF WORK AND PROJECT UNDERSTANDING
March 2, 2018

PROJECT UNDERSTANDING

This Scope of Work (SOW) outlines the project understanding and the tasks that will be performed by Anderson Perry & Associates, Inc. (AP) for the manganese treatment pilot test (Project) for Rudd Farms (Owner). The Owner requests AP to prepare detailed hand sketches, prepare an equipment and materials list, and provide assistance with the initial setup of a pilot test treatment system to remove manganese and iron from the Owner's shallow groundwater wells. The Owner also requests AP perform tests and sampling.

AP proposes to pilot test an aeration treatment system with the addition of supplemental air and/or chlorine bleach, if necessary. The Project will consist of the following components:

- Design of a pilot test treatment system to remove manganese and iron
- Construction of the pilot test treatment system (by Owner)
- Operation of the pilot test treatment system including several tests that will be modified as required to optimize manganese and iron removal
- Sampling and testing of raw and treated water

These components and the responsible parties are outlined in subsequent sections of this SOW. Pilot tests are anticipated to be conducted May 2018.

PRELIMINARY EQUIPMENT AND MATERIALS LIST

A preliminary list of the necessary equipment and materials to construct the pilot test treatment system is shown below. Please note the list in this SOW is general in nature and additions or subtractions may occur as the project progresses.

- Power and extension cords
- Inlet and outlet sample taps
- Raw water pump with flowmeter
- Raw water inlet piping/tubing and fittings as required
- Flow distribution system (i.e., a flow distributing tray or lateral spreading tubes)
- Aeration trays with perforations, splash aprons, and structural members
- Stone or other media to fill aeration trays (if needed)
- Tank to provide detention time
- Variable speed recirculation pump with flowmeter and tubing as required
- Air compressor with tubing, aeration tubing, and air flow rotameter
- Chlorine bleach
- Variable speed chemical feed pump with tubing for chlorine bleach

- Treated water outlet piping/tubing and fittings as required (treated water will be directed to drain away from the pilot test treatment system)
- Vented stainless steel enclosure for the pilot test treatment system

PRELIMINARY OUTLINE OF TESTS

Several tests will be conducted once the pilot test treatment system is constructed. Each test is anticipated to be conducted for a duration of two days. For each test, water samples will be taken at the inlet and outlet sample taps. The modifications between tests are listed below. The test modifications will be performed in the order listed.

1. Varying raw water flow rate
2. Varying water recirculation flow rate
3. Addition of supplemental air and varying the air flow rate
4. Addition of chlorine bleach and varying the chlorine bleach flow rate

In summary, raw water will initially be run through the system without any recirculation flow rate, air addition, or chlorine bleach addition. Following this test, the flow will be recirculated to test the effects. Next, air will be added to the system. Lastly, chlorine bleach will be added to the system. It is important to note modifications added from previous tests may be removed to test the effects of a different modification.

PRELIMINARY SAMPLING REQUIREMENTS

The Owner plans to develop an aquifer storage and recovery (ASR) system. This system would enable the Owner to inject treated water from shallow groundwater wells into a deep basalt well for irrigation storage purposes. The treated water must meet ASR water quality requirements for manganese, iron, and byproducts created from the use of chlorine bleach. Currently, the total manganese and iron concentrations in Well No. 1 are 0.14 milligram per liter (mg/L) and 0.16 mg/L, respectively. Water samples will be taken at the inlet and outlet sample taps. Water quality standards for the Project at the outlet sample tap are outlined below:

- Total manganese must be less than 0.05 mg/L
- Total iron must be less than 0.30 mg/L

Byproducts created by the addition of chlorine bleach must be follow the standards outlined below.

- Total trihalomethanes must be less than 80 micrograms per liter (μg/L)
- Total haloacetic acids must be less than 60 μg/L
- Chloride must be less than 250 mg/L
- Sulfate must be less than 250 mg/L
- pH must be between 6 and 8.5

Tests will be performed for the water quality analytes shown in Attachment A. Samples for analysis of water quality analytes shown in Attachment A must be collected after 24 hours of pumping the well. These analyte results will provide data for others to evaluate the potential adverse effects when mixing treated water with native groundwater in the shallow basalt wells.

GENERAL ENGINEERING SERVICES

Upon approval by the Owner for AP to proceed, AP shall provide general engineering services for the Project to include:

1. Coordinate with the analysis laboratory to have a Well No. 3 sample (collected by the Owner) analyzed for the water quality analytes shown in Attachment A.
2. Prepare for and lead a project kickoff meeting with the Owner to review the project objectives.
3. Prepare an initial project schedule and updates as needed.
4. Prepare detailed hand sketches of the pilot test treatment system.
5. Prepare an equipment and materials list for the pilot test treatment system.
6. Conduct a site meeting with the Owner to verify the system is constructed as shown on the sketches and with the appropriate equipment and materials. Sampling procedures will also be outlined at this site meeting.
7. Prepare a detailed outline of the tests to be conducted with amounts, flow rates, etc. This outline will be subject to change pending the results of each test performed.
8. Set up all tests as outlined. This outline will be subject to change pending the results of each test performed.
9. Perform water sampling as outlined. It is anticipated the water samples would be run through a filter paper to remove the precipitates. The Owner shall be responsible to pay all costs for water sampling materials, shipping, and testing. These costs are estimated to be $1,000. AP will coordinate with the analysis laboratory.
10. Review of the water sampling test results. AP will suggest changes to the subsequent tests, if required.

WORK PERFORMED BY OWNER

It is anticipated the Owner will perform the following work:

1. Obtain a water sample from Well No. 3. This sample must be taken after pumping the well for 24 hours. Coordinate with AP to have the sample analyzed by the laboratory.
2. Attend a project kickoff meeting with AP to review the project objectives.
3. Provide information to AP when requested.
4. Purchase all equipment and materials necessary for construction of the pilot test treatment system. Equipment and materials are estimated to cost $1,500. AP will provide the Owner with an equipment and materials list. This list is subject to change to ensure all needed equipment and materials for construction of the system are obtained.

5. Construct the pilot test treatment system utilizing the sketches, equipment and materials list, and guidance provided by AP.
6. Attend a site meeting with AP to verify the pilot test treatment system is constructed as shown on the sketches, and with the appropriate equipment and materials. Sampling procedures will also be outlined at this site meeting.
7. Operate the pilot test treatment system for the duration of each test, and record data as outlined by AP. AP will set up each test and perform water sampling.
8. Perform repairs/adjustments as required. The Owner will purchase all materials for repairs/adjustments.

ADDITIONAL ENGINEERING SERVICES

In addition to the general engineering services described above, the following services may be provided by AP when requested by the Owner in writing, as required. If additional services are requested, the scope and fees will be added by amendment to this SOW or under a separate Work Order.

1. If requested, AP may assist the Owner with construction of the pilot test treatment system.
2. Compile all testing results and project conclusions into a pilot study report.
3. Redesign work when requested to do so by the Owner. Such work shall include changes in the design that are beyond the control of AP.

FEE ESTIMATE

The estimated fee for "General Engineering Services" outlined herein is approximately $10,000 to $15,000 on a time and materials basis, plus direct reimbursable expenses. This amount shall not be exceeded without notification to and approval by the Owner.

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WATER QUALITY ANALYTES

Type	Parameter	Units
General	Conductivity	µS/cm
	Dissolved Oxygen	mg/L
	ORP	mV
	pH	unitless
	Temperature	degC
	Total Dissolved Solids	mg/L
Cations	Calcium	mg/L
	Magnesium	mg/L
	Potassium	mg/L
	Sodium	mg/L
Anions	Alkalinity, Total as $CaCO_3$	mg/L
	Bicarbonate	mg/L
	Carbonate	mg/L
	Chloride	mg/L
	Sulfate	mg/L
Redox Species	Iron, Dissolved	mg/L
	Iron, Total	mg/L
	Manganese, Dissolved	mg/L
	Manganese, Total	mg/L
	Nitrate + Nitrite	mg/L
	Nitrate as N	mg/L
	Nitrite as N	mg/L
Metals	Aluminum	mg/L
	Antimony	mg/L
	Arsenic	mg/L
	Barium	mg/L
	Beryllium	mg/L
	Cadmium	mg/L
	Chromium	mg/L
	Copper	mg/L
	Lead	mg/L
	Mercury	mg/L
	Nickel	mg/L
	Selenium	mg/L
	Silver	mg/L
	Thallium	mg/L
	Zinc	mg/L
Other Parameters	Color	c.u.
	Corrosivity	--
	Cyanide	mg/L
	Fluoride	mg/L
	Odor	ton
	Silica	mg/L
	Total Organic Carbon	mg/L
	Total Suspended Solids	mg/L

Type	Parameter	Units
Disinfection Byproducts	Bromate	mg/L
	Bromodichloromethane	mg/L
	Bromoform	mg/L
	Total Chlorine	mg/L
	Free Chlorine	mg/L
	Chlorite	mg/L
	Chloroform	mg/L
	Dibromoacetic Acid	mg/L
	Dibromochloromethane	mg/L
	Dichloroacetic Acid	mg/L
	Monobromoacetic Acid	mg/L
	Monochloroacetic Acid	mg/L
	Total Haloacetic Acids	mg/L
	Total Trihalomethanes	mg/L
	Trichloroacetic Acid	mg/L

Notes:

Unless otherwise notes, all values are the dissolved portion

-- Not Tested

Abbreviations:

$CaCO_3$ = calcium carbonate

c.u. = color unit

degC = degrees Celsius

mg/L = milligrams per liter

mV = millivolt

N = nitrogen

ORP = oxidation reduction potential

µS/cm = microsiemens per centimeter

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Attachment C – Storage Volume Calculation

Fatal flaws related to the volume of water that can be stored in the Basalt Well were evaluated by comparing the volume of water that has been pumped from the Basalt Well during past irrigation seasons to the volume of water that we anticipate can be stored in the Basalt Well.

Volume of Water Pumped From the Basalt Well

Table C.1 lists the volumes of water that have been pumped from the Basalt Well since 2014, based on data from the Oregon Water Resources Department (OWRD) online Water Use Reporting database.

Table C.1. Basalt Well Water Use

Water Year	Months Pumped	Water Pumped (acre-feet)
2017	May to October	75.18
2016	April to October	179.80
2015	April to October	Uncertain
2014	July to September	276.83

As shown in Table C.1, the volume of water pumped from the Basalt Well during past irrigation seasons has ranged from about 75 acre-feet (ac-ft) to 277 ac-ft.

Volume of Water That Can Be Stored in the Basalt Well

The volume of water that can be stored in the Basalt Well is a function of the number of days that water is injected, the well's specific capacity, and the available headroom in the well. Because the water level in the Basalt Well varies about 100 feet during the year (from 88 feet in March to 175 feet in October), there is significant uncertainty in the available headroom. Therefore, we calculated a range of injection volumes using the range in available headrooms.

Table C.2 shows the volume of water that we anticipate can be stored in the Basalt Well. The following assumptions were used to calculate the storage volume:

- The recharge rate is limited to 75% of the pumping rate at the Basalt Well, so that the Basalt Well is pumped at a higher rate than water is recharged. Pumping at a higher rate during recovery imparts more energy into the aquifer and removes materials introduced during injection that could clog the well. Based on the pumping rate of 522 gpm observed during the October 2017 pumping test, the injection rate is limited to 365 gpm.
- The Basalt Well is recharged from December 1 through March 31 (121 days), and operates constantly.
- Available headroom ranges from 88 feet (the depth to water in the Basalt Well measured on March 23, 2016) to 175 feet (the depth to water in the Basalt Well measured on October 24, 2017).
- The specific capacity used in the injection volume calculation was based on the assumption that specific capacity during injection is the same as specific capacity during pumping. Therefore, specific capacity can be estimated based on the 24 hour constant rate pumping test at the Basalt

Well. As shown on Figure A.2, the estimate for specific capacity is 1.6 gpm/ft, based on a drawdown of 325 feet after 120 days of pumping at 522.5 gpm.

Table C.2. Basalt Well Storage Volume.

Recharge Period (days)	Available Headroom (feet)	Specific Capacity (gpm/ft)	Recharge Rate (gpm)	Storage Volume	
				Millions of Gallons	Acre-Feet
121	88	1.6	140.8	24.7	75.6
121	175	1.6	280	49.0	150.4

We estimate that Rudd Farms can store about 113 acre-feet of water per year in the Basalt Well, which is the median in the range of storage volumes in Table C.2. During recharge, we estimate that the minimum injection rate is likely to be 141 gallons per minute, and the maximum injection rate is likely to be 280 gallons per minute.

Fatal Flaws Evaluation

Because the volume of the water that can be stored in the Basalt Well (113 acre-feet) is the same order of magnitude as the volume of water that has been pumped from the Basalt Well during previous irrigation seasons (between 75 acre-feet and 277 acre-feet), we find that storage volume is not a fatal flaw to ASR at Rudd Farms.

Attachment D – Geochemical Mixing Evaluation

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S.S. PAPADOPULOS & ASSOCIATES, INC.
Environmental & Water-Resource Consultants

Memorandum

Date: December 6, 2017

From: Brad Bessinger

To: Matt Kohlbecker, GSI Water Solutions, Inc.

Project: Rudd Farms Phase II ASR

Subject: **Water Quality Mixing Evaluation**

This memorandum summarizes an evaluation of water chemistry data for a potential Aquifer Storage and Recovery (ASR) system located at Rudd Farms, Oregon. Included is an evaluation of potential changes in water quality caused by mixing native groundwater with groundwater injected from an overlying, alluvial aquifer. Also included is an assessment of mineral precipitation reactions that could potentially occur in the ASR system.

Methodology

A summary of water chemistry data for native groundwater and proposed injection water (alluvial source groundwater) was provided in spreadsheet format by GSI Water Solutions (GSI) (Table 1). As shown in the table, concentrations of total dissolved solids (TDS) in both native (deep) and alluvial groundwater are relatively low, with no primary maximum contaminant level (MCL) exceedances for any constituent. Manganese concentrations in alluvial source groundwater (0.15 mg/L) are higher than secondary MCLs (0.05 mg/L). Also, fluoride concentrations and pH in native groundwater slightly exceed secondary MCLs.

The USGS-supported geochemical model PHREEQC (Parkhurst and Appelo 1999) was used to calculate the effect of water mixing on (1) the concentrations of dissolved constituents in groundwater-injected water mixtures, and (2) mineral saturation indices[1] (SI). The model was run at a constant temperature of native groundwater (51°C), assuming the temperature of injected water is buffered by the aquifer at the same temperature as native groundwater. Model results were reported as a function of the percentage of alluvial source groundwater contained in the mixture (from 0 to 100%).

[1] As concentrations of dissolved aqueous species that comprise a particular mineral increase, the tendency for that mineral to precipitate out of groundwater is enhanced. This tendency is defined mathematically by a value called the saturation index (SI), which is expressed on a logarithmic scale as the ratio of the concentration of ions in solution to the concentration required for mineral precipitation to occur. SI values greater than or equal to zero represent groundwater that is saturated or supersaturated (under these conditions, there is a thermodynamic driving force for mineral precipitation to occur). Conversely, values less than zero imply that a mineral is unstable, and if present in aquifer soils, will dissolve into groundwater

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Predicted Water Quality

Table 2 compares model-predicted constituent concentrations in mixed groundwater to primary and secondary MCLs. The mixing of native groundwater with injected, alluvial groundwater results in the exceedance of the secondary MCL for manganese when alluvial source groundwater comprises more than 30% of the mixture. This exceedance is due to the presence of naturally-occurring manganese in alluvial groundwater. Fluoride concentrations and pH are predicted to be less than secondary MCLs for mixtures that contain more than 30% alluvial groundwater.

Predicted Mineral Saturation Indices

The saturation states of water mixtures with respect to selected minerals are summarized at the bottom of Table 2. Results include the following:

- Silica (SiO_2) Minerals: Groundwater is close to equilibrium with several silica polymorphs, including quartz, chalcedony, and SiO_2(am) (SI values ± 1.0). Although quartz has the most-positive SI value, it is unlikely to precipitate. This is because quartz precipitation kinetics are extremely slow, and its precursor is SiO_2(am), which has negative SI values. In summary, silica precipitation is not predicted.

- Carbonate Minerals: Native groundwater is greatly undersaturated with respect to carbonate minerals (negative SI values for calcite and dolomite). This indicates there is likely an absence of these minerals in the ASR aquifer. By contrast, mixtures containing native groundwater and alluvial source groundwater are supersaturated with respect to carbonate minerals, with maximum SI values for calcite and dolomite predicted to be 0.5 and 2.2, respectively (for a mixture consisting of 60% alluvial source groundwater). The positive SI values predicted by the model indicate there is a potential for scale formation to occur in the ASR system. This potential is largely driven by the relatively-high pH of native and alluvial groundwater[2].

  Although carbonate scale formation is possible, precipitation is inhibited by the large nucleation energy required to form new minerals. For example, SI values required for calcite nucleation and crystal growth range from 1.3 to 2.5 (Morse et al., 2007; Lebron and Suarez, 1996), which are higher than predicted by the model. Also, dolomite requires greater supersaturation for mineral precipitation. For example, seawater does not precipitate dolomite even though SI values are higher than 2.4, and it has been reported that dolomite precipitation in laboratory conditions typically requires temperatures between 100 and 300°C. Modern dolomite is only believed to be forming from high ionic

[2] CO_2(g) exsolution may occur during groundwater recovery, which would further increase pH (up to 8.8). The model predicts that exsolution would increase SI values for calcite and dolomite to 0.9 and 3.1, respectively.

strength solutions that are typically derived from the evaporation of seawater or lakes in arid regions.

In summary, some calcium carbonate (calcite) mineral precipitation is possible due to alkaline (high pH) groundwater; however, there is uncertainty in this prediction because the calculated SI values are less than those that have been reported to be necessary for nucleation and mineral growth.

- Iron and Manganese Minerals: Iron oxyhydroxide, $Fe(OH)_3(am)$, is a very insoluble mineral that is known to precipitate in ASR and injection well systems (due to the oxidation/conversion of ferrous iron to ferric iron). There is a potential for mineral precipitation and/or biofouling by Fe-related bacteria in the proposed ASR system based on (1) the occurrence of ferrous iron in groundwater (Table 1), and (2) positive saturation indices predicted for $Fe(OH)_3(am)$ during mixing (Table 2). In addition, there is a potential for reduced manganese in groundwater to be oxidized and precipitate as pyrolusite, bixbyite, and/or hausmannite (as shown in Table 2, the SI values for each of these minerals is positive due to the presence of dissolved oxygen in the groundwater[3]).

  Although some iron and manganese oxyhydroxide precipitation is possible, the amount is likely to be small, based low concentrations of ferrous iron and manganese in the aquifer[4]. Therefore, it is unlikely that these minerals will significantly affect injection well operations through clogging[5]. Supporting evidence for a lack of clogging is provided in Table 3, which summarizes water quality from other regional ASR systems with similar iron and manganese concentrations, and no reported issues associated with mineral precipitation.

Conclusions and Recommendations

[3] This assumes that there was no oxygen introduced during sampling and that the relatively-low dissolved oxygen concentrations measured by the YSI Multi Parameter Meter (with flow-through cell) are accurate. Because the instrument was calibrated prior to use, and DO stabilized prior to sampling, values in Table 1 are assumed accurate.

[4] It is important to note that the aquifer likely contains some oxygen demand in the form of reduced minerals and organics. This demand will compete with dissolved manganese and iron for the available oxygen, thereby reducing the amount precipitated.

[5] In view of the predicted potential for iron and manganese precipitation, it is of interest to estimate the possible volume of precipitates that could form to evaluate whether this could pose a concern for clogging. The highest detected iron and manganese concentrations (0.13 mg/L and 0.15 mg/L, respectively, Table 1) were used to evaluate a worst-case scenario. If all the iron and manganese present in 1 liter of groundwater were to be precipitated as amorphous $Fe(OH)_3$ (density = 3.13 g/cm^3) or birnessite (density = 3.0 g/cm^3), they would occupy a total volume of less than 0.0005% of the pore volume occupied by the groundwater. This suggests that the levels of iron and manganese present in groundwater have a low potential for aquifer clogging.

No detrimental water quality changes are predicted to be caused by operation of the ASR system; however, there is some potential for mineral precipitation to occur. In the case of iron and manganese oxyhydroxides, precipitation is predicted to be minor and not affect system performance. In the case of calcite scale formation, although the model predicts that precipitation is possible, the predicted SI values are less reportedly required for nucleation and growth of calcite, and no precipitation is expected.

References

Lebron, I., and D.L. Suarez. 1996. Calcite nucleation and precipitation kinetics as affected by dissolved organic carbon. *Geochim. Cosmochim. Acta* 60:2765-2776.

Morse, J.W., R.S. Arvidson, and A. Lüttge. 2007. Calcium carbonate formation and dissolution. *Chem. Rev.* 107:342-381.

Parkhurst, D.L. and C.A.J. Appelo. 1999. User's guide to PHREEQC (Version 2)—A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. U.S. Geological Survey Water Resources Investigations Report 99-4259.

