CITY OF TUALATIN

AQUIFER STORAGE AND RECOVERY LIMITED LICENSE APPLICATION AND PILOT TEST WORK PLAN

December 2003

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In Association With:

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00-0500.104
December 5, 2003

Mr. Donn Miller
Hydrogeologist, Technical Services Division
Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, OR 97301-1271

Re: City of Tualatin – Aquifer Storage and Recovery (ASR) Limited License Application and Pilot Test Work Plan

Dear Mr. Miller:

On behalf of the City of Tualatin, please find enclosed the application for an ASR Limited License and Pilot Test Work Plan for the City of Tualatin Aquifer Storage and Recovery Well No. 1. These materials are submitted for review and approval. Please also find enclosed a check in the amount of $100 for the application fee in accordance with OAR 690-0030(1)(a).

The intended location of the proposed City of Tualatin ASR Well No. 1 is near the intersection of SW 108th Avenue and Dogwood Street in Tualatin, Oregon, as shown on the site map bound in the plan as Figure 4-2. The proposed injection water source is the City of Portland's Bull Run Watershed Water Supply System via the Washington County Supply Line. Since Tualatin does not hold a water right for the injection water, an agreement has been obtained from the City of Portland for use of water for ASR testing. A copy of this agreement is bound in the plan. The proposed pilot testing schedule anticipates that injection will begin in January 2005 and pilot testing completion is expected in November 2005.

During the pilot testing, approximately 500 gallons per minute (gpm) will be injected into the well. An anticipated maximum volume of approximately 95 million gallons (mg) of injected water will be stored for a minimum period of approximately 30 days. After the storage period, the water will be recovered and pumped into the City of Tualatin's water distribution system. The anticipated maximum withdrawal rate of the recovered water will be approximately 700 gpm. The recovered water will only enter the City's distribution system when water quality testing indicates that the water meets applicable drinking water standards. The water will be injected into the well from the City's distribution system and recovered by a deep well vertical turbine pump. The injection and discharge piping will be connected to the distribution system.

If pilot testing is successful, the injection water source, the maximum injection rate, and the maximum withdrawal rate for full-scale ASR production at ASR Well No. 1 will be similar to that used during the pilot testing. It is anticipated that the injected storage volume capacity will support an approximate 90-day production period and recover approximately 90 mg of the stored water. As described in the pilot test work plan and application materials, the City's ultimate goal is to develop an ASR system capable of delivering up to 5 mgd. The recovered water will be used during peak use demand periods, typically anticipated to occur during the summer months.

We are available to meet with you at your request to review the application materials and testing work plan in detail. During your review, please do not hesitate to contact myself or Brian Ginter at (503) 225-9010 with any questions in this regard. Thank you.

Sincerely,

MURRAY, SMITH & ASSOCIATES, INC.

Chris H. Uber, P.E.
Vice President

CHU:bmg

Enclosures

cc: Michael McKillip, City of Tualatin
Walter Burt, Groundwater Solutions Inc.
Dennis Nelson, Oregon Department of Human Services
Henning Larson, Oregon Department of Environmental Quality

AQUIFER STORAGE AND RECOVERY LIMITED LICENSE APPLICATION and PILOT TEST WORK PLAN

FOR

CITY OF TUALATIN

December 2003

REGISTERED PROFESSIONAL ENGINEER
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OREGON
JULY 25, 1990
CHRISTOPHER H. UBER

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WALTER C BURT
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GEOLOGIST

Prepared by:

Expires 05/31/04

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00-0500.104

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INTRODUCTION

General

The City of Tualatin is currently supplied water by the City of Portland through the Washington County Supply Line (WCSL). Under the City's present agreement for water service with Portland, Tualatin's peak day supply capacity is approximately 10.8 million gallons per day (mgd). It is estimated that by the year 2015 the City's peak day water demand will be approximately 14.1 mgd.

Project Scope

The City of Tualatin would like to increase its available supply of water to meet peak water demands in the summer by storing surplus water supplied by Portland during winter months using Aquifer Storage and Recovery (ASR) technology. This document contains an ASR Limited License Application prepared on behalf of the City and also includes an ASR work plan for the proposed project. The ASR application and the work plan have been completed in compliance with OAR 690-350-020.

This report document is intended to provide all required ASR Limited License submittal information. Table 1-1 identifies where required information under Oregon Administrative Rules (OAR) 690-350-020 can be found. This index was prepared to assist in preparing and reviewing the City's application for an ASR Pilot Test Limited License.