Table 1. Summary of Water Quality of Waters Used in Mixing Analysis

Type	Parameter	Units	Primary MCL	Secondary MCL	Native Groundwater	Alluvial Source Groundwater
General	Conductivity	us/cm			355	217
	Dissolved Oxygen	mg/L			0.07	0.82
	ORP	mV			-168.1	-92.5
	pH	unitless		6.5-8.5	8.65	8.03
	Temperature	degC			51	14
	Total Dissolved Solids	mg/L		500	260	180
Cations	Calcium	mg/L			< 1	17
	Magnesium	mg/L			< 0.1	6.9
	Potassium	mg/L			4.5	4
	Sodium	mg/L			74	20
Anions	Alkalinity, Total as CaCO3	mg/L			140	120
	Carbonate	mg/L			6.6	< 2
	Chloride	mg/L		250	15	1.2
	Sulfate	mg/L		250	9.3	1.7
Redox Species	Iron, Dissolved	mg/L		0.3	< 0.02	0.13
	Iron, Total	mg/L		0.3	< 0.02	0.16
	Manganese, Dissolved	mg/L		0.05	0.0046	0.15
	Manganese, Total	mg/L		0.05	<0.01	0.14
	Nitrate + Nitrite	mg/L			< 0.1	< 0.1
	Nitrate as N	mg/L	10		< 0.1	< 0.1
	Nitrite as N	mg/L	1		< 0.05	< 0.05
Metals	Aluminum	mg/L		0.05 to 2	< 0.02	< 0.02
	Antimony	mg/L	0.006		< 0.001	< 0.001
	Arsenic	mg/L	0.01		0.0026	0.0015
	Barium	mg/L	2		0.015	0.077
	Beryllium	mg/L	0.004		< 0.001	< 0.001
	Cadmium	mg/L	0.005		< 0.0005	< 0.0005
	Chromium	mg/L	0.1		< 0.001	< 0.001
	Copper	mg/L	1.3	1	< 0.002	< 0.002
	Lead	mg/L	0.015		< 0.0005	< 0.0005
	Mercury	mg/L	0.002		< 0.0002	< 0.0002
	Nickel	mg/L			< 0.005	< 0.005
	Selenium	mg/L	0.05		< 0.005	< 0.005
	Silver	mg/L		0.1	< 0.0005	< 0.0005
	Thallium	mg/L	0.002		< 0.001	< 0.001
	Zinc	mg/L		5	< 0.02	< 0.02
Other Parameters	Color	c.u.		15	5	3
	Corrosivity	--		NC	-0.76	0.18
	Cyanide	mg/L	0.2		0.066	0.045
	Fluoride	mg/L	4	2	3.1	0.2
	Odor	ton		3	2	2
	Silica	mg/L			110	60
	Total Organic Carbon	mg/L			0.97	0.5
	Total Suspended Solids	mg/L			< 10	< 10
Disinfection Byproducts (DBPs)	Bromodichloromethane	mg/L	0.08*		< 0.0005	< 0.0005
	Bromoform	mg/L	0.08*		< 0.0005	< 0.0005
	Chloroform	mg/L	0.08*		< 0.0005	< 0.0005

Notes

- Unless otherwise notes, all values are the dissolved portion

-- = Not Tested

NC = Noncorrosive

* Primary MCL for total trihalomethanes

Table 2. Summary of Mixing Calculations (Native Groundwater + Alluvial Source Groundwater)

			Primary	Secondary					Alluvial Source Groundwater						
Type	Parameter	Units	MCL	MCL	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
General	Dissolved Oxygen	mg/L			0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8
	Eh	mV			626	633	639	644	649	653	659	664	670	677	684
	pH	s.u.		6.5-8.5	8.6	8.6	8.6	8.5	8.5	8.4	8.4	8.3	8.2	8.1	8.0
	Temperature	degC			51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1	51.1
	Total Dissolved Solids	mg/L		500	388	375	362	349	336	323	310	297	284	271	258
Cations	Calcium	mg/L			ND	1.7	3.4	5.1	6.8	8.5	10.2	11.9	13.6	15.3	17.0
	Magnesium	mg/L			ND	0.7	1.4	2.1	2.8	3.5	4.1	4.8	5.5	6.2	6.9
	Potassium	mg/L			4.5	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.1	4.1	4.0
	Sodium	mg/L			74.0	68.6	63.2	57.8	52.4	47.0	41.6	36.2	30.8	25.4	20.0
Anions	Bicarbonate	mg/L			170.9	168.5	166.0	163.6	161.1	158.7	156.3	153.8	151.4	148.9	146.5
	Chloride	mg/L		250	15.0	13.6	12.2	10.9	9.5	8.1	6.7	5.3	4.0	2.6	1.2
	Sulfate	mg/L		250	9.3	8.5	7.8	7.0	6.3	5.5	4.7	4.0	3.2	2.5	1.7
Redox Species	Iron, Dissolved	mg/L		0.3	ND	0.013	0.026	0.039	0.052	0.065	0.078	0.091	0.104	0.117	0.130
	Manganese, Dissolved	mg/L		0.05	0.005	0.019	0.034	0.048	0.063	0.077	0.092	0.106	0.121	0.136	0.150
	Nitrate as N	mg/L	10		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Nitrite as N	mg/L	1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metals	Aluminum	mg/L		0.05 to 2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Antimony	mg/L	0.006		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Arsenic	mg/L	0.01		0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	Barium	mg/L	2		0.015	0.021	0.027	0.034	0.040	0.046	0.052	0.058	0.065	0.071	0.077
	Beryllium	mg/L	0.004		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Cadmium	mg/L	0.005		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chromium	mg/L	0.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Copper	mg/L	1.3	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Lead	mg/L	0.015		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mercury	mg/L	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Selenium	mg/L	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Silver	mg/L		0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Thallium	mg/L	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Zinc	mg/L		5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Other Parameters	Fluoride	mg/L	4	2	3.1	2.8	2.5	2.2	1.9	1.7	1.4	1.1	0.8	0.5	0.2
	Silica	mg/L			110	105	100	95	90	85	80	75	70	65	60
	Total Organic Carbon	mg/L			1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5
Disinfection Byproducts (DBPs)	Bromate	mg/L	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chlorine	mg/L	4		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chlorite	mg/L	1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Total Haloacetic Acids	mg/L	0.06		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Total Trihalomethanes	mg/L	0.08		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Saturation Index	Quartz	unitless			0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
	Chalcedony	unitless			0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3
	SiO2(am)	unitless			-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.5
	Calcite	unitless			-100	0.0	0.2	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.4
	Dolomite	unitless			-100	1.1	1.6	1.9	2.1	2.1	2.2	2.2	2.1	2.0	1.9
	Gypsum	unitless			-100	-4.17	-3.90	-3.77	-3.69	-3.64	-3.62	-3.63	-3.66	-3.72	-3.83
	Siderite	unitless			-100	-10.0	-9.7	-9.4	-9.3	-9.1	-8.9	-8.8	-8.6	-8.4	-8.3
	Fe(OH)3(am)	unitless			-100	2.8	3.1	3.3	3.5	3.6	3.8	3.9	4.0	4.1	4.1
	Pyrolusite	unitless			8.0	8.6	8.8	8.9	9.0	9.1	9.1	9.2	9.2	9.2	9.1
	Bixbyite	unitless			9.9	10.9	11.2	11.4	11.5	11.7	11.7	11.8	11.8	11.7	11.6
	Hausmannite	unitless			9.4	10.8	11.3	11.5	11.7	11.9	12.0	12.0	12.0	11.9	11.7
	Rhodochrosite	unitless			-1.2	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	-0.1	0.0	0.0

Table 3.Water Quality Data for Select Columbia River Basalt Wells

Analyte	Unit	Regulatory Standard	Regulatory Criteria	City of Beaverton (Hanson Well) ASR 1 (WASH 8988)	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 10	City of Tigard ASR 1	City of Tigard ASR 2	Grabhorn Well	TVWD Miller Hill Road Well	Cornelius Test Well
Date Sampled				7/14/1994	3/18/2004	11/29/2001	8/4/2004	5/15/2003	10/21/2011	1/20/2015
Alkalinity	mg/L	250	SMCL	110	NT	109	139	135	100	140
Calcium	mg/L	None	None	36	58	25	26.1	23.4	15	31
Chloride	mg/L	250	SMCL	47.5	210	3.7	16	3.86	3.5	380
Total Hardness, as CaCO3	mg/L	250	SMCL	140	256	108	120	107	70	120
Bicarbonate (HCO3)	mg/L	None	None	110	NT	133	139	138	120	170
Potassium	mg/L	None	None	2.6	7.9	3	5.3	2.8	2.6	30
Magnesium	mg/L	None	None	19	27	11	13.7	11.9	7.7	10
Manganese Total	mg/L	0.05	SMCL	NT	0.085	0.0024	0.14	ND	0.021	0.14
Manganese Dissolved	mg/L	None	None	NT	NT	NT	0.14	0.01	ND	0.15
Iron Total	mg/L	0.3	SMCL	ND	0.12	ND	0.13	ND	0.18	0.15
Iron Dissolved	mg/L	None	None	NT	NT	NT	ND	NT	ND	0.16
Fluoride	mg/L	2	SMCL	ND	NT	0.09	ND	0.11	0.18	1.2
Sodium	mg/L	20	URC (advisory)	12.1	73	8.2	21.3	13.3	20	220
Nitrite as N	mg/L	1	MCL	0	NT	ND	ND	ND	ND	ND
Nitrate as N	mg/L	10	MML	0.56	NT	1.7	0.9	0.09	ND	ND
Silica	mg/L	None	None	NT	NT	NT	55.1	66.5	59	66
Sulfate	mg/L	250	URC, SMCL	ND	NT	4.3	ND	2.33	2.3	ND
Total Dissolved Solids	mg/L	500	SMCL	245	530	200	220	210	150	870
Total Organic Carbon	mg/L	None	None	0.7	NT	NT	ND	ND	ND	0.54
Total Suspended Solids	mg/L	None	None	ND	NT	NT	ND	NT	ND	ND
Field pH	Units	6 - 8.5	None	6.88	6.78	6.78	7.14	7.2	7.45	7.53
Field Temperature	Celsius	None	None	NT	15.7	11.7	15.2	14.4	15.7	19.7
Field Specific Conductance	umho/cm	None	None	377	902	NT	349	252	218	957
Field Dissolved Oxygen	mg/l	None	None	4.2	6.3	6.98	1.5	NT	1.86	0.39
Odor	TON	3	SMCL	NT	NT	NT	NT	ND	1	ND
Radon 222	pCi/l	300 or 4000	Proposed MCL	NT	NT	NT	NT	NT	330	460
Field Oxidation-Reduction Potential	mV	None	None	NT	NT	NT	NT	72.9	NT	-89.8

Footnotes:

Analytical data shown in shading exceed the applicable regulatory standard
ND = not detected
NT = not tested
SMCL = Secondary Maximum Contaminant Levels -- Federal Regulations
MCL = Maximum Contaminant Levels -- Federal Regulations
MML = Maximum Measurable Level -- Oregon Department of Environmental Quality
URC = Oregon Health Authority Unregulated Contaminants
mg/l = milligrams per liter
umhos/cm = micromhos per centimeter
Celsius (C = 5/9 (F - 32))

Attachment E – Cooper Jacob Calculations

Cooper Jacob Equation (Confined)

(Equation 7-50 of Fetter, pg. 224, 1988)

$$\Delta s=[(2.303*Q)/(4*\pi*T)]*\log[(2.25*T*t)/(r^2*S)]$$

Input Parameters		
K	NA	ft/day
b	NA	ft
T	3,621	ft^2/day
Q	53,900	ft^3/day
S	0.00005	ft/ft
t	121	day

Calculators				
Q	280	gpm is	53,900	ft^3/d
T	0	ft^2/d	0	gpd/ft
T	27089	gpd/ft	3,621.0	ft^2/d

Well	r (feet)	Δs (feet)	u (<0.01) (dimensionless)
UNIO 50763	5,808	7.551515	0.0010
UNIO 50687	10,560	6.134231	0.0032
UNIO 50684	11,088	6.018565	0.0035
UNIO 2046	19,536	4.675819	0.0109
UNIO 52334	21,648	4.432458	0.0134
UNIO 50683	22,176	4.37533	0.0140
UNIO 271	22,704	4.319547	0.0147
UNIO 273	22,704	4.319547	0.0147
UNIO 174	22,704	4.319547	0.0147
UNIO 325	23,232	4.265046	0.0154
UNIO 173	23,232	4.265046	0.0154
UNIO 208	27,984	3.823856	0.0223
UNIO 50833	27,984	3.823856	0.0223

Appendix B: AR Limited License Application and Land Use Compatibility Statement

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)
Brett Rudd				541-962-9522
PHONE (WK) 541-910-1812	CELL 541-910-1812			FAX None
ADDRESS 62913 Wallsinger Road				
CITY Cove	STATE OR	ZIP 97824	E-MAIL * ruddfarms@gmail.com	

Agent Information

NAME	PHONE	FAX
Matt Kohlbecker	971-200-8531	
ADDRESS 55 SW Yamhill Street, Suite 200		CELL 503-877-8086
CITY Portland; STATE OR; ZIP 97204	E-MAIL * mkohlbecker@gsiws.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:** Groundwater from Well 1 a tributary of Wright Slough Basin
2. **AMOUNT OF WATER** to be diverted;
   Maximum and instantaneous rate (cubic feet or gallons per minute): 350 gpm
   Total volume (gallons or acre-feet): 243,900,000 gallons per year. If water is to be used from more than one source, give the quantity from each: NA
3. **INTENDED USE(S) OF WATER:** (check all that apply)
   - ☐ Road construction or maintenance
   - ☐ General construction
   - ☐ Forestland and rangeland management; o
   - x☐ Other: Artificial 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 attached map and supplemental report describing project. Water will be diverted from Well 1 at rates up to 0.78 cfs, and will be conveyed through the systems shown on the accompanying limited license application map. Additional information about Well 1 is documented in certificate 90977 and UNIO 51770. The lengths and dimensions of the supply pipelines and locations where water will be used for artificial recharge are shown on the accompanying limited license application map.
5. **PROJECT SCHEDULE:** (List day, month, and year)
   Date water use will begin: Date of LL issuance
   Date water use will be completed: 5 years from date of LL issuance

   Months of the year water would be diverted and used: 5 years from date of LL issuance

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

[signature] Applicant Signature — Brett Rudd Print Name *and title if applicable* — 11/25/19 Date

PLEASE READ CAREFULLY

NOTE: A completed water availability statement from the local watermaster, Land Use Information Form completed by the local Planning Department, fees and site map meeting the requirements of OAR 690-340-030 must accompany this request. The fee for this request is **$280** for the first point of diversion plus **$30** for each additional point of diversion. Please review the Department's fee schedule to view fees required to request a limited license for Aquifer Storage and Recovery testing purposes or for Artificial Groundwater Recharge testing purposes.

Failure to provide any of the required information will result in return of your application. The license, if granted, will not be issued or replaced by a new license for a period of more than five consecutive years. The license, if granted, will be subordinate to all other authorized uses that rely upon the same source, or water affected by the source, and may be revoked at any time it is determined the use causes injury to any other water right or minimum perennial streamflow.

If water source is well, well logs or adequate information for the Department to determine aquifer, well depth, well seal and open interval, etc. are required. The licensee shall indicate the intended aquifer. If for multiple wells, each map location shall be clearly tired to a well log.

If a limited license is approved, the licensee shall give notice to the Department (Watermaster) at least 15 days in advance of using the water under the Limited License and shall maintain a record of use. The record of use shall include, but need not be limited to, an estimate of the amount of water used, the period of use and the categories of beneficial use to which the water is applied. During the period of the Limited License, the record of use shall be available for review by the Department upon request.

**A summary of review criteria and procedures that are generally applicable to these applications is available at: http://www.oregon.gov/owrd/pages/pubs/forms.aspx*

Mapping Requirements (OAR 690-340-0030):

(1) A request for a limited license shall be submitted on a form provided by the Water Resources Department, and shall be accompanied by the following:

a. A site map of reproducible quality, drawn to a standard, even scale of not less than 2 inches = 1 mile, showing:

i. The locations of all proposed points of diversion referenced by coordinates or by bearing and distance to the nearest established or projected public land survey corner;

ii. The general course of the source for the proposed use, if applicable;

iii. Other topographical features such as roads, streams, railroads, etc., which may be helpful in locating the diversion points in the field.

REMARKS:

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For WRD Use Only

This page to be completed by the local Watermaster.

WATER AVAILABILITY STATEMENT

Name of Applicant: Brett Rudd Limited License Number: ____________

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

☐ Yes ☐ 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?

☐ Yes ☐ No

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

☐ Yes ☐ 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?

☐ Yes ☐ No ☐ N/A

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

5. Any other recommendations you would like to make?

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Signature ______________________ WM District #: ____ 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

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 <u>**all**</u> 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; <u>and</u>
   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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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: Brett (First) Rudd (Last)

Mailing Address: 62913 Wallsinger Road

Cove (City) OR (State) 97824 (Zip) Daytime Phone: 541-910-1812

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:
2S	39E	30		2S39000011800	EFU	☒ Diverted ☒ Conveyed ☐ Used	Artificial
2S	39E	20		2S39000008500	EFU	☐ Diverted ☒ Conveyed ☒ Used	Groundwater
2S	39E	29		2S39000011300	EFU	☐ Diverted ☒ Conveyed ☐ Used	Recharge
						☐ Diverted ☐ Conveyed ☐ Used	

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

Union County

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) ____________

Estimated quantity of water needed: 350 ☐ 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 Artificial Groundwater Recharge

Briefly describe:

An application for a limited water use license is being submitted to the Oregon Water Resources Department requesting to use water from Rudd Farms Irrigation Well No. 1 for artificial groundwater recharge.

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. ⟶

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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): UCZPSO Sec. 2.02

☐ 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:	
Ministerial	UCZPSO Sec. 2.02	☒ 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: Stacy Warren Title: Associate Planner

Signature: Stacy Warren Phone: 541-963-1014 Date: Feb. 7, 2019

Government Entity: Union County Planning Dept.

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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This page to be completed by the local Watermaster.

WATER AVAILABILITY STATEMENT

Name of Applicant: Brett Rudd Limited License Number: LL-1811

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

☒ Yes ☐ No

If yes, please explain:

Surface water sources, particularly Grande Ronde river is regulated annually in the months of July - September.

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?

☒ Yes ☐ No

It is not clear the extent to which ground water appropriation might impact surface water sources outside the proposed diversion period December to April 14

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

☒ Yes ☐ No

If yes, what are your observations for the stream?

Demand is low except the months of June thru october. Flow levels are typically low December until the middle of February. Flows are typically high from the middle of February thru April.

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?

likely but unknown ☐ Yes ☐ No ☐ N/A

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

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5. Any other recommendations you would like to make?

Signature Shad Hattan WM District #: 6 Date: 1/10/20

Appendix C: OWRD Water Availability Analysis

Water Availability Analysis

GRANDE RONDE R > SNAKE R - AB WILLOW CR
GRANDE RONDE BASIN

Water Availability as of 2/11/2019

Watershed ID #: 30810407 (Map)
Date: 2/11/2019

Exceedance Level: 50%
Time: 2:50 PM

Water Availability | Limiting Watersheds | Complete Water Availability Analysis

Water Availability

Select any Watershed for Details

	Nesting Order	Watershed ID #	Stream Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sto
Select	1	227	GRANDE RONDE R> SNAKE R- AT MOUTH	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes
Select	2	228	GRANDE RONDE R> SNAKE R- AB SHEEP CR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes
Select	3	30810416	GRANDE RONDE R> SNAKE R- AB WALLOWA R	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes
Select	4	30810406	GRANDE RONDE R> SNAKE R- AB GORDON CR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes
Select	**5**	**30810407**	**GRANDE RONDE R> SNAKE R- AB WILLOW CR**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**No**	**Yes**	**No**	**Yes**	**Yes**

Download Data (Text - Formatted , Text - Tab Delimited , Excel)

Appendix D: Groundwater Quality Results – Well No. 1 and Basalt Well

Table 1

Laboratory Analytical Results

Rudd Farms - Phase II ASR Evaluation

Sample Location / *Lab*	Rudd Farms / Eaton Analytical — Standard	Criteria	Unit	**Source Water** Well No. 1 10/18/2017	**Native Groundwater** Basalt Well 10/17/2017
Geochemical and Inorganic Constituents					
Alkalinity			mg/L	120	140
Antimony (Dissolved)			mg/L	< 0.01	< 0.001
Antimony (Total)	0.006	MCL	mg/L	< 0.01	< 0.001
Aluminum (Dissolved)			mg/L	< 0.02	< 0.02
Aluminum (Total	0.05 - 0.2	SMCL	mg/L	< 0.02	< 0.02
Arsenic (Dissolved)			mg/L	0.0015	0.0026
Arsenic (Total)	0.01	MCL	mg/L	0.0015	0.0024
Barium (Dissolved)			mg/L	0.077	0.015
Barium (Total)	2	MCL	mg/L	0.079	0.015
Beryllium (Dissolved)			mg/L	< 0.001	< 0.001
Beryllium (Total)	0.004	MCL	mg/L	< 0.001	< 0.001
Bicarbonate as $CaCO_3$			mg/L	140	160
Cadmium (Dissolved)			mg/L	< 0.0005	< 0.0005
Cadmium (Total)	0.005	MCL	mg/L	< 0.0005	< 0.0005
Calcium (Dissolved)			mg/L	17	< 1
Calcium (Total)			mg/L	18	< 1
Carbonate as $CaCO_3$			mg/L	< 2	6.6
Chloride	250	SMCL	mg/L	1.2	15
Chromium (Dissolved)			mg/L	< 0.001	< 0.001
Chromium (Total)	0.1	MCL	mg/L	< 0.001	< 0.001
Copper (Dissolved)			mg/L	< 0.002	< 0.002
Copper (Total)	1.3	MCL	mg/L	0.0036	< 0.002
Cyanide (Total)	0.2	MCL	mg/L	0.045	0.066
Fluoride (Total)	2	MCL, MML, SMCL	mg/L	0.2	3.1
Hardness (as $CaCO_3$)			mg/L	73	< 3
Iron (Dissolved)			mg/L	0.13	< 0.02
Iron (Total)	0.3	SMCL	mg/L	0.16	< 0.02
Langelier Index - 25 degree				0.18	-0.76
Lead (Dissolved)			mg/L	< 0.0005	< 0.0005
Lead (Total)	0.015	MCL	mg/L	0.00087	< 0.0005
Magnesium (Dissolved)			mg/L	6.9	< 0.1
Magnesium (Total)			mg/L	6.9	< 0.1
Manganese (Dissolved)			mg/L	0.15	0.0046
Manganese (Total)	0.05	SMCL	mg/L	**0.14**	0.0046
Mercury (Dissolved)			mg/L	< 0.0002	< 0.0002
Mercury (Total)			mg/L	< 0.0002	< 0.0002
Nitrite as N	1	MCL	mg/L	< 0.05	< 0.05
Nitrate as N	10	MCL	mg/L	< 0.1	< 0.1
Nickel (Dissolved)			mg/L	< 0.005	< 0.005
Nickel (Total)			mg/L	< 0.005	< 0.005
pH of CaCO3 saturation			--	8.03	8.65
Potassium (Dissolved)			mg/L	4	4.5
Potassium (Total)			mg/L	4	4.7
Selenium (Dissolved)			mg/L	< 0.005	< 0.005
Selenium (Total)			mg/L	< 0.005	< 0.005
Silica (Dissolved)			mg/L	60	110
Silica (Total)			mg/L	53	110
Silver (Dissolved)			mg/L	< 0.0005	< 0.0005
Silver (Total)			mg/L	< 0.0005	< 0.0005
Sodium (Dissolved)			mg/L	20	74
Sodium (Total)			mg/L	20	77
Sulfate	250	SMCL	mg/L	1.7	9.3
Total Nitrate-Nitrite			mg/L	< 0.1	< 0.1
Thallium (Dissolved)			mg/L	< 0.001	< 0.001
Thallium (Total)	0.002	MCL	mg/L	< 0.001	< 0.001
Total Dissolved Solids	500	SMCL	mg/L	180	260
Total Hardness			mg/L	73	< 3
Total Organic Carbon			mg/L	0.5	0.97
Total Suspended Solids			mg/L	< 10	< 10
Zinc (Dissolved)			mg/L	< 0.02	< 0.02
Zinc (Total)	5	SMCL	mg/L	< 0.02	< 0.02

GSI Water Solutions, Inc.

Sample Location / Lab	Rudd Farms / Eaton Analytical Standard	Criteria	Unit	Source Water Well No. 1 10/18/2017	Native Groundwater Basalt Well 10/17/2017
Disinfection By-Products					
Chloroform (Trichloromethane)			ug/L	< 0.5	< 0.5
Bromodichloromethane			ug/L	< 0.5	< 0.5
Bromoform (Tribromomethane)			ug/L	< 0.5	< 0.5
Dibromochloromethane			ug/L	--	--
Total Trihalomethanes	80	MCL, MML	ug/L	--	--
Bromochloroacetic Acid	*	*	ug/L	--	--
Dibromoacetic Acid			ug/L	--	--
Dichloroacetic Acid			ug/L	--	--
Monobromoacetic Acid			ug/L	--	--
Monochloroacetic Acid			ug/L	--	--
Trichloroacetic Acid			ug/L	--	--
Total Haloacetic Acids	60	MCL	ug/L	--	--
Synthetic Organic Compounds (SOCs)					
2, 4-D	70	MCL, MML	ug/L	< 0.1	< 0.1
2, 4-DB			ug/L	< 2	< 2
2, 4, 5-T			ug/L	< 0.2	< 0.2
2, 4, 5-TP (Silvex)	10	MCL, MML	ug/L	< 0.2	< 0.2
3, 5-Dichlorobenzoic acid			ug/L	< 0.5	< 0.5
3-Hydroxycarbofuran			ug/L	< 0.5	< 0.5
Acifluorfen			ug/L	< 0.2	< 0.2
Alachlor (Alanex)	2	MCL	ug/L	< 0.1	< 0.1
Aldicarb (temik)			ug/L	< 0.5	< 0.5
Aldicarb sulfone			ug/L	< 0.5	< 0.5
Aldicarb sulfoxide			ug/L	< 0.5	< 0.5
Aldrin			ug/L	< 0.01	< 0.01
Atrazine	3	MCL	ug/L	< 0.05	< 0.05
Baygon			ug/L	< 0.5	< 0.5
Bentazon			ug/L	< 0.5	< 0.5
Benzo(a)Pyrene	0.2	MCL	ug/L	< 0.02	< 0.02
BHC-gamma (Lindane)	0.2	MCL, MML	ug/L	< 0.01	< 0.01
Carbaryl			ug/L	< 0.5	< 0.5
Carbofuran	40	MCL	ug/L	< 0.5	< 0.5
Chlordane	2	MCL	ug/L	< 0.1	< 0.1
Dalapon	200	MCL	ug/L	< 1	< 1
Di(2-ethylhexyl)adipate *(adipates)*	400	MCL	ug/L	< 0.6	< 0.6
Di(2-ethylhexyl)phthalate *(phthalates)*	6	MCL	ug/L	2.4	**7.6**
Dibromochloropropane (DBCP)	0.02	MCL	ug/L	< 0.01	< 0.01
Dicamba			ug/L	< 0.1	< 0.1
Dichlorprop			ug/L	< 0.5	< 0.5
Dieldrin			ug/L	< 0.01	< 0.01
Dinoseb	7	MCL	ug/L	< 0.2	< 0.2
Diquat	20	MCL	ug/L	< 0.4	< 0.4
Ethylene Dibromide (EDB)	0.05	MCL	ug/L	< 0.01	< 0.01
Endothall	100	MCL	ug/L	< 5	< 5
Endrin	0.2	MCL, MML	ug/L	< 0.01	< 0.01
Glyphosate	700	MCL	ug/L	< 6	< 6
Heptachlor	0.4	MCL	ug/L	< 0.01	< 0.01
Heptachlor Epoxide	0.2	MCL	ug/L	< 0.01	< 0.01
Hexachlorobenzene (HCB)	1	MCL	ug/L	< 0.05	< 0.05
Hexachlorocyclopentadiene	50	MCL	ug/L	< 0.05	< 0.05
Methomyl			ug/L	< 0.5	< 0.5
Methoxychlor	40	MCL, MML	ug/L	< 0.05	< 0.05
Methiocarb			ug/L	< 0.5	< 0.5
Molinate			ug/L	< 0.1	< 0.1
Paraquat			ug/L	< 2	< 2
Pentachlorophenol	1	MCL	ug/L	< 0.04	< 0.04
Picloram	500	MCL	ug/L	< 0.1	< 0.1
Simazine	4	MCL	ug/L	< 0.05	< 0.05
Thiobencarb (ELAP)			ug/L	< 0.2	< 0.2
Total Polychlorinated Biphenyls (PCBs)	0.5	MCL	ug/L	< 0.1	< 0.1
Toxaphene	3	MCL, MML	ug/L	< 0.5	< 0.5
Vydate (Oxamyl)	200	MCL	ug/L	< 0.5	< 0.5

RECEIVED NOV 27 2020 OWRD — Sample Location / Lab	Rudd Farms Eaton Analytical Standard	Criteria	Unit	**Source Water** Well No. 1 10/18/2017	**Native Groundwater** Basalt Well 10/17/2017
Volatile Organic Compounds (VOCs)					
1, 1-Dichloroethane			ug/L	< 0.5	< 0.5
1, 1-Chloroethylene			ug/L	< 0.5	< 0.5
1, 1-Dichloroethylene	7	MCL, MML	ug/L	< 0.5	< 0.5
1, 1-Dichloropropene			ug/L	< 0.5	< 0.5
1, 2-Dichloroethane (EDC)	5	MCL, MML	ug/L	< 0.5	< 0.5
1, 2-Dichloropropane	5	MCL	ug/L	< 0.5	< 0.5
1, 3-Dichloropropane			ug/L	< 0.5	< 0.5
2, 2-Dichloropropane			ug/L	< 0.5	< 0.5
1, 2, 3-Trichlorobenzene			ug/L	< 0.5	< 0.5
1, 2, 3-Trichloropropane			ug/L	< 0.5	< 0.5
1, 2 ,4-Trichlorobenzene	70	MCL	ug/L	< 0.5	< 0.5
1, 2, 4,-Trimethylbenzene			ug/L	< 0.5	< 0.5
1, 3, 5-Trimethylbenzene			ug/L	< 0.5	< 0.5
1, 1, 1,2-Tetrachloroethane			ug/L	< 0.5	< 0.5
1, 1, 2, 2-Tetrachloroethane			ug/L	< 0.5	< 0.5
1, 1, 1-Trichloroethane	200	MCL, MML	ug/L	< 0.5	< 0.5
1, 1, 2-Trichloroethane	5	MCL	ug/L	< 0.5	< 0.5
2-Butanone (MEK)			ug/L	< 5	< 5
4-Methyl-2-Pentanone			ug/L	< 5	< 5
Benzene	5	MCL, MML	ug/L	< 0.5	< 0.5
Bromobenzene			ug/L	< 0.5	< 0.5
Bromochloromethane			ug/L	< 0.5	< 0.5
Bromoethane			ug/L	< 0.5	< 0.5
Bromomethane (Methyl Bromide)			ug/L	< 0.5	< 0.5
Chlorobenzene (monochlorobenzene)	100	MCL	ug/L	< 0.5	< 0.5
Carbon Disulfide			ug/L	< 0.5	< 0.5
Carbon Tetrachloride			ug/L	< 0.5	< 0.5
Chlorodibromomethane			ug/L	< 0.5	< 0.5
Chloroethane			ug/L	< 0.5	< 0.5
Chloromethane (Methyl Chloride)			ug/L	< 0.5	< 0.5
cis-1,2-Dichloroethylene	70	MCL	ug/L	< 0.5	< 0.5
cis-1, 3-Dichloropropene			ug/L	< 0.5	< 0.5
Dibromomethane			ug/L	< 0.5	< 0.5
Dichloromethane			ug/L	< 0.5	< 0.5
Dichlorodifluoromethane			ug/L	< 0.5	< 0.5
Di-isopropyl ether			ug/L	< 3	< 3
Ethylbenzene	700	MCL	ug/L	< 0.5	< 0.5
Hexachlorobutadiene			ug/L	< 0.5	< 0.5
Isopropylbenzene			ug/L	< 0.5	< 0.5
m, p-Xylenes			ug/L	< 0.5	< 0.5
m-Dichlorobenzene (1, 3-DCB)			ug/L	< 0.5	< 0.5
Methylene Chloride	0.005	MCL	ug/l	< 0.5	< 0.5
Methyl Tert-butyl ether (MTBE)			ug/L	< 0.5	< 0.5
Napthalene			ug/L	< 0.5	< 0.5
n-Butylbenzene			ug/L	< 0.5	< 0.5
n-Propylbenzene			ug/L	< 0.5	< 0.5
o-Chlorotoluene			ug/L	< 0.5	< 0.5
o-Dichlorobenzene (1, 2-DCB)			ug/L	< 0.5	< 0.5
o-Xylene			ug/L	< 0.5	< 0.5
p-Chlorotoluene			ug/L	< 0.5	< 0.5
p-Dichlorobenzene (1, 4-DCB)			ug/L	< 0.5	< 0.5
p-Isopropyltoluene			ug/L	< 0.5	< 0.5
sec-Buytlbenzene			ug/L	< 0.5	< 0.5
Styrene	100	MCL	ug/L	< 0.5	< 0.5
tert-amyl Methyl Ether			ug/L	< 3	< 3
tert-Butyl Ethyl Ether			ug/L	< 3	< 3
tert-Butylbenzene			ug/L	< 0.5	< 0.5
Tetrachloroethylene (PCE)	5	MCL	ug/L	< 0.5	< 0.5
Toluene	1000	MCL	ug/L	< 0.5	< 0.5
Total Xylenes	10000	MCL	ug/L	< 0.5	< 0.5
Total 1,3-Dichloropropene			ug/L	< 0.5	< 0.5
Total THM			ug/L	< 0.5	< 0.5
trans-1,2-Dichloroethylene	100	MCL	ug/L	< 0.5	< 0.5
trans-1, 3-Dichloropropene			ug/L	< 0.5	< 0.5
Trichloroethylene (TCE)	5	MCL, MML	ug/L	< 0.5	< 0.5
Trichlorofluoromethane			ug/L	< 0.5	< 0.5
Trichlorotrifluoroethane (Freon 113)			ug/L	< 0.5	< 0.5
Vinyl chloride	2	MCL, MML	ug/L	< 0.3	< 0.3

GSI Water Solutions, Inc.

Sample Location / Lab	Rudd Farms / Eaton Analytical Standard	Criteria	Unit	Source Water Well No. 1 10/18/2017	Native Groundwater Basalt Well 10/17/2017
Radionuclides					
Alpa, Gross			pCi/L	< 3	< 3
Alpha, Min Detectable Activity			pCi/L	1.8	2.8
Alpha, Two Sigma Error			pCi/L	0.64	0.7
Beta, Gross			pCi/L	5.1	< 3.0
Beta, Min Detectable Activity			pCi/L	1.5	1.4
Beta, Two Sigma Error			pCi/L	0.6	0.5
Radium 226			pCi/L	< 1	< 1
Radium 226 Min. Detect Activity			pCi/L	0.42	0.38
Radium 226 Two Sigma Error			pCi/L	< 1	< 1
Radium 228			pCi/L	< 1	< 1
Radium 228 Min Detect Activity			pCi/L	0.82	0.65
Radium 228 Two Sigma error			pCi/L	< 1	< 1
Radium 226, 228 Combined			pCi/L	< 2	< 2
Radon 222			pCi/L	300	140
Radon 222, Two Sigma Error			pCi/L	15	9.5
Uranium			ug/L	< 1	< 1
Microbial					
E. Coli Bacteria			MPN/100 mL	< 1	<1
Total Coliform Bacteria			MPN/100 mL	2	<1
Total Coliform Bacteria (P/A)				P	A
E.Coli Bacteria (P/A)				A	A

Notes

ASR Injection Standards = Lowest value within MCL/2, MML/2, or SMCL except disinfection by-products.

ASR Injection Standards for disinfection by-products = Lowest value within MCL, MML, or SMCL.

ASR = aquifer storage and recovery

MCL = maximum contaminant level for drinking water

-- = not tested

Appendix E: Theis Calculations

1) *THEIS EQUATION:*

$$s = \frac{114.6\, Q\, W(u)}{T} \qquad where, u = \frac{1.87 r^2 S}{Tt}$$

EQUATION PARAMETERS				Well No. 1
Description	Variable	Units		Input/Result
Drawdown	s	Length		-
Pumping Rate	Q	Length^3/time	gpm	280
			ft3/s	0.62
Transmissivity	T	Length^2/length * time	gpd/ft	2333
			ft2/day	311.8567036
Storativity	S	*		0.2
Pumping Time	t	Time	days	135
			sec	11664000

Notes:

Input Cell

Parameters From:

Transmissivity is late-time transmissivity from a 74 hour pumping test of Well No. 1.

Storativity is the midrange storativity for a sand (Driscoll, 1986).

2) CALCULATED DRAWDOWN:

Drawdown at Wells					
Well No.	Well ID	Distance (ft)	*u*	*W(u)*	*s* (ft)
-	Well No. 1	0.5	3.0E-07	14.449	198.73
1	UNIO 51734	147	2.6E-02	3.082	42.38
	Extent of Interference	1,060	1.3E+00	0.073	1.00
2	UNIO 705	1,420	2.4E+00	0.018	0.25
3	UNIO 2533	2,070	5.1E+00	0.001	0.01
4	UNIO 50450	2,550	7.7E+00	0.001	0.01
5	UNIO 50227	2,757	9.0E+00	0.001	0.01

Cooper Jacob Equation (Confined)

(Equation 7-50 of Fetter, pg. 224, 1988)

$$\Delta s=[(2.303*Q)/(4*\pi*T)]*\log[(2.25*T*t)/(r^2*S)]$$

Input Parameters		
K	NA	ft/day
b	NA	ft
T	3,621	ft^2/day
Q	53,900	ft^3/day
S	0.00005	ft/ft
t	135	day

Calculators				
Q	280	gpm is	53,900	ft^3/d
T	0	ft^2/d	0	gpd/ft
T	27089	gpd/ft	3,621.0	ft^2/d

Well	r (feet)	Δs (feet)	u (<0.01) (dimensionless)
UNIO 50763	5,808	7.681291	0.0009
UNIO 50687	10,560	6.264007	0.0029
UNIO 50684	11,088	6.148341	0.0031
UNIO 2046	19,536	4.805595	0.0098
UNIO 52334	21,648	4.562234	0.0120
UNIO 50683	22,176	4.505107	0.0126
UNIO 271	22,704	4.449323	0.0132
UNIO 273	22,704	4.449323	0.0132
UNIO 174	22,704	4.449323	0.0132
UNIO 325	23,232	4.394822	0.0138
UNIO 173	23,232	4.394822	0.0138
UNIO 208	27,984	3.953632	0.0200
UNIO 50833	27,984	3.953632	0.0200

Appendix F: Record Keeping Form

RUDD AR MONITORING FORM

Sampler: ______________________________

Date: ________________________________

AR Opertions (circle one): Recharge Storage Recovery

WELL NO. 1

Flow rate information:

Time	
Inst. Flow Rate (gpm)	
Totalizer Reading (ac-ft x 0.001)	

Water level information:

Time	
Measuring Point	
Depth to Water (ft below measuring point)	

Field Parameters at time of sample collection:

Sample Time	Temp (°C)	Conductivity (uS/cm^2)	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)

Sample ID and Analyste Suite (see AR Limited License Report for instructions):

Sample ID	
Analyte Suite	

BASALT WEL

Flow rate information:

Time	
Inst. Flow Rate (gpm)	
Totalizer Reading (ac-ft x 0.001)	

Water level information:

Time	
Measuring Point	
Depth to Water (ft below measuring point)	

Field Parameters at time of sample collection:

Sample Time	Temp (°C)	Conductivity (uS/cm^2)	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)

Sample ID and Analyste Suite (see AR Limited License Report for instructions):

Sample ID	
Analyte Suite	

SCHWEPKE WELL

Flow rate information:

Time	
Inst. Flow Rate (gpm)	
Totalizer Reading (ac-ft x 0.001)	

Water level information:

Time	
Measuring Point	
Depth to Water (ft below measuring point)	

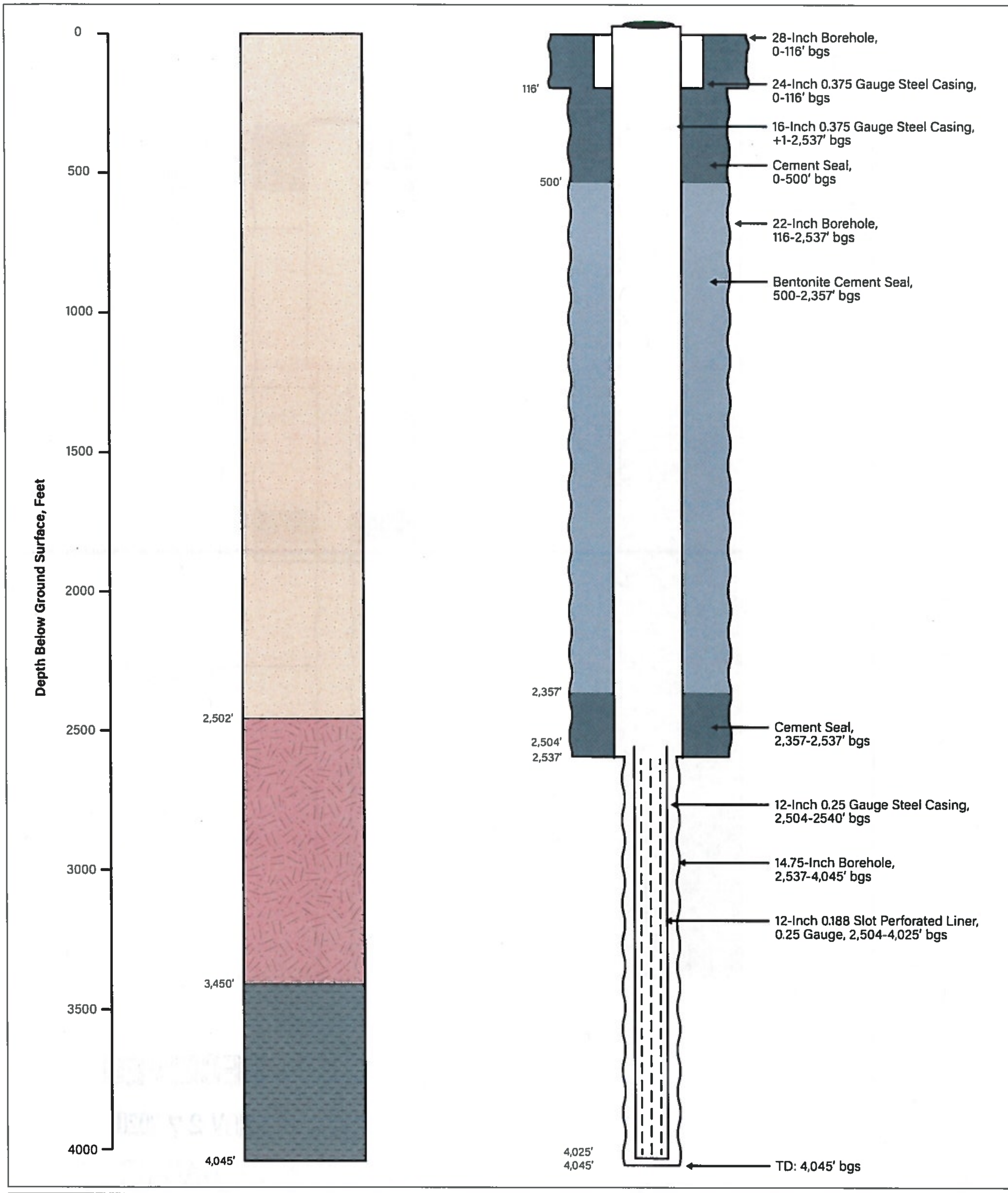
Field Parameters at time of sample collection:

Sample Time	Temp (°C)	Conductivity (uS/cm^2)	pH	DO (mg/L)	ORP (mV)	Turbidity (NTU)

Sample ID and Analyste Suite (see AR Limited License Report for instructions):

Sample ID	
Analyte Suite	

Appendix G: As-Built Diagrams and Driller Logs for the Basalt Well, Schwepke Well, and Well No. 1



LEGEND

- Valley-Fine Deposits
- Powder River Volcanic Field
- Columbia River Basalt Group

FIGURE X

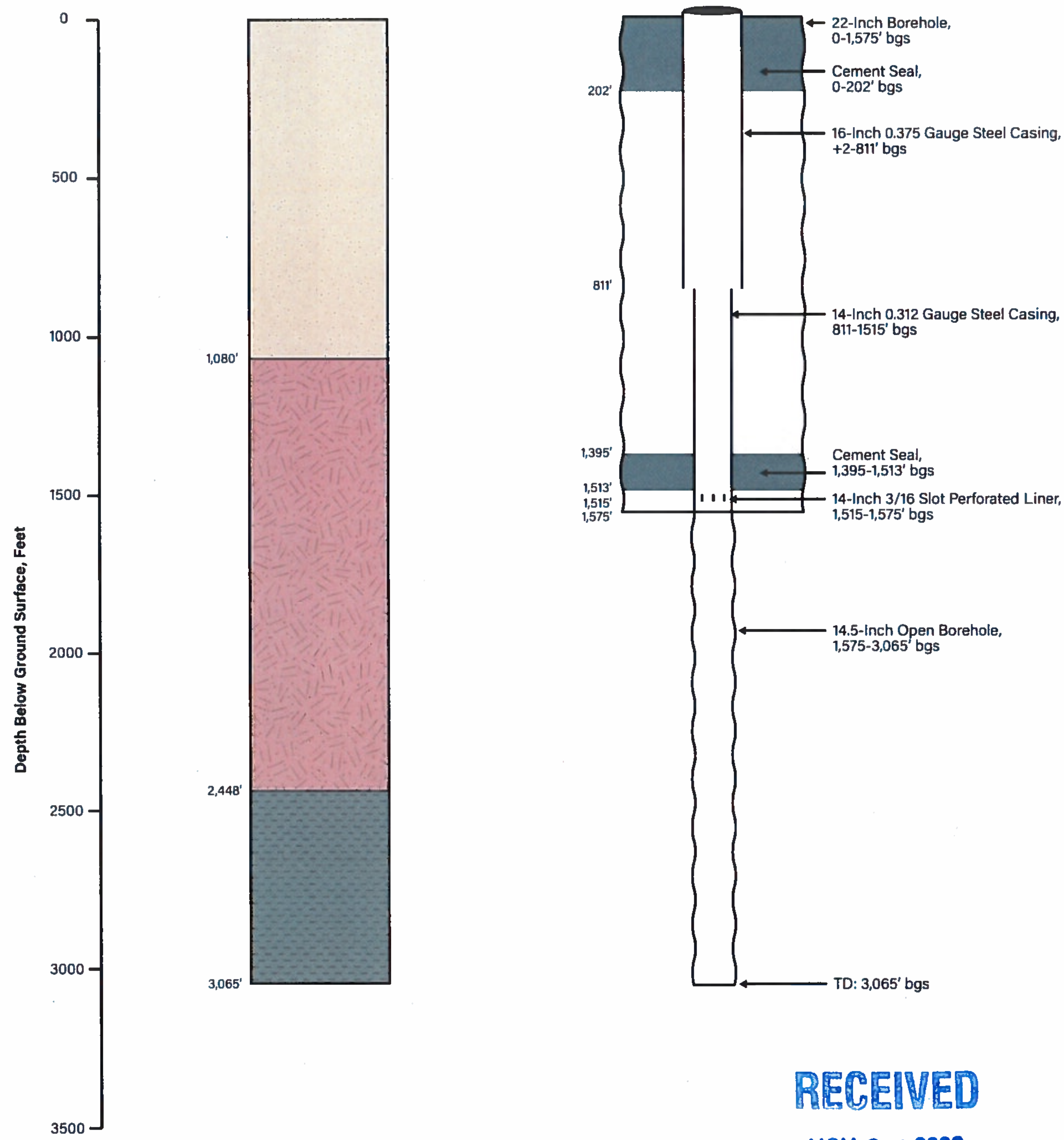
Rudd Basalt Well, UNIO 52415

Rudd Farms

AR Limited License Application

GSI Water Solutions, Inc.

Y:\0702_Rudd_Farms\Source_Figures\004_AR_LL_Application



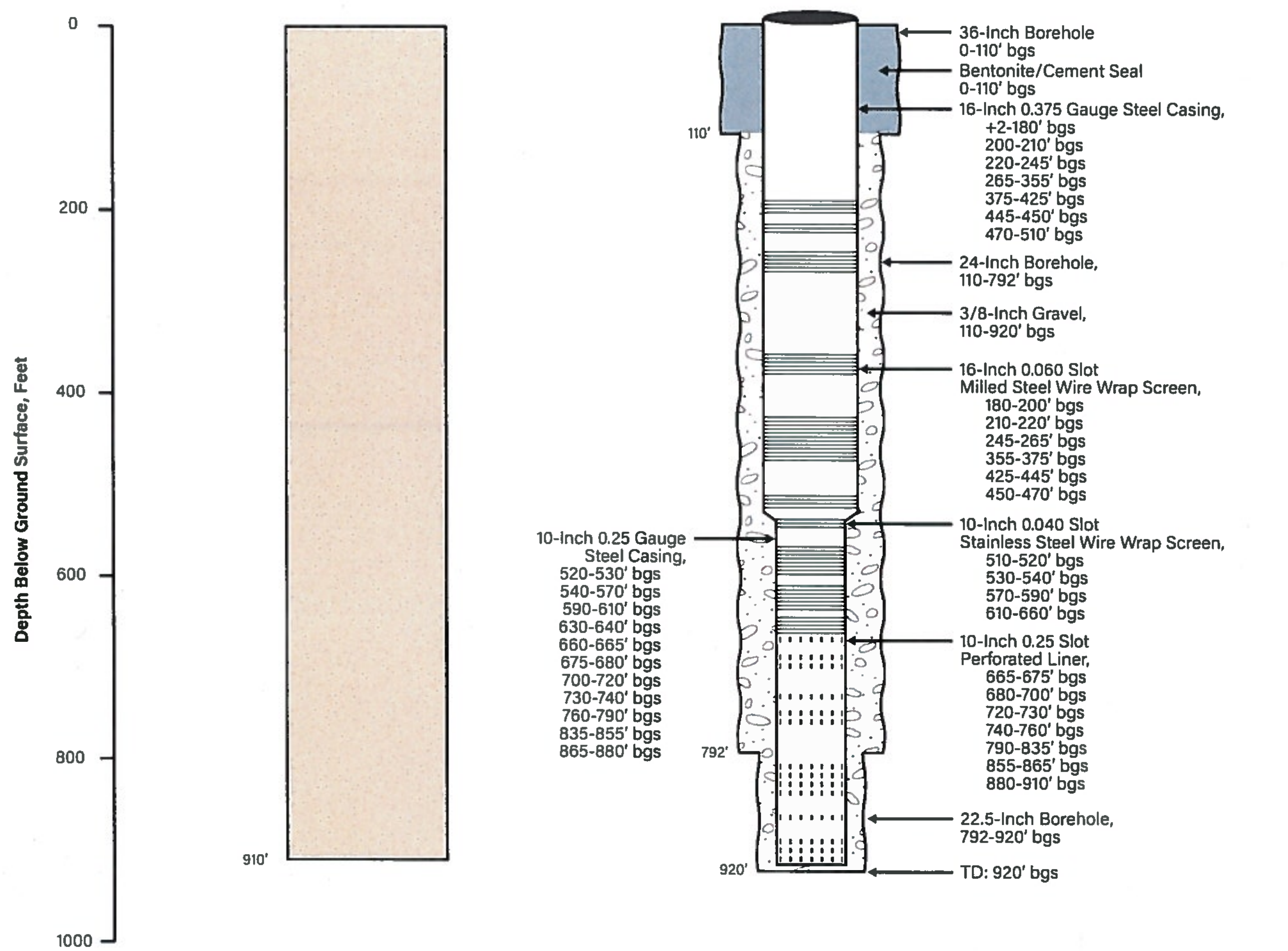
LEGEND
- Valley-Fine Deposits
- Powder River Volcanic Field
- Columbia River Basalt Group

FIGURE X

Rudd Schwepke Well, UNIO 50687

Rudd Farms
AR Limited License Application

GSI Water Solutions, Inc.



LEGEND

- Neogene Sedimentary Rocks and Quaternary Surficial Deposits
- Powder River Volcanic Field
- Columbia River Basalt Group

FIGURE X

Rudd Well 1, UNIO 51770/51835

Rudd Farms

AR Limited License Application

GSI Water Solutions, Inc.

UNIO 50687 · RECEIVED APR 13 2000 WATER RESOURCES DEPT. SALEM, OREGON

RECEIVED NOV 27 2020 OWRD

① of (12)

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

WELL I.D. # L 40698
START CARD # W73877

(1) OWNER: Well Number ______
Name Shawta DE LINT-Rudd
Address 6405 GEKER LANE / 65324 AliceLLN
City LAGRANDE State OR Zip 97850
COVE 97824

(2) TYPE OF WORK
☑ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☑ Rotary Mud ☐ Cable ☐ Auger
☐ Other + AIR REVERSE

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☑ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☑ Yes ☐ No Depth of Completed Well 306 ft.
Explosives used ☐ Yes ☑ No Type ______ Amount ______

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
22	0	1575	cement	0	202	200 SK
			cement	1395	1513	150 SK
14 3/4	1575	3065	cement Float Shoe 1498			
3	cement Basket			1498 - 1513		

How was seal placed: Method ☑ A ☐ B ☑ C ☐ D ☐ E
☐ Other ______
Backfill placed from ____ ft. to ____ ft. Material ______
Gravel placed from ____ ft. to ____ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	16"	2 +	680	375	☑	☐	☑	☐
	16"	680	811	312	☑	☐	☑	☐
	14"	811	1575	312	☑	☐	☑	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☑ Perforations Method MANUFACTURE 3/16 x 3
☐ Screens Type ______ Material Steel

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
1513	1375	3/16 x 3	2620	14"	.250	☑	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
1000	100		1 hr.

Temperature of water 104 Depth Artesian Flow Found 300 GPM
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County UNION Latitude ______ Longitude ______
Township T 2 S ~~N or~~ S Range 39 E E ~~or W.~~ WM.
Section 8 SE 1/4 NW 1/4
Tax Lot 3708 Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) 65324 AliceLLN COVE OR. 97824

(10) STATIC WATER LEVEL:
Flowing ft. below land surface. Date ______
Artesian pressure 11 lb. per square inch. Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found 12'

From	To	Estimated Flow Rate	SWL
37	62	Estimated Flow 300 gpm Total	2'
78	90		
176	174		
541	544		
598	603		

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Top Soil	0	1	
Sand + clay - Tan	1	4	
Clay Tan - Hard	4	9	
Sand + clay Tan	9	21	
Clay + Sand Tan	21	34	
Clay Tan	34	57	
Sand	57	62	
Clay + Sand Brown	62	78	
Sand	78	90	
Clay Green	90	170	
Sand	170	174	
Clay + Sand	174	204	
Sandstone + Sand	204	211	
Clay Tan	211	309	
Clay Dark Green	309	407	
Clay Black - SOFT	407	418	
Clay Dark Green - SOFT	418	427	
Sand + Clay Green	427	431	
Sand + Clay Green - HARD	431	448	
Clay Tan - SOFT	448	457	

Date started 8-19-96 Completed 8-15-98

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number ______
Signed ______ Date ______

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1399
Signed Waldo Lowe Date 3-15-99

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

RECEIVED

APR 13 2000

WATER RESOURCES DEPT.
SALEM, OREGON

UNIO
50687

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # L 40698
START CARD # W73877

(1) OWNER: Well Number ______
Name ______
Address ______
City ______ State ______ Zip ______

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other ______

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other ______

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ______ ft.
Explosives used ☐ Yes ☐ No Type ______ Amount ______

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ______
Backfill placed from ______ ft. to ______ ft. Material ______
Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ______
☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

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(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ______ Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County ______ Latitude ______ Longitude ______
Township ______ N or S Range ______ E or W. WM.
Section ______ ______ 1/4 ______ 1/4
Tax Lot ______ Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) ______

(10) STATIC WATER LEVEL:
______ ft. below land surface. Date ______
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found ______

From	To	Estimated Flow Rate	SWL
804	807	50 gpm	2'
834	839	50 gpm	2'
1540	1570	150 GPM →	Flowing
1906	1971	Can't Determine	|
2119	2120	" "	|

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Clay Tan + Shale HARD	457	476	
Clay Green + Sandstone Tan	476	481	
Clay Tan + Brown - SOFT	481	538	
Clay Green Hard	538	541	
Sand Course	541	544	
Clay Gray SOFT + Sandstone Gray HARD	544	564	
Clay Tan + Brown SOFT	564	579	
Clay Tan + Brown + Sand White	579	598	
Sand course + clay	598	603	
Clay Gray SOFT	603	608	
Clay Green + Sand course	608	621	
Clay Gray SOFT	621	632	
Clay + Shale Brown	637	674	
Clay Green + Gray SOFT	674	725	
Clay Black SOFT	725	728	
Clay Gray SOFT	728	749	
Clay Gray + Sand Course	749	753	
Clay Gray SOFT	753	779	
Clay Gray-Green HARD	779	804	
Sand Course	804	807	

Date started ______ Completed ______

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number ______
Signed ______ Date ______

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1399
Signed [signature] Date 3-5-98

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STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

WELL I.D. # L 40698

START CARD # W73877

(1) OWNER: Well Number

Name

Address

City State Zip

(2) TYPE OF WORK

☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:

☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger

☐ Other

(4) PROPOSED USE:

☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation

☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:

Special Construction approval ☐ Yes ☐ No Depth of Completed Well ___ ft.

Explosives used ☐ Yes ☐ No Type ___ Amount ___

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E

☐ Other

Backfill placed from ___ ft. to ___ ft. Material

Gravel placed from ___ ft. to ___ ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s)

(7) PERFORATIONS/SCREENS:

☐ Perforations Method

☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

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(8) WELL TESTS: Minimum testing time is 1 hour

☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ___ Depth Artesian Flow Found

Was a water analysis done? ☐ Yes By whom

Did any strata contain water not suitable for intended use? ☐ Too little

☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other

Depth of strata:

(9) LOCATION OF WELL by legal description:

County Latitude Longitude

Township N or S Range E or W. WM.

Section 1/4 1/4

Tax Lot Lot Block Subdivision

Street Address of Well (or nearest address)

(10) STATIC WATER LEVEL:

___ ft. below land surface. Date

Artesian pressure ___ lb. per square inch. Date

(11) WATER BEARING ZONES:

Depth at which water was first found

From	To	Estimated Flow Rate	SWL
2677	2698	120 GPM 103.4	temp
2716	2718	350 GPM Temp 107.5	
2731	2738	35 GPM 106.9	
2756	2767	50 GPM	
2770	2799	100 GPM	

Flowin ↓

(12) WELL LOG:

Ground Elevation

Material	From	To	SWL
Clay Green-Grey SOFT	807	834	
Sand Course	834	839	
Clay Green SOFT + HARD	839	857	
Sand + Clay Green	857	989	
Clay Green SOFT	989	1015	
Clay Green + Sand	1015	1024	
Clay Green ~~[illegible]~~ SOFT	1024	1042	
Clay Green HARD	1042	1052	
Sand + Clay Green	1052	1061	
Clay Green SOFT	1061	1080	
Basalt Black + Pink	1080	1082	
Clay Green SOFT + shale	1082	1089	
Basalt Brown Green Black	1089		
shale Green		1091	
Basalt Brown + shale Green HARD	1091	1132	
Basalt Grey HARD + shale Green	1132	1149	
Basalt Black + Clay Green SOFT	1149	1198	
Basalt red + Grey VERY HARD	1198	1204	
Basalt Red - Clay Grey -	1204		
Shale Green		1217	

Date started ___ Completed ___

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number

Signed ___ Date

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1399

Signed Walt Lowe Date

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SALEM, OREGON

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STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # L 40698
START CARD # W73877

(1) OWNER:
Well Number ________
Name ________
Address ________
City ________ State ________ Zip ________

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other ________

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other ________

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ______ ft.
Explosives used ☐ Yes ☐ No Type ________ Amount ________

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ________
Backfill placed from ______ ft. to ______ ft. Material ________
Gravel placed from ______ ft. to ______ ft. Size of gravel ________

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ________

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ________
☐ Screens Type ________ Material ________

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From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour

☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ________ Depth Artesian Flow Found ________
Was a water analysis done? ☒ Yes By whom ________
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ________
Depth of strata: ________

(9) LOCATION OF WELL by legal description:
County ________ Latitude ________ Longitude ________
Township ________ N or S Range ________ E or W. WM.
Section ________ ________ 1/4 ________ 1/4
Tax Lot ________ Lot ________ Block ________ Subdivision ________
Street Address of Well (or nearest address) ________

(10) STATIC WATER LEVEL:
________ ft. below land surface. Date ________
Artesian pressure ________ lb. per square inch. Date ________

(11) WATER BEARING ZONES:

Depth at which water was first found ________

From	To	Estimated Flow Rate	SWL
2889	2897	GPM 20	Flowing
2928	2942	Can't Determine	↓
2961	2969	" "	↓
3031	3030	" "	↓
3051	3054	Temp 106.8	↓

(12) WELL LOG:
Ground Elevation ________

Material	From	To	SWL
Basalt Black - shale red +	1217		
gray + clay Green + Gray SOFT		1274	
Basalt Gray HARD - Clay Gray SOFT	1274	1441	
Basalt Gray with Brown	1441		
coating + Clay		1459	
Basalt Brown + Clay Gray	1459	1468	
Shale Orange HARD + Clay Gray SOFT	1468	1487	
Basalt Brown + Clay red SOFT	1487	1504	
Shale Red + Clay	1504	1570	
Basalt Black + Shale Red	1570	1599	
Basalt Brown not very Hard	1599		
clay Green		1631	
Basalt Gray + Black - shale Green	1631	1672	
Basalt Brown + Black - shale	1672		
Green + Gray HARD		1677	
Basalt Red + [illegible] SOFT	1677		
Shale Green + Basalt Black		1699	
Basalt Red + Green HARD +	1699		
Shale Gray + Green HARD		1719	
Basalt Brown Gray - Clay Gray Green	1719	1721	

Date started ________ Completed ________

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number ________
Signed ________ Date ________

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1399
Signed [signature] Date ________

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SALEM, OREGON

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # L 40698
START CARD # N 73877

(1) OWNER: Well Number ______
Name ______
Address ______
City ______ State ______ Zip ______

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ______ ft.
Explosives used ☐ Yes ☐ No Type ______ Amount ______

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ______
Backfill placed from ______ ft. to ______ ft. Material ______
Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ______
☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

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(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ______ Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County ______ Latitude ______ Longitude ______
Township ______ N or S Range ______ E or W. WM.
Section ______ ______ 1/4 ______ 1/4
Tax Lot ______ Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) ______

(10) STATIC WATER LEVEL:
______ ft. below land surface. Date ______
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found ______

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Basalt Gray + Clay Green SOFT	1721	1748	
Basalt Gray + Shale Green + Clay Gray	1748	1906	
Basalt Gravel, Tike	1906	1971	
Basalt Gray + Clay Gray	1971	1993	
Basalt Black + Clay Gray	1993	1999	
Basalt Gray VERY HARD	1999	2004	
Basalt Black + Clay Black SOFT	2004		
Shale Green		2029	
Basalt Black + Clay Gray SOFT	2029	2070	
Basalt Green + shale	2070		
Clay Gray + Green SOFT		2119	
Basalt Gray	2119	2120	
Basalt Black + Clay Green, Gray	2120	2175	
Basalt Gray HARD + Clay Gray	2175	2222	
Basalt Black + Clay Gray + Shale Green	2222	2229	
Basalt Gray + Clay Gray + Shale Green	2229	2251	
Basalt Black + shale Green +	2251		
Clay Gray HARD		22[illegible]	
Clay Brown Gray Green Soft	2267		
+ HARD - Basalt Black		2275	

Date started ______ Completed ______

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number ______
Signed ______ Date ______

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1399
Signed [signature] Date ______

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WATER RESOURCES DEPT.
SALEM, OREGON

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # L 40698
START CARD # W 73877

(1) OWNER: Well Number ______
Name ______
Address ______
City ______ State ______ Zip ______

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other ______

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other ______

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ______ ft.
Explosives used ☐ Yes ☐ No Type ______ Amount ______

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ______
Backfill placed from ______ ft. to ______ ft. Material ______
Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

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Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ______
☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ______ Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County ______ Latitude ______ Longitude ______
Township ______ N or S Range ______ E or W. WM.
Section ______ ______ 1/4 ______ 1/4
Tax Lot ______ Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) ______

(10) STATIC WATER LEVEL:
______ ft. below land surface. Date ______
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found ______

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Basalt Black + Brown	2276	2278	
Clay Brown Black Green -	2278		
Basalt Black + Shale		2288	
Basalt Black-Clay Green + Shale Green	2288	2297	
Basalt Black - Shale Black Clay Gray	2297	2302	
Basalt Black VES.	2302	2329	
Basalt Black	2329	2336	
Basalt Black HARD	2336	2349	
Basalt Gray	2349	2353	
Basalt Green + Clay Green SOFT	2353	2355	
Shale Green HARD Clay Green	2355	2357	
Basalt Black + Clay Gray Green	2357	2359	
Basalt Gray + Clay Gray HARD	2359	2368	
Basalt Gray + Clay Grey	2368	2382	
Basalt Black + Clay Black SOFT	2382	2387	
Shale Brown Gray Green Red	2387	2390	
Basalt Black + Clay Gray	2390	2394	
Basalt Gray - shale Green -	2394	[redacted]	
Clay Grey - Basalt HARD		2429	
Basalt Green + Shale Green	2429	2448	

Date started ______ Completed ______

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number ______
Signed ______ Date ______

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1399
Signed Walt Love Date 3-5-98

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WATER RESOURCES DEPT. SALEM, OREGON

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

WELL I.D. # L 40698
START CARD # W73877

(1) OWNER: Well Number ____
Name ____
Address ____
City ____ State ____ Zip ____

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other ____

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other ____

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ____ ft.
Explosives used ☐ Yes ☐ No Type ____ Amount ____

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ____
Backfill placed from ____ ft. to ____ ft. Material ____
Gravel placed from ____ ft. to ____ ft. Size of gravel ____

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ____

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ____
☐ Screens Type ____ Material ____

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

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(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ____ Depth Artesian Flow Found ____
Was a water analysis done? ☐ Yes By whom ____
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ____
Depth of strata: ____

(9) LOCATION OF WELL by legal description:
County ____ Latitude ____ Longitude ____
Township ____ N or S Range ____ E or W. WM.
Section ____ ____ 1/4 ____ 1/4
Tax Lot ____ Lot ____ Block ____ Subdivision ____
Street Address of Well (or nearest address) ____

(10) STATIC WATER LEVEL:
____ ft. below land surface. Date ____
Artesian pressure ____ lb. per square inch. Date ____

(11) WATER BEARING ZONES:
Depth at which water was first found ____

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:
Ground Elevation ____

Material	From	To	SWL
Cinder Red - Shale Green -	2448		
Basalt Black.		2468	
Basalt Black-shale red, Green brown	2468	2476	
Cinder Brown-Tan - shale Green	2476	2480	
Cinder Red - Shale Green	2480	2482	
Basalt Gray - Clay Gray	2482	2486	
Cinder Brown Black - shale Green Tan	2486	2503	
Basalt Black + Shale Green Gray	2503	2506	
Basalt Green + Clay Green	2506	2510	
Basalt Gray + Clay Gray	2510	2560	
Basalt Black + white - shale Green	2560	2569	
Basalt Gray + Black spots shale Green	2569	2581	
Basalt Gray HARD - Clay Gray	2581	2590	
Basalt Black - shale Green - Cinder	2590		
Brown + Black - quartz White			
red cinder VES.		2592	
Cinder Black Brown Blue Green	2592	2594	
Basalt Black - shale Green - Clay Gray	2594	2597	
Basalt Gray - Quartz white - Clay Gray	2597	2599	
Basalt Black - shale Green HARD	2599	2605	

Date started ____ Completed ____

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number ____
Signed ____ Date ____

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1399
Signed [signature] Date ____

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SALEM, OREGON

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STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # L 40698
START CARD # W73877

(1) OWNER: Well Number ______
Name ______
Address ______
City ______ State ______ Zip ______

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other ______

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other ______

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ______ ft.
Explosives used ☐ Yes ☐ No Type ______ Amount ______

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ______
Backfill placed from ______ ft. to ______ ft. Material ______
Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ______
☐ Screens Type ______ Material ______

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From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour

☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ______ Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County ______ Latitude ______ Longitude ______
Township ______ N or S Range ______ E or W. WM.
Section ______ ______ 1/4 ______ 1/4
Tax Lot ______ Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) ______

(10) STATIC WATER LEVEL:
______ ft. below land surface. Date ______
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:

Depth at which water was first found ______

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Basalt Gray - Shale Green	2605	2611	
Basalt Black Shale Green Quartz	2611		
GPM 25 TEMP 91.5		2618	
Basalt Gray + Shale Green Quartz	2618	2627	
Basalt Black + Gray - Red Cinder	2627		
Shale Green		2629	
Shale Black + Green HARD	2629	2635	
Basalt Gray + Shale Green	2635	2639	
Basalt Gray - Shale Green + Red	2639	2646	
Basalt Gray VES. Quartz White	2646	2648	
Shale Green - Cinder Red + Black	2648	2650	
Cinder Red + Black - Shale Green [illegible]	2650	2653	
Basalt Black - Shale Green + Red	2653	2661	
Cinder Red + Black - Shale Green	2661	2663	
Basalt Black - Clay Gray	2663		
Shale Green Brown Red		2667	
Basalt Gray - Clay Gray Shale	2667		
Green		2671	
Basalt Green Clay Gray Shale Green	2671	2675	
Basalt Green + Clay Gray	2675	2677	

Date started ______ Completed ______

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number ______
Signed ______ Date ______

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1399
Signed [signature] Date ______

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WATER RESOURCES DEPT.
SALEM, OREGON

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

WELL I.D. # L 40698
START CARD # W73877

Instructions for completing this report are on the last page of this form.

(1) OWNER:

Well Number ______
Name ______
Address ______
City ______ State ______ Zip ______

(2) TYPE OF WORK

☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:

☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:

☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:

Special Construction approval ☐ Yes ☐ No Depth of Completed Well ______ ft.
Explosives used ☐ Yes ☐ No Type ______ Amount ______

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ______
Backfill placed from ______ ft. to ______ ft. Material ______
Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:

☐ Perforations Method ______
☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

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(8) WELL TESTS: Minimum testing time is 1 hour

☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ______ Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:

County ______ Latitude ______ Longitude ______
Township ______ N or S Range ______ E or W. WM.
Section ______ ______ 1/4 ______ 1/4
Tax Lot ______ Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) ______

(10) STATIC WATER LEVEL:

______ ft. below land surface. Date ______
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:

Depth at which water was first found ______

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:

Ground Elevation ______

Material	From	To	SWL
Basalt Black Loose	2677		
GPM 120 TEMP 103.4		2698	
Basalt Black	2698	2701	
Basalt Black-shale Green-Cinder Red	2701	2708	
Basalt Black-Cinder Red	2708	2712	
Basalt Gray shale Green HARD	2712		
Quartz		2716	
Basalt Black-Clay Gray-shale Green	2716		
BPM 350 TEMP 106.6		2718	
Basalt Gray-shale Green Loose	2718	2731	
Basalt Black-Quartz white VES.	2731	2738	
Basalt Black+Quartz SOFT	2738		
GPM 35 TEMP 106.6		2740	
Basalt Black Clay Gray	2740		
Cinder Red		2747	
Basalt Gray-Clay Gray	2747	2750	
Basalt Gray-Black Clay	2750	?	
Gray-Cinder Red VES		2756	
Basalt Gray-Clay Gray-shale	2756		
GPM 50 TEMP 107.5		2767	

Date started ______ Completed ______

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number ______
Signed ______ Date ______

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1399
Signed [signature] Date ______

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SALEM, OREGON

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STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

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(START CARD) # W73877

Instructions for completing this report are on the last page of this form.

(1) OWNER:
Well Number ______

Name ______

Address ______

City ______ State ______ Zip ______

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger

☐ Other ______

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation

☐ Thermal ☐ Injection ☐ Livestock ☐ Other ______

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ______ ft.

Explosives used ☐ Yes ☐ No Type ______ Amount ______

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E

☐ Other ______

Backfill placed from ______ ft. to ______ ft. Material ______

Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ______

☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

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(8) WELL TESTS: Minimum testing time is 1 hour

☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ______ Depth Artesian Flow Found ______

Was a water analysis done? ☐ Yes By whom ______

Did any strata contain water not suitable for intended use? ☐ Too little

☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______

Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County ______ Latitude ______ Longitude ______

Township ______ N or S Range ______ E or W. WM.

Section ______ ______ 1/4 ______ 1/4

Tax Lot ______ Lot ______ Block ______ Subdivision ______

Street Address of Well (or nearest address) ______

(10) STATIC WATER LEVEL:
______ ft. below land surface. Date ______

Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:

Depth at which water was first found ______

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Basalt Black-Shale Green	2767	2769	
Basalt Gray With Brown Tint	2769		
Quartz white Clay LOOSE		2799	
Basalt Black: Brown Cinder	2799		
Red-Quartz White		2803	
Basalt Gray + Quartz	2803	2811	
Basalt Black VES. Quartz	2811	[redacted]	
Cinder Brown SOFT		2827	
Basalt Gray-Clay Gray	2827	2832	
Basalt Black-Clay VES.	2832	2840	
Basalt Black-Quartz White SOFT	2840	2843	
Basalt Gray-shale Green HARD	2843	2845	
Basalt Black. Quartz White SOFT	2845	2849	
Basalt Gray-Shale Green	2849	2851	
Basalt Black-shale Gray SOFT	2851	2881	
Basalt Black: Gray-Clay Gray HARD	2881	2889	
Basalt Gray: Green-Cinder Red	2889		
GPM 20		2897	
Basalt Black + Clay Gray	2897	2907	
Basalt Gray-Quartz White	2907	2923	

Date started ______ Completed ______

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number ______

Signed ______ Date ______

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1599

Signed Walter Lane Date ______

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SALEM, OREGON

UNIO 50687

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STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

(START CARD) # W73877

Instructions for completing this report are on the last page of this form.

(1) OWNER: Well Number ______
Name ______
Address ______
City ______ State ______ Zip ______

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other ______

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other ______

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ______ ft.
Explosives used ☐ Yes ☐ No Type ______ Amount ______

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ______
Backfill placed from ______ ft. to ______ ft. Material ______
Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ______
☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

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(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ______ Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County ______ Latitude ______ Longitude ______
Township ______ N or S Range ______ E or W. WM.
Section ______ ______ 1/4 ______ 1/4
Tax Lot ______ Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) ______

(10) STATIC WATER LEVEL:
______ ft. below land surface. Date ______
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found ______

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Basalt Black - Shale	2923	2925	
Cinder Black Brown Red-Shale	2925	2927	
Basalt Black - Shale Green -	2927		
Cinder Black SOFT		2928	
Basalt Black VES. Quartz White	2928	2942	
Basalt Gray Quartz White Clay Gray	2942	2954	
Basalt Black + Shale Green Quartz	2954	2957	
Basalt Gray - Clay Gray	2957	2969	
Basalt Black Quartz White	2969	2975	
Cinder Brown + Black - Quartz	2975	2977	
Basalt Black + Cinder	2977	2979	
Basalt Gray + Quartz	2979	3004	
Basalt Gray with Brown cast HARD	3004	3020	
Basalt Gray + Green Clay Gray	3020	3031	
Basalt Black VES. Cinder	3031		
Red + Brown + Shale Green			
HARD		3033	
Cinder red + Brown Shale Green SOFT	3033	3036	
Black Shale	3036	3037	
Clay Black SOFT	3037	3038	

Date started ______ Completed ______

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number ______
Signed ______ Date ______

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1399
Signed [signature] Date ______

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WATER RESOURCES DEPT. SALEM, OREGON

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form.

WELL I.D. # L 40698
START CARD # N73877

(1) OWNER: Well Number ______
Name ______
Address ______
City ______ State ______ Zip ______

(2) TYPE OF WORK
☐ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other ______

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other ______

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☐ No Depth of Completed Well ______ ft.
Explosives used ☐ Yes ☐ No Type ______ Amount ______

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ______
Backfill placed from ______ ft. to ______ ft. Material ______
Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ______
☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.

Temperature of water ______ Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County ______ Latitude ______ Longitude ______
Township ______ N or S Range ______ E or W. WM.
Section ______ ______ 1/4 ______ 1/4
Tax Lot ______ Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) ______

(10) STATIC WATER LEVEL:
______ ft. below land surface. Date ______
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found ______

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Basalt Black - shale +	3038		
Clay Green SOFT		3043	
Cinder Red + Brown Basalt Black	3043	3045	
Basalt Black - shale Green	3045	3047	
Basalt Black - shale White	3047	3049	
Basalt Black + Grey shale Green	3049	3051	
Basalt Grey Quartz + white silicone	3051	3054	
Basalt Grey clay Grey - Quartz	3054	3065	
Basalt Grey clay Grey shale Brown	3065		

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Date started ______ Completed ______

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number ______
Signed ______ Date ______

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1399
Signed [signature] Date ______

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3877

Flint Shaw Rock

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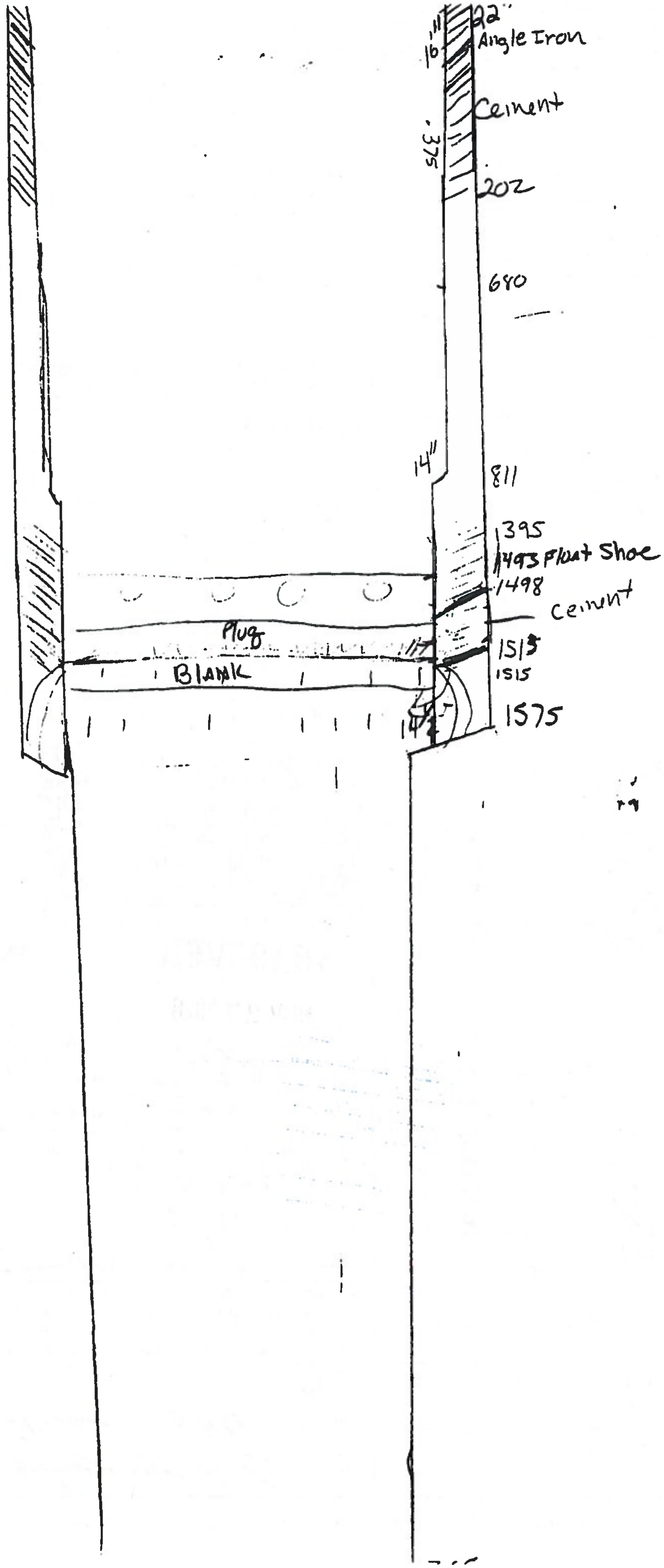
SALEM, OREGON



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COMPLETION OF WELL ORIGINALLY STARTED BY WALDO LOWE DRILLING PAGE #1

UNIO 51770

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

WELL I.D. # L 82655

START CARD # 172224

Instructions for completing this report are on the last page of this form.

(1) LAND OWNER Well Number
Name PAUL L RUDD
Address 64053 GEKLER LN
City LAGRANDE State OR Zip 97850

(2) TYPE OF WORK ☐ New Well
☐ Deepening ☑ Alteration (repair/recondition) ☐ Abandonment ☐ Conversion

(3) DRILL METHOD
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger ☐ Cable Mud
☑ Other REVERSE

(4) PROPOSED USE
☐ Domestic ☐ Community ☐ Industrial ☑ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION Special Construction: ☐ Yes ☑ No
Depth of Completed Well 910 ft.
Explosives used: ☐ Yes ☑ No Type Amount

BORE HOLE Diameter	From	To	SEAL Material	From	To	Sacks or Pounds
22 1/2"	792	920				

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other
Backfill placed from ft. to ft. Material
Gravel placed from 0 ft. to 920 ft. Size of gravel 3/8"

(6) CASING/LINER

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	16"	+2	180	.250	☒	☐	☒	☐
	16	200	210	.250	☒	☐	☒	☐
	16	220	245	.375	☒	☐	☒	☐
	16	265	355	.375	☒	☐	☒	☐
Liner:	16	375	425	.375	☒	☐	☒	☐
	16	445	450	.375	☒	☐	☒	☐

Drive Shoe used ☐ Inside ☐ Outside ☒ None
Final location of shoe(s)

(7) PERFORATIONS/SCREENS
☐ Perforations Method
☒ Screens Type WIRE WRAP Material M.S.

From	To	Slot Size	Number	Diameter	Tele/pipe size	Casing	Liner
180	200	.060		16"		☒	☐
210	220	.060		16"		☒	☐
245	265	.060		16"		☒	☐
355	375	.060		16"		☒	☐
425	445	.060		16"		☒	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
	N/A		

Temperature of water Depth Artesian Flow Found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other
Depth of strata:

(9) LOCATION OF WELL (legal description)
County UNION
Tax Lot Lot
Township 2 N or (S) Range 39 (E) or W WM
Section 30 SW 1/4 NW 1/4
Lat ° ' " or (degrees or decimal)
Long ° ' " or (degrees or decimal)
Street Address of Well (or nearest address) BOOTH LANE HWY 82, APPX 1 1/4 MI EAST

(10) STATIC WATER LEVEL
15 ft. below land surface. Date 7-6-06
ft. below land surface. Date
Artesian pressure lb. per square inch Date

(11) WATER BEARING ZONES
Depth at which water was first found

From	To	Estimated Flow Rate	SWL
ALL SAND + GRAVELS			
BELOW 15'			

(12) WELL LOG Ground Elevation

Material	From	To	SWL
GREEN, GREY CLAY SAND MIX	792	825	
COARSE SAND	825	834	
GREEN CLAY SHALE	834	855	
MED-COARSE SAND	855	864	
GREEN CLAY SHALE	864	882	
MED - COARSE SAND	882	886	
GREEN CLAY	886	893	
MED-COARSE SAND W/CLAY	893	907	
GREY CLAY	907	920	

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Date Started 4-30-06 Completed 7-8-06

(unbonded) Water Well Constructor Certification
I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number 1673 Date 7-31-06
Signed [signature]

(bonded) Water Well Constructor Certification
I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1595 Date 7-31-06
Signed [signature]

UNIO 51770

Page #2

Well I.I.#L 82655
Start Card# 172224

Name: Paul Rudd
Address 64053 Gekler Ln
City LaGrande State: OR Zip:97850

(6) CASING/LINER

Dia	From	To	Gauge	Steel	Welded
16"	470'	510'	0.375	X	X
16"x10" Reducer @ 510'					
10"	520'	530'	0.25	X	X
10"	540'	570'	0.25	X	X
10"	590'	610'	0.25	X	X
10"	630'	640'	0.25	X	X
10"	660'	665'	0.25	X	X
10"	675'	680'	0.25	X	X
10"	700'	720'	0.25	X	X
10"	730'	740'	0.25	X	X
10"	760'	790'	0.25	X	X
10"	835'	855'	0.25	X	X
10"	865'	880'	0.25	X	X

(7) PERFORATIONS/SCREENS

From	To	Slot Size	Dia	Casing			
450'	470'	0.06	16"	X	Type: Wire Wrap	Material:	M.S
510'	520'	0.04	10"	X			M.S
530'	540'	0.04	10"	X			M.S
570'	590'	0.03	10"	X	Type: Wire Wrap	Material:	S.S.
610'	630'	0.03	10"	X			S.S.
640'	660'	0.03	10"	X			S.S.
665'	675'	0.25	10"	X	Perforated Pipe	Method:	Factory
680'	700'	0.25	10"	X	Perforated Pipe		Factory
720'	730'	0.25	10"	X	Perforated Pipe		Factory
740'	760'	0.25	10"	X	Perforated Pipe		Factory
790'	835'	0.25	10"	X	Perforated Pipe		Factory
855'	865'	0.25	10"	X	Perforated Pipe		Factory
880'	910'	0.25	10"	X	Perforated Pipe		Factory

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STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

"Department Generated" off of Rough Well Log By Robert Maynard 12-7-06

WELL I.D. # L 82655

START CARD # 159560

Instructions for completing this report are on the last page of this form.

(1) LAND OWNER Well Number ______
Name PAUL RUDD
Address 64053 GEKELER LANE
City LAGRANDE State OR Zip 97850

(2) TYPE OF WORK ☒ New Well
☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment ☐ Conversion

(3) DRILL METHOD
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger ☐ Cable Mud
☒ Other REVERSE ROTARY

(4) PROPOSED USE
☐ Domestic ☐ Community ☐ Industrial ☒ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other ______

(5) BORE HOLE CONSTRUCTION Special Construction: ☐ Yes ☒ No
Depth of Completed Well ______ ft.
Explosives used: ☐ Yes ☒ No Type ______ Amount ______

BORE HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or Pounds
36	0	110	BENT.	0	10	UNKNOWN
			CEMENT	10	110	37,715 LBS
24	110	1100				

How was seal placed: Method ☐ A ☐ B ☒ C ☐ D ☐ E
☐ Other POUR DRY
Backfill placed from ______ ft. to ______ ft. Material ______
Gravel placed from ______ ft. to ______ ft. Size of gravel ______

(6) CASING/LINER

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	24	+1	110		☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

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Drive Shoe used ☐ Inside ☐ Outside ☐ None
Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS
☐ Perforations Method ______
☐ Screens Type ______ Material ______

From	To	Slot Size	Number	Diameter	Tele/pipe size	Casing	Liner
N/A						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
N/A			

Temperature of water ______ Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use?
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL (legal description)
County UNION
Tax Lot ______ Lot ______
Township 2 S N or S Range 39 E E or W WM
Section 30 SW 1/4 NW 1/4
Lat ___°___'___" or ______ (degrees or decimal)
Long ___°___'___" or ______ (degrees or decimal)
Street Address of Well (or nearest address) BOOTH LANE

(10) STATIC WATER LEVEL
15 ft. below land surface. Date ______
______ ft. below land surface. Date ______
Artesian pressure ______ lb. per square inch Date ______

(11) WATER BEARING ZONES
Depth at which water was first found ______

From	To	Estimated Flow Rate	SWL
15	1100		15

(12) WELL LOG Ground Elevation ______

Material	From	To	SWL
SOIL	0	5	
SAND + FINE GRAVEL	5	100	15
GRAY CLAY	100	217	
COURSE SAND + GRAVEL	217	230	
ALL CLAYS WITH	230	–	
SAND AND SAND	–	–	
STREAKS	–	1100	15
DRILLER DECEASE	ON	10-17-05	
WELL TEMPORARY	ABAN	AND	
RIG MOVED OFF	OF WELL		
RIVERSIDE WILL COMPLETE WELL			
UNDER START CARD	[illegible]	172224	

Date Started 8-25-05 Completed 10-17-05

(unbonded) Water Well Constructor Certification
I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number ______ Date ______

Signed ______

(bonded) Water Well Constructor Certification
I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1399 Date ______

Signed WALD LOWE

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300 ft sand

0		
5	Topsoil	
25	sand.	
95-100	fine gravel - sand.	
100-114	Brown clay	
114-125	gray clay	
126-127	gray clay	ash ?
128-137	" "	
138-139	" "	
140-148	" "	
148½-150	" "	
150-170	" " with fine sand	
171-195	" "	
195-217	clay with fine sand silt	
218-230 2	course sand with clean gravel	12
231-243	clay	
244-260	clay with fine sand	6
261-267	clay	
270-272	Sand.	5
273-290	clay / sand	17 ?
291-305	Clay. Blue.	
306-313	clay Blue / Sand.	
313-325	Blue Clay stickey.	
325-332	Blue Clay - Sand.	3) ?
333-345	Blue Clay - ~~Blue~~ sand.	2
345-350	" Clay with sand	5
350-365	" clay	
~~365~~-378	~~sand / gravel~~ Tan clay crumbly	
~~365-377~~ 377		

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SALEM, OREGON

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~~3??~~/383	clay with some gravel. /Sand.	6	?
383/389	yellow clay		
389/390	yellow clay /Sand	1	
391/~~4~~40	Sticky yellow clay		
~~4~~40-452	yellow clay - Rocks?		
452-460	Gray clay ~~[redacted]~~ course sand /ROCK?	8	?
461-467	Gray clay sand Rock	6	
465-467	Rock - sand.	2	
468-480	yellow clay		
480-484	Sand - sm gravel.	4	
485-493	Tan clay		
494-498	Clay Sand sm gravel.	4	
498-501	Tan clay		
501-507	Brown Sand	6	
508.516	Tan clay		
517-520	Sand (like granite)	3	
520-527	Gray Clay with Sand	7	
527-542	Sand Brown - granite like. [illegible]	27	good
542-545	gray Clay - Sand	3	
545-547	Sand	2	
547-550	Brown clay	8	
551-559	Sand white.		
560-566	Brown Clay hard		
567-574	Clay Brown		
575-580	Clay Tan w/ fine sand?		
575-580	Clay Tan w ~~1 1/2 inch River Rock~~? Fine Sand		
580-586	clay Tan w 1 1/2 inch River Rock		

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587-599	Brown clay	
599-601	Sand granite [illegible]	2
602-605	Brown clay / sand	3
605-610	clay sand	5
610-612	Sand w gray clay	2
612-612 1/2	Brown clay / sand	
612-615	Sand clay sm gravel.	3
616-626	Brown clay	
626-628	Brown clay /sand	8
629-632	Brown clay	
633-637	Br clay - sand	4
637-638	Br clay	
638-647	Gr Clay - sand	9
648-649 1/2	Sm gravel. some brown clay	2
650-652	Br clay	
652-654	Grey clay	
654-656	grey clay / sand	1
655-658	small gravel	3
658-660	gray clay sm gravel/sand	2
660-661	small gravel	1
661-663	Gr clay fine sand	2
663-664	Gr clay sand	1
664-665	Gr clay	
665-666	Gr clay sand sm gravel	1
666-670	Sand small gravel	4
670-73	Gray clay small gravel	3
676-681	" "	
673-675	Brown clay	
681-82	Small gravel clay	1

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682-685	clay Tan	
685 to 87	"	
687-688	"	
688-89	" small gravel	1
689-695	Sand - small gravel	
695-710	Brown clay	
710-713	clay sand	3
713-717	Sand sm gravel	4
717-722	Gr clay - sand	5
722-724	Sand - sm gravel	2
24-25	Clay - sand	1
725-727	Br clay	
727-729	Br Clay sand	2
729-733	Sand sm gravel .05" gravel	4
733-734	Brown clay - sand/gravel 1"	1
734-751	Clay - Brown grey	
751-762	Sand Small gravel (good)	11) screen
762-780	" " "	18
780-783	Sand - sm gravel like granite.	3
783-84	Clay green	
84-790	green clay / sand	
791-793	Small gravel some clay	2
794-795	small to 1/2" gravel	1
795-798	Clay some sand	3
798-801	small gravel, sand some clay	3
802-811	Br clay	
812-813	Sm gravel some Br Clay	1
814-820	Sand - gravel small some Br clay	6
820-847	Brown Clay - some sand	

UNIO 51835

846-848 Sand - gravel small some clay gray 2

848-853 Sm gravel 1< 1/2" 5

853-855 Sand - clay green .855-856 2 pee gravel

855-873 Green clay

873-876 green clay some sand

877-887 Gr clay

888-889 Gr clay - sand.

890-901 Gr clay - sand.

901-906 ~~Gr clay~~ Sand Float - sand gravel 1/2". 5

907-915 " " shale 8

915-918 Gr Shale? Hard

918-921 Gr clay

921-924 Br clay 50% sand

925-932 Gr clay

933-935 Gr clay - sand

935-945 Gr clay

946-950 Gr clay - sand

950-962 Gr clay some sand at 954-955. 1

963-964 Sand 1

965-974 Gr clay

975-983 Gr clay some sand

983-995 Gr clay

995-997 Sand Gr clay

997-1005 Gr Clay 5

1005-1010 Sand clay

1010-1036 Gr clay

1036-1039 Tan clay

1039-1045 Green clay

1045-1058 Brown clay.

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1060-1065	clay - ~~coarse sand 1/4" gravel~~ (1065)
1065-1088	(Green clay. < 3/4" gravel · sand →
1089-1090	Tan clay.
1090-1095	Green clay.
1096-1104	Gr. clay
1104-1106	Br. clay
1106-1120	coal - peat
1121-1135	Br. clay soft
1135-1145	Blue Clay
1145-1148	Brown - Black clay
1148-1155	Blue-Green clay
1155-1165	Brown clay · Black.

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SALEM, OREGON

0 - 280	16"	pipe solid		
280 - 290	16"	screen	10'	
290 - 300	16"	solid / Reducer to 10"		
300 - 360	10"	solid		
360 - 370	10"	screen.	10'	
370 - 390	10"	perf pipe.		20
390 - 450	10"	solid		
450 - 490	10"	perf.		40'
490 - 500'	10"	screen	10'	
500 - 520	10"	perf		20
520 - 550	10"	screen	30'	
550 - 570	10"	perf		20
570 - 590	10"	solid		
590 - 670	10"	perf		80
670 - 680	10"	screen	10'	
680 - 720	10"	solid		
720 - 740	10"	perf.		
740 - 760	10"	solid		
760 - 780	10"	screen	20'	
780 - 840	10"	perf.		60'
840 - 860	10"	screen	20'	
860 - 880	10"	solid		
880 - 920	10"	perf		40'
920 - 940	10"	solid		
940 - 960	10"	perf		20'
960 - 980	10"	solid		
980 - 1000	10"	perf		20'
1000 - 1020	10'	- solid		
1020 - 1040	10"	perf.		20'

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1040 - 1060	10"	solid
1060 - 1080	10"	perf.
1080 - 1100	10"	solid

452 - 460

UNIO 51835

Sand [illegible] gravel

[illegible] clay sand [illegible] gravel

Screen 512-542 29'

517 - 5[illegible] [illegible]

clay [illegible]

600'

Screen [illegible] 5 [illegible] 5

680'

720'

Screen 10 ft

750 - 780 sand [illegible] gravel

Perf

800'

Screen 10 ft

812 - 820 sm gravel - sand

[illegible] sand [illegible]

845 - 855 small gravel < 1/2"

845 - 855 10 ft

900 855 - 856 [illegible] gravel

901 - 906 Sand - gravel [illegible]

905 - 915 10 ft

907 - 915 sand [illegible]

1000

1005 - 1010 clay [illegible]

clay

1060 - 1065 clay coarse sand 1/4" gravel

1080 - 1088 < 1/4" gravel sand - clay

1100

perf 20 ft

solid 7 ft

20 - 18 ft

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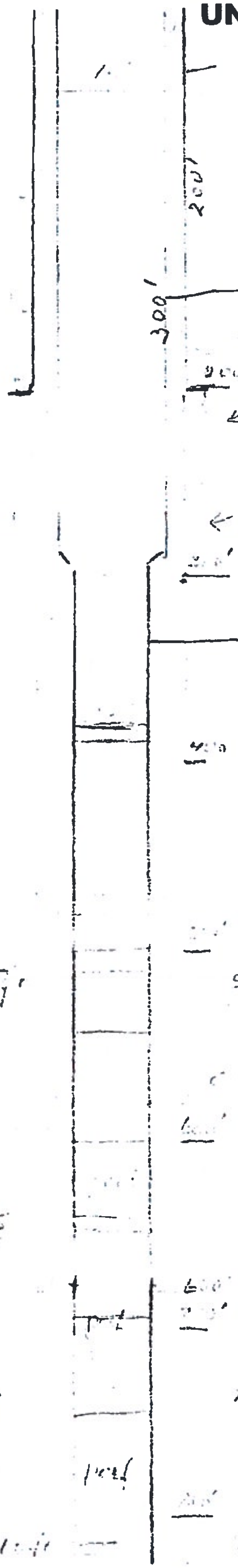

200' 24" casing 0.375

300' 16" liner 0250

195 - 217 clay

218 - 220 ... clay ...

231 - 242 clay

... clay - fine sand

... - 273 sand

10" ...

800' 10" liner + screen 0.250

377 - 383 clay ... gravel ...

517 - 5...

Screen 512-542 29'

clay ...

Screen 5 5

perf

750 - 780 sand ... gravel

Screen 10 ft

perf

812 - 820 sm gravel - sand

Screen 10 ft

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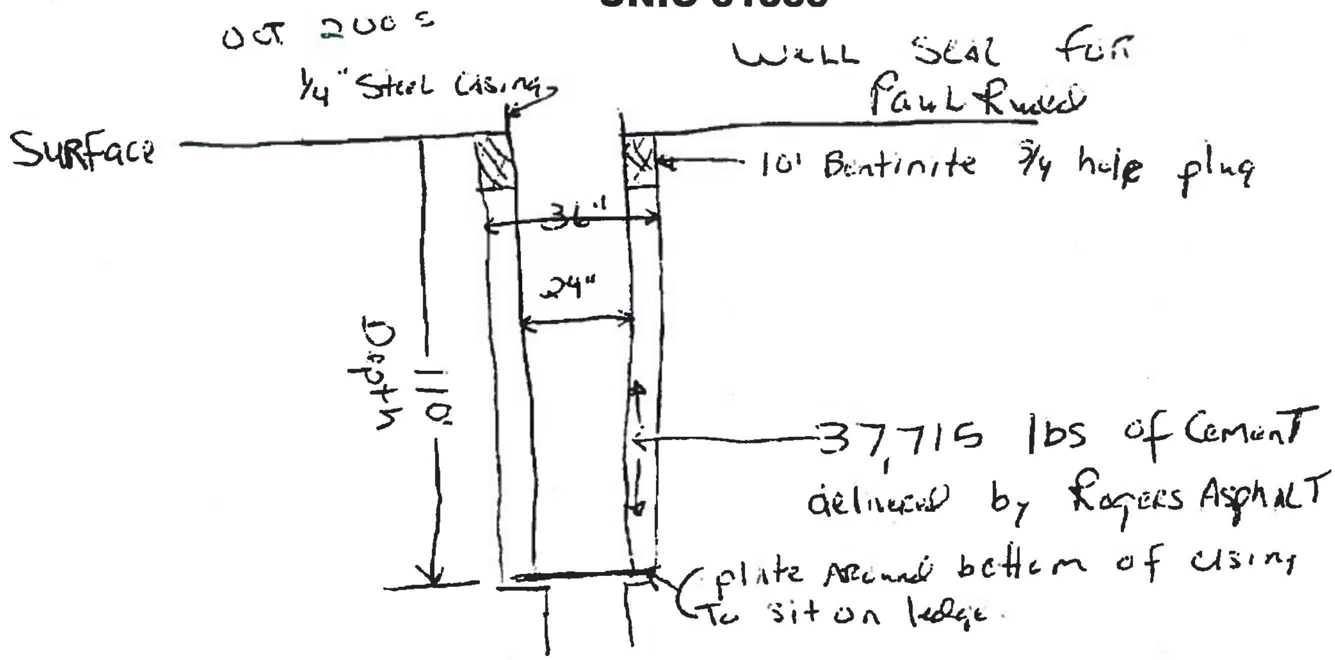

Att Bob M.

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SALEM, OREGON

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765 & OAR 690-205-0210)

UNIO 52415

9/11/2013

WELL I.D. LABEL# L 111099
START CARD # 1019118
ORIGINAL LOG #

(1) LAND OWNER

Owner Well I.D. RUDD 1
First Name BRETT Last Name RUDD
Company
Address 62913 WALLSINGER RD
City COVE State OR Zip 97824

(2) TYPE OF WORK

[X] New Well [ ] Deepening [ ] Conversion
[ ] Alteration (complete 2a & 10) [ ] Abandonment(complete 5a)

(2a) PRE-ALTERATION

	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
Casing:									

	Material	From	To	Amt	sacks/lbs
Seal:					

(3) DRILL METHOD

[ ] Rotary Air [ ] Rotary Mud [ ] Cable [ ] Auger [ ] Cable Mud
[X] Reverse Rotary [ ] Other

(4) PROPOSED USE

[ ] Domestic [X] Irrigation [ ] Community
[ ] Industrial/ Commericial [ ] Livestock [ ] Dewatering
[ ] Thermal [ ] Injection [ ] Other

(5) BORE HOLE CONSTRUCTION

Special Standard [ ] (Attach copy)

Depth of Completed Well 4045.00 ft.

BORE HOLE Dia	From	To	SEAL Material	From	To	Amt	sacks/ lbs
28	0	116	Cement	0	116	149	S
22	116	2537	Cement	116	500	628	S
14.75	2537	4045	Cement	2357	2537	256	S

How was seal placed: Method [ ] A [ ] B [X] C [ ] D [ ] E
[ ] Other
Backfill placed from 500 ft. to 2357 ft. Material CEMENT/BENTONI
Filter pack from ft. to ft. Material Size
Explosives used: [ ] Yes Type Amount

(5a) ABANDONMENT USING UNHYDRATED BENTONITE

Proposed Amount Actual Amount

(6) CASING/LINER

Casing	Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
(●)	( )	16	[X]	1	2537	.375	(●)	( )	[X]	[ ]
(●)	( )	24	[ ]	0	116	.375	(●)	( )	[X]	[ ]
( )	(●)	12	[ ]	2504	4045	.25	(●)	( )	[X]	[ ]
( )	( )		[ ]				( )	( )	[ ]	[ ]
( )	( )		[ ]				( )	( )	[ ]	[ ]

Shoe [ ] Inside [ ] Outside [ ] Other Location of shoe(s)
Temp casing [ ] Yes Dia From To

(7) PERFORATIONS/SCREENS

Perforations Method Machine Slot
Screens Type Material

Perf/ Screen	Casing/ Liner	Screen Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size
Perf	Liner	12	2540	4025	.188	2.5	21360	

(8) WELL TESTS: Minimum testing time is 1 hour

(●) Pump ( ) Bailer ( ) Air ( ) Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)
800	450	500	12

Temperature 110 °F Lab analysis [ ] Yes By
Water quality concerns? [ ] Yes (describe below) TDS amount

From	To	Description	Amount	Units

(9) LOCATION OF WELL (legal description)

County UNION Twp 2.00 S N/S Range 39.00 E E/W WM
Sec 20 SW 1/4 of the NW 1/4 Tax Lot 02S3929 300
Tax Map Number Lot
Lat ° ' " or 45.38022900 DMS or DD
Long ° ' " or -117.97217000 DMS or DD
( ) Street address of well (●) Nearest address
62913 WALLSINGER RD

(10) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Pre-Alteration			[ ]	
Completed Well	7/20/2013		[ ]	55

Flowing Artesian? [ ] Dry Hole? [ ]

WATER BEARING ZONES Depth water was first found 160.00

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
3/12/2013	160	2537	0			160
3/27/2013	2537	4045	0			55

(11) WELL LOG

Ground Elevation

Material	From	To
Geologic Info is attached	0	4045

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Date Started 3/2/2013 Complete 8/25/2013

(unbonded) Water Well Constructor Certification

I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

License Number Date

Signed

(bonded) Water Well Constructor Certification

I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

License Number 1523 Date 9/11/2013

Signed ROBERT STADELI (E-filed)

Contact Info (optional) Robert Stadeli - 503-572-9396

WATER SUPPLY WELL REPORT - continuation page

UNIO 52415

9/11/2013

WELL I.D. LABEL# L	111099
START CARD #	1019118
ORIGINAL LOG #	

(2a) PRE-ALTERATION

Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd

Material	From	To	Amt	sacks/lbs

Water Quality Concerns

From	To	Description	Amount	Units

(5) BORE HOLE CONSTRUCTION

BORE HOLE

Dia	From	To

SEAL

Material	From	To	Amt	sacks/ lbs

FILTER PACK

From	To	Material	Size

(10) STATIC WATER LEVEL

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)

(6) CASING/LINER

Casing	Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd

(11) WELL LOG

Material	From	To

(7) PERFORATIONS/SCREENS

Perf/ Screen	Casing/ Liner	Screen Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size

(8) WELL TESTS: Minimum testing time is 1 hour

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)

Comments/Remarks

This well was drilled flooded reverse with mud, all well flow data and static water levels were not available until well development. Geologic data is attached.

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Appendix H: 30 Percent Design Drawings

TECHNICAL MEMO - DRAFT

To:	Brett Rudd, Rudd Farms
From:	Brad D. Baird, P.E.
Subject:	**Aquifer Recharge Project**
Date:	September 24, 2019
Job/File No.	1199-714-02 (w/encl.)
cc:	Matt Kohlbecker, R.G., GSI Water Solutions, Inc. (w/encl.)

The purpose of this technical memo is to provide a general description of the work to be completed to utilize Rudd Well No. 1 (alluvial well) to recharge the Rudd Basalt Well for Rudd Farms, located in the Grande Ronde Valley in Union County, Oregon. This technical memo is intended to meet the plans for recharge project construction requirements for submission to Oregon Water Resources Department (OWRD) for aquifer recharge (AR) permitting. OWRD permitting work is being completed by GSI Water Solutions, Inc. An aerial photograph showing the general location of each well is shown on Figure 1, Project Location.

Existing Wells (for Aquifer Recharge Project) and Irrigation System

Rudd Farms utilizes an alluvial well and a deep basalt well for irrigating a portion of its farm ground. The locations of Rudd Well No. 1 and the Rudd Basalt Well are shown on Figure 1. These wells are connected to a piping network that allows each well to serve more than one pivot. Both wells discharge into the same piping network at opposite ends. Figure 1 shows the approximate location of the piping network; only the relevant piping between each well is shown. Additional piping is present to convey irrigation water to other areas of Rudd Farms.

Aquifer Recharge Project, General Description

The intent of this project is to utilize the alluvial well to pump alluvial water to the location of the deep basalt well for basalt AR. At the deep well location, treatment of the alluvial well water will occur prior to injection into the deep basalt well. Injection will occur in the winter and early spring months (December through March) during the non-irrigation season.

Well and Pipeline Flushing Ability

During implementation and operation of the AR system, it will be important to have the ability to properly flush each well as well as the pipeline route between the wells. Each well will be modified to allow discharge to waste to help ensure the wells and piping are clear prior to utilization. Each well's discharge to waste piping and valving will be configured so the pipeline between the wells can be flushed to waste in either direction utilizing either well.

Sampling Ports and Sampling Ability

At least five sampling ports will be installed to allow the means to sample water in several stages of the AR operation. Sampling ports will be installed to allow the following sampling to occur:

- Alluvial well raw water at the alluvial well
- Alluvial well chlorinated water at the alluvial well
- Alluvial well water prior to manganese filtration at the basalt well
- Alluvial well water post manganese filtration at the basalt well
- Basalt well discharge water (i.e., recovered water) at the basalt well

Chlorination Improvements

A chlorine injection system will be installed at the alluvial well. The chlorine system will consist of a hypochlorination system poly tank and metering pump. The metering pump will discharge into the well discharge piping utilizing a chlorine injector pipe. The metering pump flow rate will be adjustable, allowing the operator to adjust the chlorine solution injection rate proportional to the well flow rate and to continue to modify the injection rate until the desired chlorine residual concentration is obtained. The chlorine injection into the alluvial well water will facilitate oxidation of manganese, allowing manganese to come out of the solution and precipitate into the water. The length of pipeline between each well is more than sufficient for precipitation to occur (based on jar testing conducted by Anderson Perry & Associates, Inc., to measure the contact time required for manganese precipitation to occur). This operation will allow the manganese to be removed by treatment, as described hereafter.

Bag Filter Manganese Filtration System

A dual cannister manganese bag filter filtration system will be installed in line with the alluvial well water injection line at the basalt well. The bag filter system will facilitate removal of the precipitated manganese particulates from the alluvial well water prior to injection into the basalt well. The system will have adequate controls to protect from system failure, over-pressurization, etc.

Flowmeters

Both existing and new flowmeters will be utilized and installed in the AR system so the operator can closely monitor all flow volumes during system operation. The following flowmeters will be in use:

- **Existing Alluvial Well Discharge Flowmeter** - Allows for alluvial water to be metered at the well.

- **New Flowmeter at Basalt Well Injection Line** - Allows for alluvial water to be metered just prior to injection, both to log injection flow rates and to compare to the source well flowmeter for calculating water loss between the point of diversion and the place of recharge.

- **Existing Flowmeter at Basalt Well Discharge Line** - Allows for all basalt pumping rates to be logged.

List of Needed Improvements to Implement Aquifer Recharge

Several operation-related improvements are needed at each well location as well as at key locations along the pipeline route between each well. These improvements are generally shown on Figures 2 and 3 and are described in general hereafter. The purpose of each improvement is also listed.

Alluvial Well No. 1 Improvements

- Piping and valving to pump the well to waste for well flushing and clearing and to allow flushing of the pipeline using the basalt well's pump
- Sample ports to allow alluvial water sampling (both raw and post-chlorination)
- Hypochlorination system with a metering pump to allow adjustable chlorine solution dosage for the alluvial well water
- Heated and insulated enclosure to facilitate winter operation

Basalt Well Improvements

- Piping and valving to route chlorinated alluvial water to a manganese filtration system
- Sample ports on the injection pipeline to facilitate sampling prior to and after manganese filtration
- A dual cannister manganese bag filtration system for manganese precipitate removal
- Flowmeter to monitor injection flow rates and water losses between the point of diversion and the place of recharge
- Pump to waste piping and valving to allow alluvial water to be discharged to waste and to allow pipeline flushing utilizing the alluvial well
- Pump to waste piping and valving to allow the basalt well to be discharged to waste to facilitate well flushing
- Heated and insulated enclosure to facilitate winter operation

General Related Improvements

- Buried valve and piping improvements at a center pivot to isolate aboveground piping to allow for winter operation
- Relocation of pressure relief valves to insulated vaults to facilitate winter operation
- Other general piping and valving improvements, as required, to isolate the pipeline network between each well

Additional Design Engineering

Prior to construction of the needed improvements, design Drawings will be completed to adequately depict the needed improvements. Specifications and a specific equipment list will be provided so the operator can secure the necessary equipment to complete the needed treatment for proper AR system operation. Operation and maintenance (O&M) materials will also be secured and provided to the operator to assist with proper O&M. Engineering support will also be provided during construction and operation, as needed.

Proposed Construction

The proposed improvements will be constructed by the farm owner/operator and subcontractors, as required. As stated above, the engineer will provide detailed Drawings for system construction and will be available to assist with equipment purchase, setup, startup, and operation, as needed.

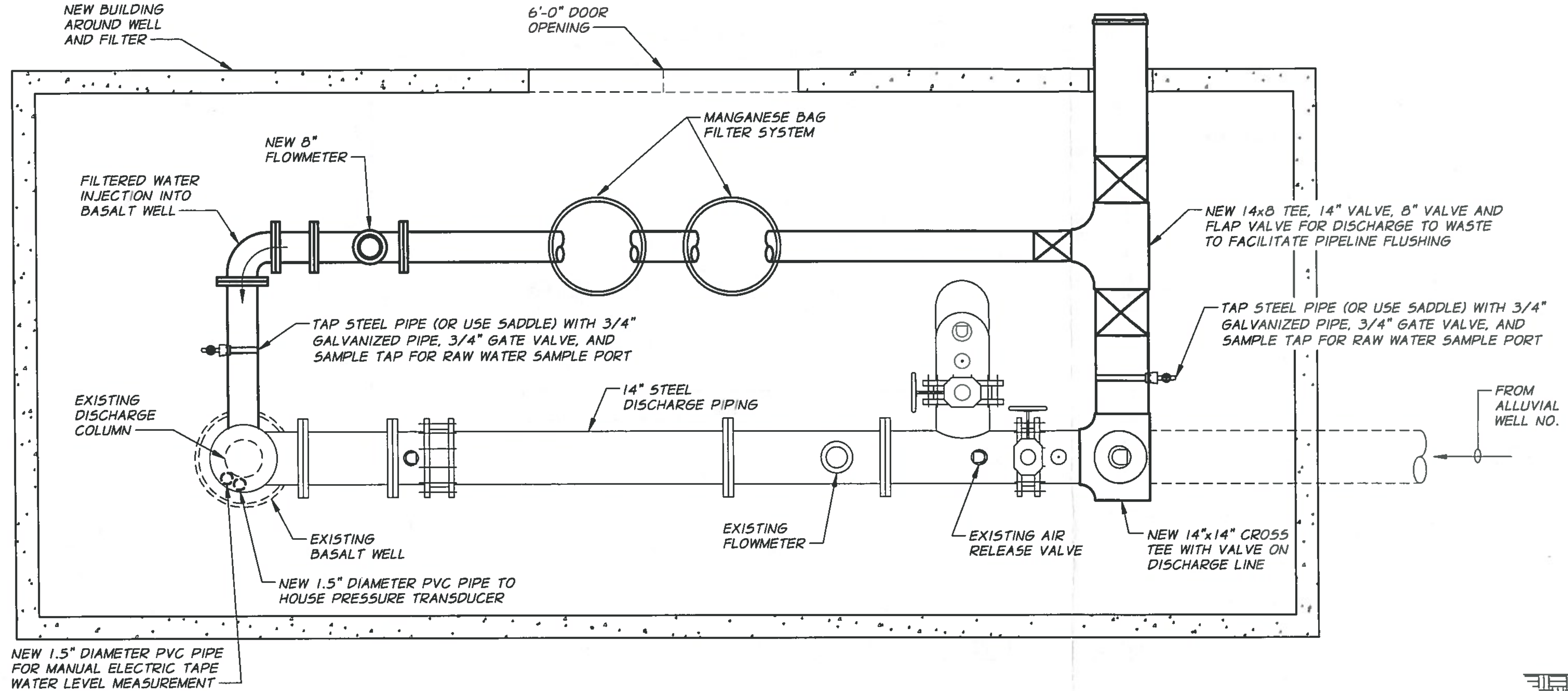
Conclusion

This technical memo provides a general description of the proposed improvements to be completed by Rudd Farms for its proposed AR project. If there are questions or clarification is needed, please feel free to call me.

BDB/cd

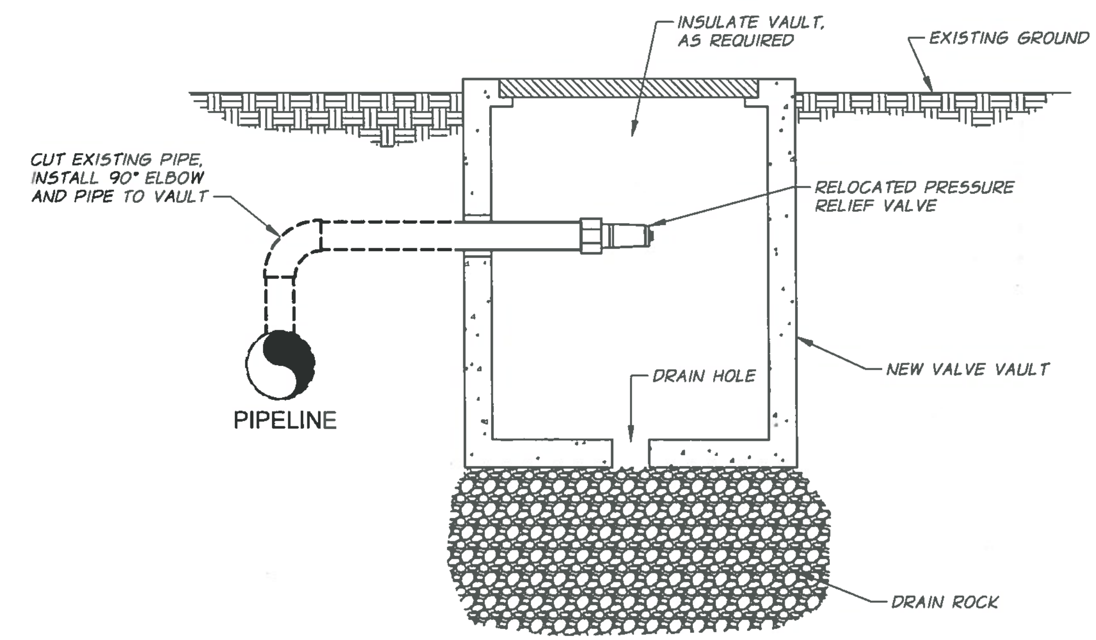
Enclosures

G:\Clients\Rudd Farms\1199-714 Pilot Test\Correspondence\Aquifer Recharge Memo\Memo.doc



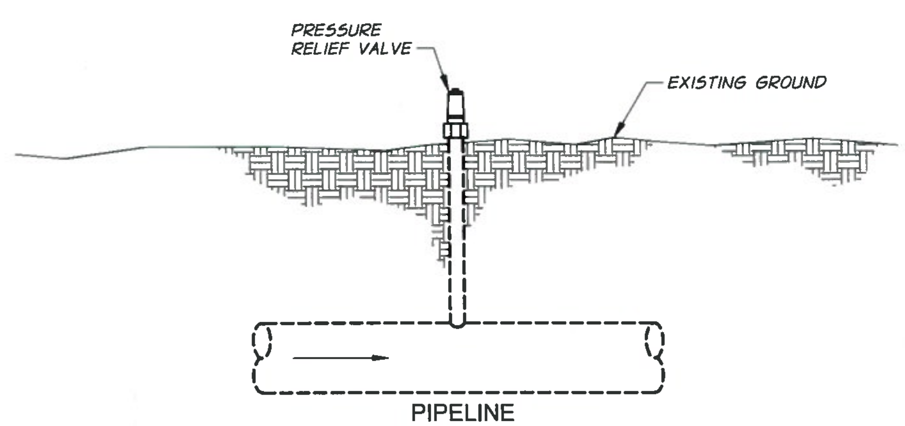
BASALT WELL IMPROVEMENTS

N.T.S.



PRESSURE RELIEF VALVE MODIFICATIONS

N.T.S.



EXISTING PRESSURE RELIEF VALVE

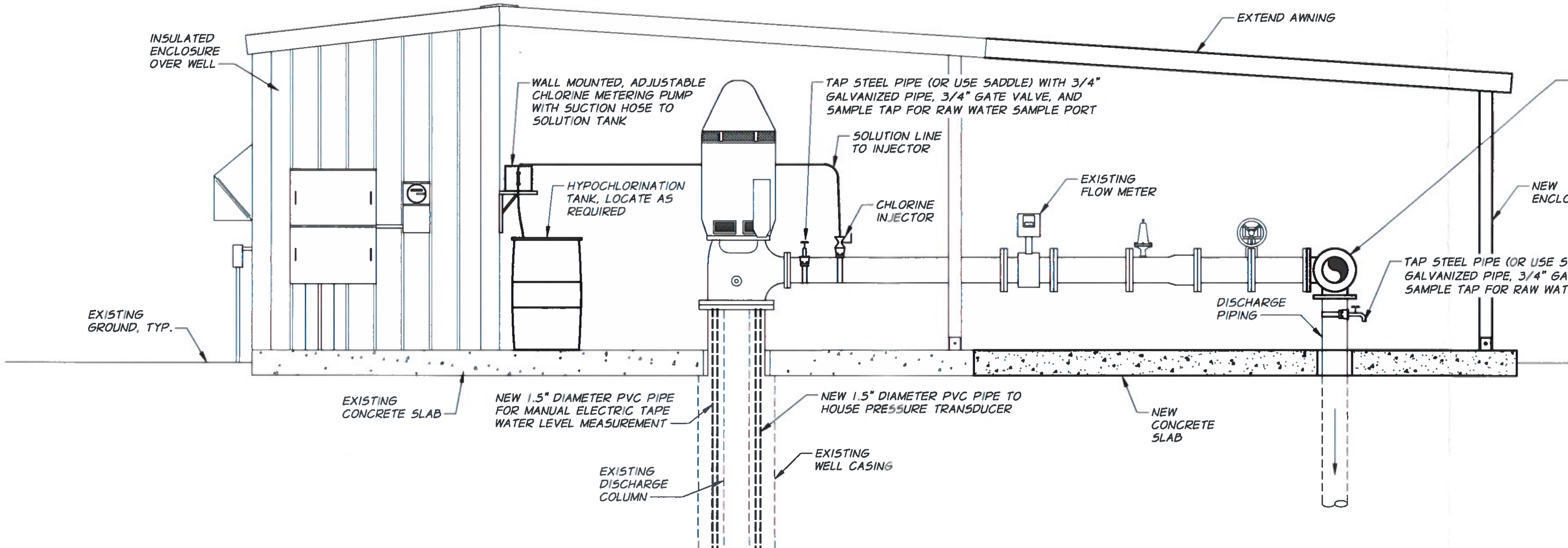
N.T.S.

anderson perry & associates, inc.

RUDD FARMS
AQUIFER RECHARGE
TECHNICAL MEMO

CONCEPTUAL DETAILS II

FIGURE 3

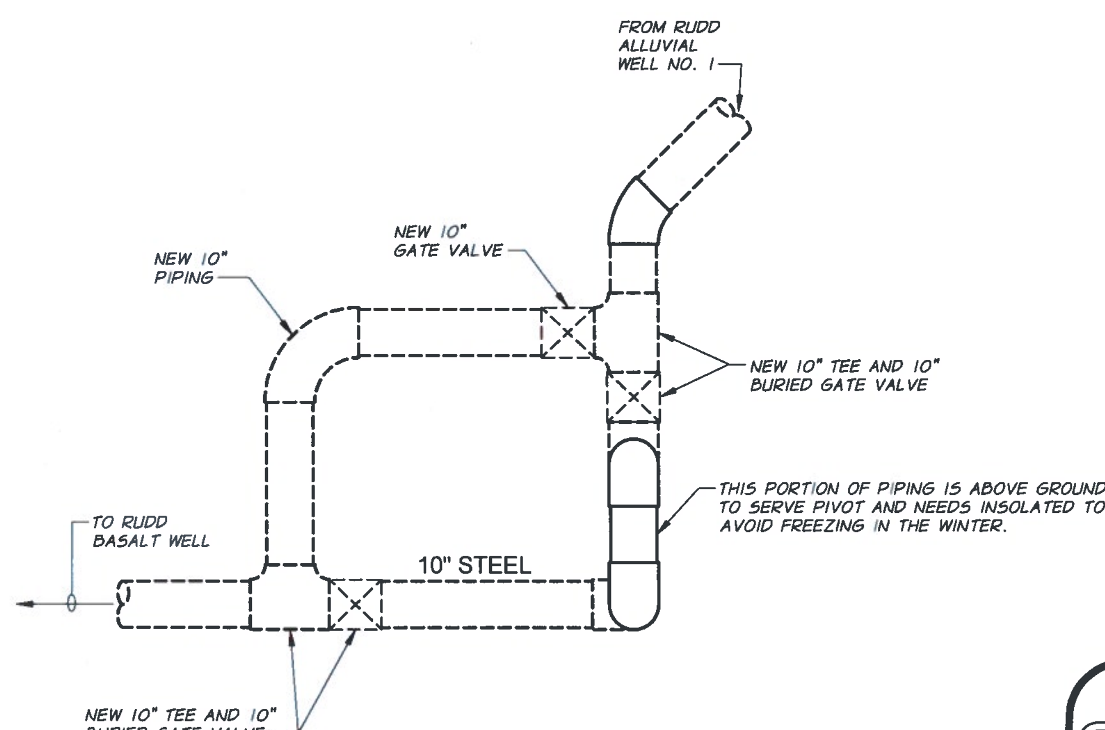


RUDD WELL NO. 1 IMPROVEMENTS

N.T.S.

WELL NO. 1 IMPROVEMENTS

1. EXTEND AWNING TO COVER DISCHARGE PIPING.
2. ENCLOSE AND INSULATE AWNING AREA TO AVOID WINTER FREEZING.
3. INSTALL LIGHTING, HEATER, AND ELECTRICAL SERVICE TO NEWLY ENCLOSED AREA.
4. INSTALL A TEE AND VALVE IN DISCHARGE LINE FOR PUMP TO WASTE ABILITY.
5. INSTALL A SODIUM HYPOCHLORINATION SYSTEM IN NEWLY ENCLOSED AND HEATED AREA, CONSISTING OF A SOLUTION TANK, ADJUSTABLE METERING PUMP, AND INJECTOR.
6. INSTALL SAMPLING TAPS FOR RAW WATER AND CHLORINATED WATER.
7. INSTALL DOWN HOLE 1.5" PVC PIPES FOR PRESSURE TRANSDUCER AND WATER LEVEL MEADUREMENTS.



PIVOT BYPASS / ISOLATION IMPROVEMENTS

N.T.S.

anderson perry & associates, inc.

RUDD FARMS
AQUIFER RECHARGE
TECHNICAL MEMO

CONCEPTUAL DETAILS I

FIGURE 2

Appendix I: Water Rights

STATE OF OREGON

COUNTY OF UNION

CERTIFICATE OF WATER RIGHT

THIS CERTIFICATE ISSUED TO

BRETTON S. RUDD
KARA L. RUDD
JANET K. RUDD
62913 WALLSINGER RD
COVE OR 97824

NORTHWEST FARM CREDIT SERVICES, FLCA
PO BOX 2515
SPOKANE WA 99220-2515

confirms the right to use the waters of WELL 1, WELL 2, AND WELL 3 IN WRIGHT SLOUGH BASIN, for IRRIGATION USE ON 365.6 ACRES.

This right was perfected under Permit G-15541. The date of priority is JUNE 5, 2003. The amount of water to which this right is entitled is limited to an amount actually used beneficially, and shall not exceed 4.46 CUBIC FEET PER SECOND or its equivalent in case of rotation, measured at the well.

The period of use is March 1 through October 31.

The wells are located as follows:

Twp	Rng	Mer	Sec	Q-Q	Measured Distances
2 S	39 E	WM	29	SW NE	WELL 3 - 100 FEET NORTH AND 2748 FEET EAST FROM W1/4 CORNER, SECTION 29
2 S	39 E	WM	29	SW NW	WELL 2 - 110 FEET NORTH AND 100 FEET EAST FROM W1/4 CORNER, SECTION 29
2 S	39 E	WM	30	SW NE	WELL 1 - 44 FEET NORTH AND 2589 FEET WEST FROM W1/4 CORNER, SECTION 29

The amount of water used for irrigation under this right, together with the amount secured under any other right existing for the same lands, is limited to a diversion of ONE-EIGHTIETH of one cubic foot per second and 3.0 acre-feet for each acre irrigated during the irrigation season of each year.

STATE OF OREGON THE UNION 1859

NOTICE OF RIGHT TO PETITION FOR RECONSIDERATION OR JUDICIAL REVIEW

This is an order in other than a contested case. This order is subject to judicial review under ORS 183.484.and ORS 536.075. Any petition for judicial review must be filed within the 60-day time period specified by ORS 183.484(2). Pursuant to ORS 183.484, ORS 536.075 and OAR 137-004-0080, you may petition for judicial review and petition the Director for reconsideration of this order. A petition for reconsideration may be granted or denied by the Director, and if no action is taken within 60 days following the date the petition was filed, the petition shall be deemed denied. In addition, under ORS 537.260 any person with an application, permit or water right certificate subsequent in priority may jointly or severally contest the issuance of the certificate within three months after issuance of the certificate.

A description of the place of use is as follows:

Twp	Rng	Mer	Sec	Q-Q	Acres
2 S	39 E	WM	29	NW NE	40.0
2 S	39 E	WM	29	SW NE	18.0
2 S	39 E	WM	29	NE NW	40.0
2 S	39 E	WM	29	NW NW	40.0
2 S	39 E	WM	29	SW NW	35.0
2 S	39 E	WM	29	SE NW	39.2
2 S	39 E	WM	30	NE NE	39.2
2 S	39 E	WM	30	NW NE	40.0
2 S	39 E	WM	30	SW NE	39.2
2 S	39 E	WM	30	SE NE	35.0

Measurement, recording and reporting conditions:

A. The water user shall maintain the meter or other suitable measuring device as approved by the Director in good working order, shall keep a complete record of the amount of water used each month, and shall submit a report which includes the recorded water use measurements to the Department annually or more frequently as may be required by the Director. Further, the Director may require the water user to report general water-use information, including the place and nature of use of water under the right.

B. The water user shall allow the watermaster access to the meter or measuring device; provided however, where the meter or measuring device is located within a private structure, the watermaster shall request access upon reasonable notice.

The wells shall produce groundwater from no shallower than 40 feet below land surface.

Use of water under authority of this right may be regulated if analysis of data available after the right is issued discloses that the appropriation will measurably reduce the surface water flows necessary to maintain the free-flowing character of a scenic waterway in quantities necessary for recreation, fish and wildlife in effect as of the priority date of the right or as those quantities may be subsequently reduced.

If substantial interference with a senior water right occurs due to withdrawal of water from any well listed on this right, then use of water from the wells shall be discontinued or reduced and/or the schedule of withdrawal shall be regulated until or unless the Department approves or implements an alternative administrative action to mitigate the interference. The Department encourages junior and senior appropriators to jointly develop plans to mitigate interference.

The wells shall be maintained in accordance with the General Standards for the Construction and Maintenance of Water Wells in Oregon. The works shall be equipped with a useable access port, and may also include an air line and pressure gauge adequate to determine water level elevation in the wells at all times.

The Director may require water level or pump test results every ten years.

Failure to comply with any of the provisions of this right may result in action including, but not limited to, restrictions on the use, civil penalties, or cancellation of the right.

This right is for the beneficial use of water without waste. The water user is advised that new regulations may require the use of best practical technologies or conservation practices to achieve this end.

By law, the land use associated with this water use must be in compliance with statewide land-use goals and any local acknowledged land-use plan.

The use of water shall be limited when it interferes with any prior surface or ground water rights.

The right to the use of the water for the above purpose is restricted to beneficial use on the place of use described.

Issued JAN 08 2016.

Dwight French
Water Right Services Division Administrator, for
Thomas M. Byler, Director
Oregon Water Resources Department

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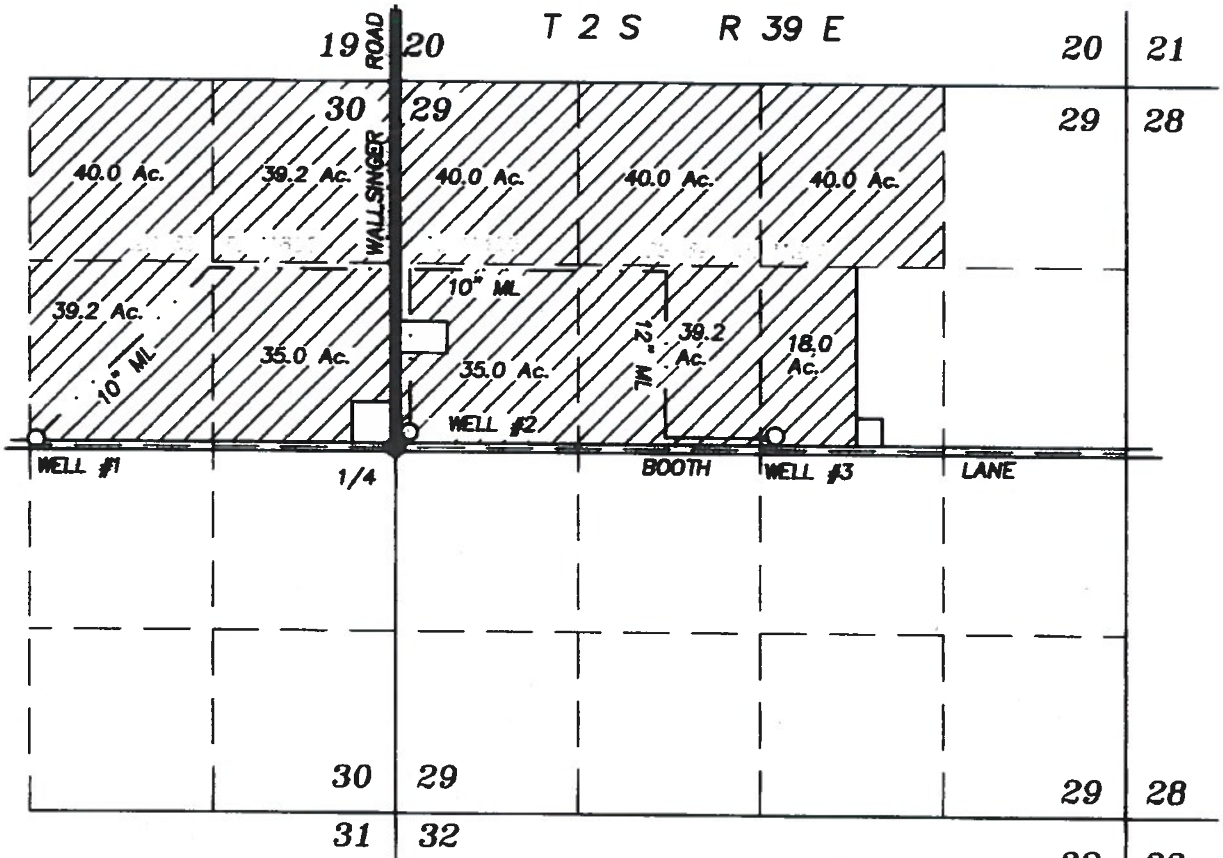

Lands with primary rights from Wells 1, 2 and 3.

Existing buried mainline

Well number 1 is 44' North and 2589' West of the West quarter corner of Section 29.

Well number 2 is 110' North and 100 East of the West quarter corner of Section 29.

Well number 3 is 100 North and 2748' East of the West quarter corner of Section 29.

SCALE: 1"=1320'

Certified Water Right Examiner # 021
Gregory T. Blackman
Nov. 19, 1987
STATE OF OREGON

JUNE 17, 2008

FINAL PROOF MAP OF WATER RIGHTS FROM WELLS #1, #2 AND #3

FOR

BRETT RUDD, PAUL & JANET RUDD

BY

BAGETT – GRIFFITH & BLACKMAN
2006 ADAMS AVENUE
LAGRANDE, OREGON 97850

NOTE: The preparation of this map was for the purpose of identifying the location of the proposed water right and has no intent to provide dimensions or location of property ownership lines. Location information shown hereon was furnished by the applicant.

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WATER RESOURCES DEPT
SALEM, OREGON

APPLICATION NO. G– 16028

PERMIT NUMBER G– 16028

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STATE OF OREGON

COUNTY OF UNION

PERMIT TO APPROPRIATE THE PUBLIC WATERS

THIS PERMIT IS HEREBY ISSUED TO

BRETT RUDD
62913 WALLSINGER RD
COVE, OR 97824

The specific limits and conditions of the use are listed below.

APPLICATION FILE NUMBER: G-17558

SOURCE OF WATER: WELL 1, WELL 2, AND WELL 3 IN WRIGHT SLOUGH BASIN

PURPOSE OR USE: IRRIGATION OF 750.0 ACRES AND SUPPLEMENTAL IRRIGATION OF 368.0 ACRES

MAXIMUM RATE: 4.46 CUBIC FEET PER SECOND

PERIOD OF USE: MARCH 1 THROUGH OCTOBER 31

DATE OF PRIORITY: MAY 21, 2012

WELL LOCATIONS:

WELL 1: SW ¼ NW ¼, SECTION 20, T2S, R39E, W.M.; 3960 FEET NORTH AND 435 FEET EAST FROM SW CORNER, SECTION 20

WELL 2: SE ¼ NW ¼, SECTION 20, T2S, R39E, W.M.; 3960 FEET NORTH AND 1325 FEET EAST FROM SW CORNER, SECTION 20

WELL 3: SE ¼ NW ¼, SECTION 20, T2S, R39E, W.M.; 3960 FEET NORTH AND 2575 FEET EAST FROM SW CORNER, SECTION 20

The amount of water used for irrigation under this right, together with the amount secured under any other right existing for the same lands, is limited to a diversion of ONE-EIGHTIETH of one cubic foot per second and 3.0 acre-feet for each acre irrigated during the irrigation season of each year.

THE PLACE OF USE IS LOCATED AS FOLLOWS:

QQ	PRIMARY	SUPPLEMENTAL
SW ¼ NE ¼	40.0 ACRES	
SE ¼ NE ¼	40.0 ACRES	
NE ¼ SE ¼	40.0 ACRES	

QQ	PRIMARY	SUPPLEMENTAL
NW ¼ SE ¼	40.0 ACRES	
SW ¼ SE ¼	40.0 ACRES	
SE ¼ SE ¼	40.0 ACRES	
	SECTION 19	
NE ¼ NE ¼	40.0 ACRES	
NW ¼ NE ¼	40.0 ACRES	
SW ¼ NE ¼	40.0 ACRES	
NE ¼ NW ¼	40.0 ACRES	
NW ¼ NW ¼	10.0 ACRES	
SW ¼ NW ¼	40.0 ACRES	
SE ¼ NW ¼	40.0 ACRES	
NE ¼ SW ¼	40.0 ACRES	
NW ¼ SW ¼	40.0 ACRES	
SW ¼ SW ¼	40.0 ACRES	
SE ¼ SW ¼	40.0 ACRES	
	SECTION 20	
NE ¼ NE ¼	40.0 ACRES	
NW ¼ NE ¼		40.0 ACRES
SW ¼ NE ¼	20.0 ACRES	18.0 ACRES
SE ¼ NE ¼	40.0 ACRES	
NE ¼ NW ¼		40.0 ACRES
NW ¼ NW ¼		40.0 ACRES
SW ¼ NW ¼		35.0 ACRES
SE ¼ NW ¼		40.0 ACRES
	SECTION 29	
NE ¼ NE ¼		40.0 ACRES
NW ¼ NE ¼		40.0 ACRES
SW ¼ NE ¼		40.0 ACRES
SE ¼ NE ¼		35.0 ACRES
	SECTION 30	

TOWNSHIP 2 SOUTH, RANGE 39 EAST, W.M.

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Measurement, recording and reporting conditions:

A. Before water use may begin under this permit, the permittee shall install a totalizing flow meter or other suitable measuring device as approved by the Director at each point of appropriation. The permittee shall maintain the meter or measuring device in good working order.

B. The permittee shall keep a complete record of the amount of water diverted each month, and shall submit a report which includes the recorded water-use measurements to the Department

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annually or more frequently as may be required by the Director. Further, the Director may require the permittee to report general water-use information, including the place and nature of use of water under the permit.

C. The permittee shall allow the watermaster access to the meter or measuring device; provided however, where any meter or measuring device is located within a private structure, the watermaster shall request access upon reasonable notice.

D. The Director may provide an opportunity for the permittee to submit alternative measuring and reporting procedures for review and approval.

Dedicated Measuring Tube: Wells with pumps shall be equipped with an unobstructed, dedicated measuring tube pursuant to figure 200-5 in OAR 690-200.

The Department requires the water user to obtain, from a qualified individual (see below), and report annual static water levels for each well on the permit. The static water level shall be measured in the month of March. Reports shall be submitted to the Department within 30 days of measurement.

The permittee shall report an initial March static water-level measurement once well construction is complete and annual measurements thereafter. Annual measurements are required whether or not the well is used. The first annual measurement will establish a reference level against which future measurements will be compared. However, the Director may establish the reference level based on an analysis of other water-level data. The Director may require the user to obtain and report additional water levels each year if more data are needed to evaluate the aquifer system.

All measurements shall be made by a certified water rights examiner, registered professional geologist, registered professional engineer, licensed well constructor or pump installer licensed by the Construction Contractors Board. Measurements shall be submitted on forms provided by, or specified by, the Department. Measurements shall be made with equipment that is accurate to at least the standards specified in OAR 690-217-0045. The Department requires the individual performing the measurement to:

A. Associate each measurement with an owner's well name or number and a Department well log ID; and
B. Report water levels to at least the nearest tenth of a foot as depth-to-water below ground surface; and
C. Specify the method of measurement; and

D. Certify the accuracy of all measurements and calculations reported to the Department.

The water user shall discontinue use of, or reduce the rate or volume of withdrawal from, the well(s) if any of the following events occur:

A. Annual water-level measurements reveal an average water-level decline of three or more feet per year for five consecutive years; or
B. Annual water-level measurements reveal a water-level decline of 15 or more feet in fewer than five consecutive years; or
C. Annual water-level measurements reveal a water-level decline of 25 or more feet; or
D. Hydraulic interference leads to a decline of 25 or more feet in any neighboring well with senior priority.

The period of restricted use shall continue until the water level rises above the decline level which triggered the action or the Department determines, based on the permittee's and/or the Department's data and analysis, that no action is necessary because the aquifer in question can sustain the observed declines without adversely impacting the resource or causing substantial interference with senior water rights. The water user shall not allow excessive decline, as defined in Commission rules, to occur within the aquifer as a result of use under this permit. If more than one well is involved, the water user may submit an alternative measurement and reporting plan for review and approval by the Department.

Ground water production shall only occur from the basalt ground water reservoir.

The wells shall be constructed in such a manner as to produce ground water from a single basalt aquifer.

The permittee shall notify the Groundwater/Hydrology Section of the Department at least five business days prior to beginning well construction. The Department may require the well constructor to collect drill cuttings during the construction of the well.

Prior to using water from any well listed on this permit, the permittee shall ensure that the well has been assigned an OWRD Well Identification Number (Well ID tag), which shall be permanently attached to the well. The Well ID shall be used as a reference in any correspondence regarding the well, including any reports of water use, water level, or pump test data.

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Use of water under authority of this permit may be regulated if analysis of data available after the permit is issued discloses that the appropriation will measurably reduce the surface water flows necessary to maintain the free-flowing character of a scenic waterway in quantities necessary for recreation, fish and wildlife in effect as of the priority date of the right or as those quantities may be subsequently reduced.

STANDARD CONDITIONS

Failure to comply with any of the provisions of this permit may result in action including, but not limited to, restrictions on the use, civil penalties, or cancellation of the permit.

If the number, location, source, or construction of any well deviates from that proposed in the permit application or required by permit conditions, this permit may be subject to cancellation, unless the Department authorizes the change in writing.

If substantial interference with a senior water right occurs due to withdrawal of water from any well listed on this permit, then use of water from the well(s) shall be discontinued or reduced and/or the schedule of withdrawal shall be regulated until or unless the Department approves or implements an alternative administrative action to mitigate the interference. The Department encourages junior and senior appropriators to jointly develop plans to mitigate interferences.

The well(s) shall be constructed in accordance with the General Standards for the Construction and Maintenance of Water Wells in Oregon. The works shall be equipped with a usable access port, and may also include an air line and pressure gauge adequate to determine water level elevation in the well at all times.

If the riparian area is disturbed in the process of developing a point of appropriation, the permittee shall be responsible for restoration and enhancement of such riparian area in accordance with ODFW's Fish and Wildlife Habitat Mitigation Policy OAR 635-415. For purposes of mitigation, the ODFW Fish and Wildlife Habitat Mitigation Goals and Standards, OAR 635-415, shall be followed.

The use may be restricted if the quality of downstream waters decreases to the point that those waters no longer meet state or federal water quality standards due to reduced flows.

Where two or more water users agree among themselves as to the manner of rotation in the use of water and such agreement is placed in writing and filed by such water users with the watermaster, and such rotation system does not infringe upon such prior rights of any water user not a party to such rotation plan, the watermaster shall distribute the water according to such agreement.

Prior to receiving a certificate of water right, the permit holder shall submit to the Water Resources Department the results of a pump test meeting the Department's standards for each point of appropriation (well), unless an exemption has been obtained in writing under OAR 690-217. The Director may require water-level or pump-test data every ten years thereafter.

This permit is for the beneficial use of water without waste. The water user is advised that new regulations may require the use of best practical technologies or conservation practices to achieve this end.

By law, the land use associated with this water use must be in compliance with statewide land-use goals and any local acknowledged land-use plan.

Completion of construction and application of the water shall be made within five years of the date of permit issuance. If beneficial use of permitted water has not been made before this date, the permittee may submit an application for extension of time, which may be approved based upon the merit of the application.

Within one year after making beneficial use of water, the permittee shall submit a claim of beneficial use, which includes a map and report, prepared by a Certified Water Rights Examiner.

Issued February 14, 2013

E. Timothy Wallin

E. Timothy Wallin, Water Rights Program Manager
for Phillip C. Ward, Director

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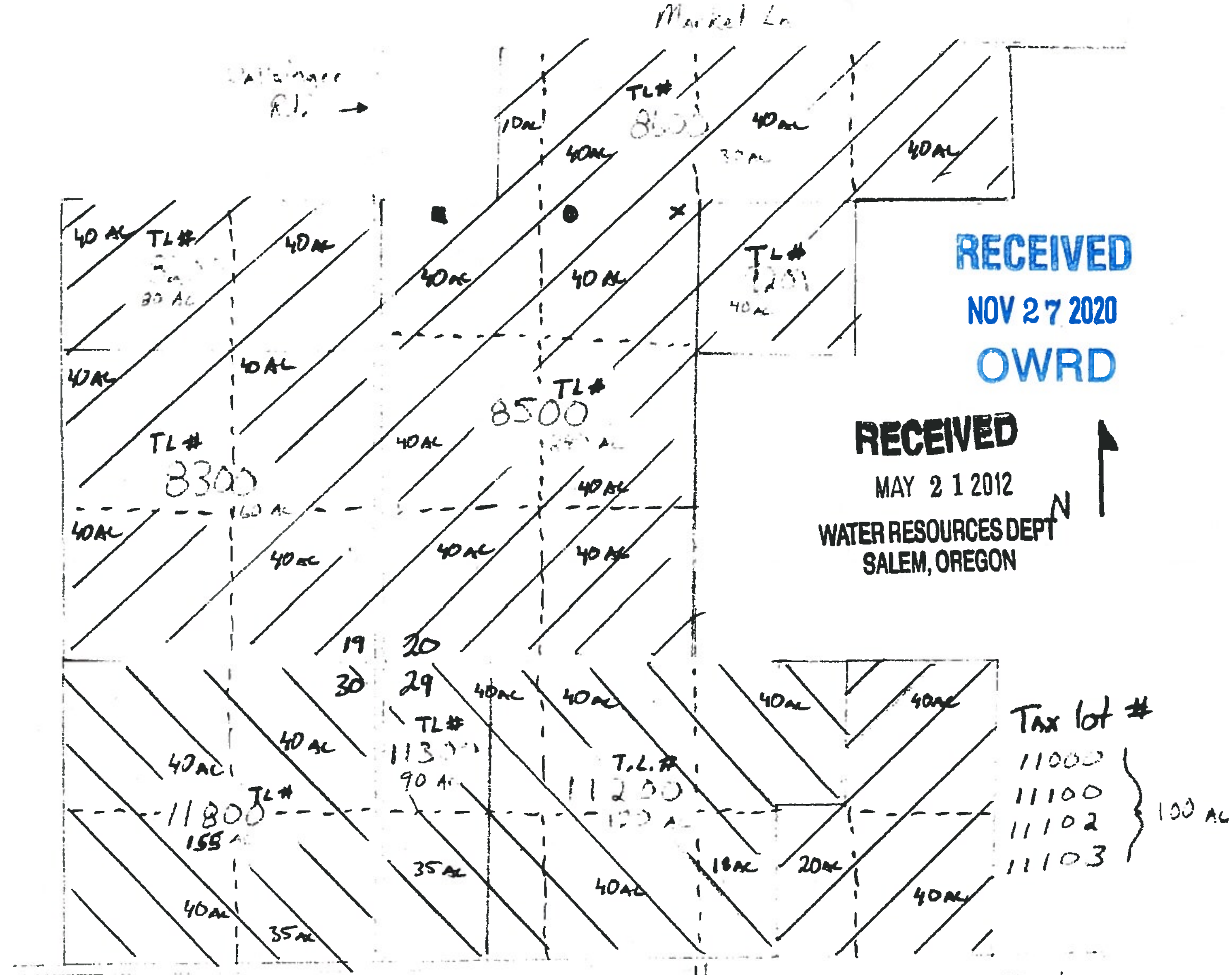

■ Well #1, 3960' N of SW corner of sec. 20, 435' E

● Well #2, 3960' N of SW corner of Sec. 20, 1325' E

× #3 3960' N of SW corner of Sec 20. 2575' E

1" = 1320 Ft.

T 2 S R 39 E

= Primary
750 AC

G-17558

= Supplemental
370 AC

Appendix J: Underground Injection Control (UIC) Application

Class V Underground Injection Control Authorization by Rule

Aquifer Storage and Recovery, Low Temperature Geothermal, Remediation, and Other UICs that **do not** Drain Stormwater

DEQ State of Oregon Department of Environmental Quality

DEQ Use Only
Received:________
Amount:________
Check #:________
From:________
UIC #:________

This form will be processed within two weeks of receipt. All sections must be filled out unless the form indicates that that a section is "optional." Instructions begin on page 2.

A. Fee for authorization by rule

Number of injection systems 1 x $125 = 125 (total payment) **Note: See instructions for fees related to remediation projects**

B. Owner information

Organization: Rudd Farms	Site contact: Brett Rudd		
Mailing address: 62913 Wallsinger Road	City: Cove	State: OR	Zip code: 97824
Phone number: 541-910-1812	Email address: ruddfarms@gmail.com		

C. Facility information

Facility name: Well No. 1			
Physical address: 62913 Wallsinger Road	City: Cove	State: OR	Zip code: 97824

D. Consultant information (optional)

Consultant contact name: Matt Kohlbecker	Company: GSI Water Solutions, Inc.
Phone number: 971-200-8531	Email address: mkohlbecker@gsiws.com

E. UIC system type

☐ Aquifer Storage and Recovery (5R21, 2-ASR)	Limited License or Permit #:
☐ Low Temp Geothermal (5A7, 2-Geo Heat Pump)	Water Right Permit or Certificate #:
☐ Remediation (5X26, 2-Remediation)	ECSI Site ID and/or LUST #: ☐ Voluntary Cleanup Program
☒ Other	Describe fluid: Groundwater for Artificial Recharge

F. Individual UIC information

1. ID: Basalt Well	Fluid type: Groundwater	Status: ☐ Under Construction ☒ Active		Depth: 4,045 feet
☒ Site map is attached		Latitude: 45.362485	Longitude: -117.983947	
2. ID:	Fluid type:	Status: ☐ Under Construction ☐ Active		Depth:
☐ Site map is attached		Latitude:	Longitude:	
3. ID:	Fluid type:	Status: ☐ Under Construction ☐ Active		Depth:
☐ Site map is attached		Latitude:	Longitude:	
4. ID:	Fluid type:	Status: ☐ Under Construction ☐ Active		Depth:
☐ Site map is attached		Latitude:	Longitude:	

G. Signature of legally authorized representative

I hereby certify that the information contained in this registration is true and correct to the best of my knowledge and belief.

Brett Rudd

Signature of legally authorized representative	Date 2/7/19		
Legally authorized representative: Brett Rudd	Title: Owner		
Mailing address: 62913 Wallsinger Road	City: Cove	State: OR	Zip code: 97824
Phone number: 541-910-1812	Email address: ruddfarms@gmail.com		

Revised date: 11/15/2018

Application Instructions for Class V Underground Injection Control Authorization by Rule

Important Note: This form is regularly updated. Always download a new copy of this form from DEQ's website when applying for rule authorization.

A. Fee for authorization by rule

A fee of $125 per UIC must be submitted with the application. DEQ waives the per UIC fee when the UIC is located at a remediation site, **and** remediation is being conducted under the DEQ Voluntary Cleanup Program. Fees for a remediation project that is not part of the Voluntary Cleanup Program fees can be discussed with the permit coordinator at 503-229-5623.

B. Owner information

Organization: the person, business, or public organization that controls the facility where the UIC is located. A business or public organization must be registered with the Oregon Secretary of State's Business Registry: http://egov.sos.state.or.us/br/pkg_web_name_srch_inq.login. Business registration information is available online at: http://sos.oregon.gov/business/Pages/register.aspx . If the company operates under an assumed business name, the organization name should be listed by the name of the legal representative. The organization will receive official DEQ correspondence.

Site contact: the person DEQ will contact for questions concerning the facility's UICs.

C. Facility information

Facility name: the name of the facility or business operation where the UIC is located.
Physical address: the physical location (not the mailing address) of the facility where the UIC is located.

D. Consultant information

Consultant: the individual hired by the organization to provide the applicant technical assistance.

C. UIC system type

Select a UIC type and provide the information to the right of the system type category.

D. Individual UIC information

If you are applying for authorization of more than four UICs, please provide the individual UIC information on a separate sheet of paper and attach it to this application.

- Enter the **ID** used to identify your UIC, **fluid type**, **status**, **depth**, **latitude** and **longitude** in decimal degrees NAD 83 datum for each UIC (for example,45.407666/-122.669015).
- A site map is required. The site map must show the UIC (labeled by name), property lines, adjoining streets, buildings, and a north arrow.

E. Signature of legally authorized representative

The signature and contact information of the person responsible for signing official according to the table below:

Entity	Legally Authorized Representative
Corporation	President, secretary, treasurer, vice-president, or any other person who performs principal business functions, or a manager of one or more facilities authorized in accordance to corporate procedure to sign such documents
Partnership	General partner
Sole Proprietorship	Owner(s)
City, County, State, Federal, Public Facility	Principal executive officer or ranking elected official
Limited Liability Company	Member
Trusts	Acting Trustee

Please submit a hard copy <u>and</u> an electronic copy of your application materials	
Submit a hard copy of your application and payment to: Oregon DEQ Attn: Business Office 700 NE Multnomah Suite 600 Portland, Oregon 97232-4100	**Submit an electronic copy of your application to:** UIC@deq.state.or.us
Call the UIC Permit Coordinator at 503-229-5623 with questions	

DEQ will discard oversize (larger than 11" by 17") application documentation, and other documentation that is not required.

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