The City's goal is to ultimately develop an ASR system with at least a 5 mgd recovery capacity that is sustainable for at least 90 days in the summer months. If the City is able to achieve this goal, it will realize a number of benefits, including:

- Increasing the volume of water available to the City to meet peak summer water demands
- Providing a reliable backup/emergency source in the event that the City of Portland is not able to provide adequate supply

The benefit of ASR to the City is to provide storage for surface water during times of limited demand and, in turn, deliver the stored water during times of peaking demand.

Pilot Test Purpose

The purpose of the pilot test is to confirm full scale ASR feasibility for the basalt aquifer underlying the City of Tualatin and to develop design criteria for full-scale ASR operation at this location. The pilot test will consist of a shakedown test and two cycles of recharge,

Table 1-1
Required Information Index and Location Summary

Oregon Administrative Rule Number	Information Location
690-350-020 (2) **Pre-Application Conference**	Held on September 9, 2003 at OWRD offices; attended by MSA, GSI, OHD, Oregon DEQ and OWRD
690-350-020 (3)(a)(B) **Applicant Information**	Application Form (Appendix A)
690-350-020 (3)(a)(B) **Operations Information**	Application Form (Appendix A) ASR Pilot Test Work Plan (Section 4)
690-350-020 (3)(a)(C) **License Duration**	Application Form (Appendix A)
690-350-020 (3)(a)(D) **Proposed Use**	Application Form (Appendix A)
690-350-020 (3)(a)(E) **Ultimate Project Size**	Application Form (Appendix A) Introduction (Section 1)
690-350-020 (3)(a)(F) **Water Availability Statement**	Water Availability Statement (Appendix B)
690-350-020 (3)(a)(G) **Water Right Holder Agreement**	Water Right Holder Agreement (Appendix D)
690-350-020 (3)(a)(H) **Legal Land Use**	Legal Land Use Documentation (Appendix E)
690-350-020 (3)(a)(I) **Map and Coordinates**	ASR Pilot Program Study Area – (Section 1 - Figure 1-1)
690-350-020 (3)(a)(J) **DHS Compliance**	Permits and Approvals (Section 2)
690-350-020 (3)(a)(K) **Supplemental Information**	Hydrogeological Characterization Summary Technical Memorandum (Appendix C)
690-350-020 (3)(b)(A) **Proposed ASR Test Program**	ASR Pilot Test Work Plan (Section 4)
690-350-020 (3)(b)(B) **Proposed System Design**	Preliminary Wellhead Design (Appendix G)
690-350-020 (3)(b)(C) **Groundwater Information**	Hydrogeological Characterization Memo (Appendix C)
690-350-020 (3)(b)(D) **Source Water Quality**	Hydrogeological Characterization Memo (Appendix C) Appendix K
690-350-020 (3)(b)(E) **Comments on Source Water/Standards**	Water Quality Monitoring Program (Section 5) Hydrogeological Characterization Memo (Appendix C)
690-350-020 (3)(b)(F) **Receiving Water Quality**	Hydrogeological Characterization Memo (Appendix C) Appendix K
690-350-020 (3)(b)(G) **Comments on Compatibility**	Hydrogeological Characterization Memo (Appendix C)
690-350-020 (3)(c) **Other Information**	Underground Injection Control (UIC) Registration of proposed ASR well as Class V well – forms submitted to Oregon DEQ 12/2003 (Appendix F)

storage, and recovery. The testing will be conducted in a manner intended to provide the data necessary to develop an initial ASR operations plan. The pilot testing program will evaluate the following:

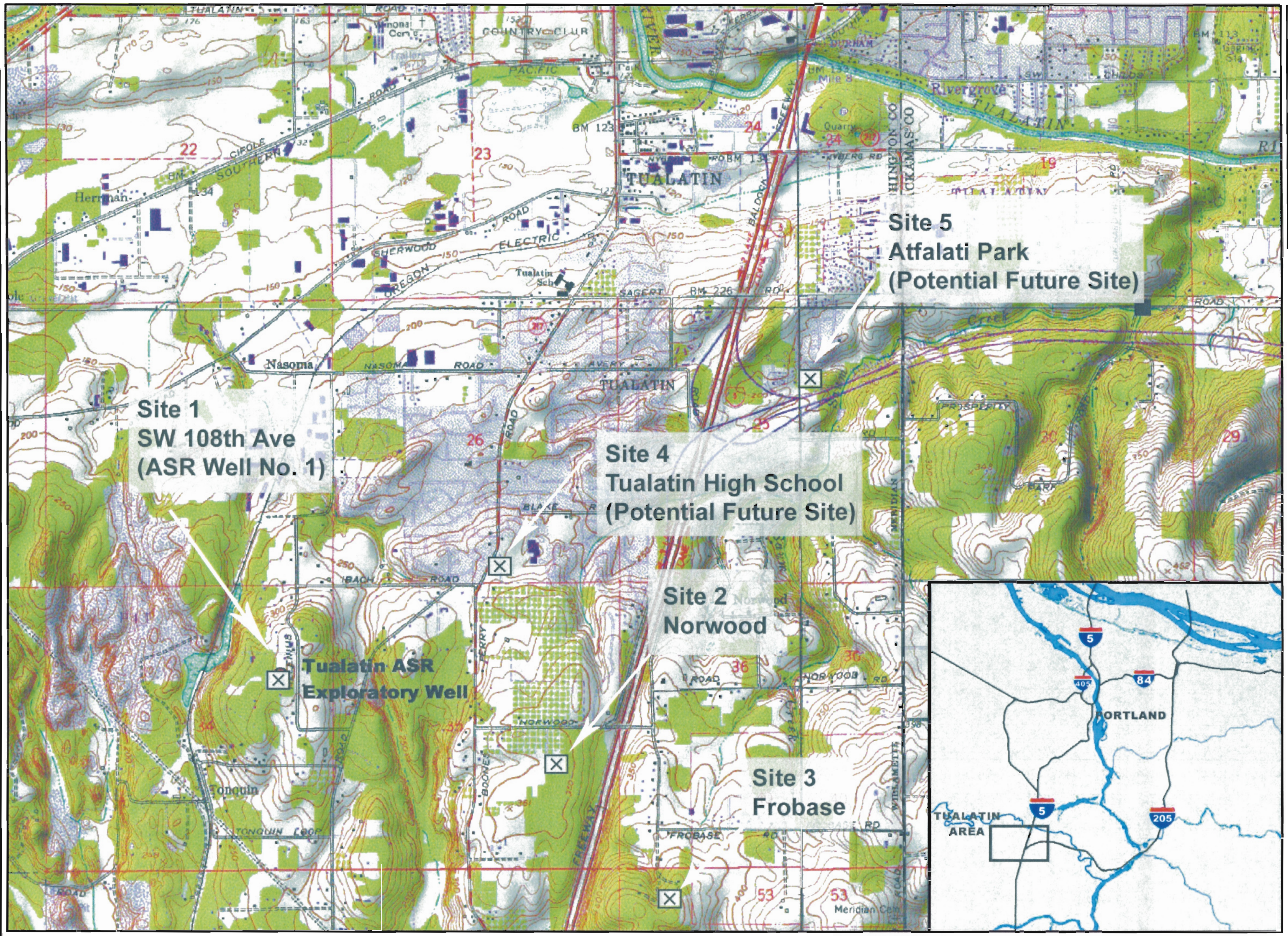
- Wellhead facility operation and response to ASR operations
- Aquifer hydraulic response to ASR operations
- Long-term performance of the well
- Optimal rate of injection and target storage volume
- Recovery rate and sustainability of pumping
- Quality of recovered water over time
- Chemical compatibility of the native and injected waters, including an assessment of potential clogging rate, mixing, and water quality changes
- Frequency of redevelopment necessary to maintain an acceptable and sustainable degree of efficiency during full-scale operations
- Potential impacts on surrounding wells as a result of injection and recovery

Pilot Test Study Area

The pilot test study area, as illustrated on Figure 1-1, is located within the Willamette Valley. The elevation of the City ranges from approximately 100 to 300 feet mean sea level (msl). The hydrogeologic setting is presented in the Hydrogeological Summary Report Technical Memorandum in Appendix C. A five-day aquifer test was performed in August 2002 at an exploratory test well drilled at the proposed ASR Well No. 1 site to determine aquifer hydraulic characteristics and boundary conditions. The site of the proposed ASR production well is at a City-owned future reservoir site on SW 108th Avenue, and is approximately 300 feet from the test well. The testing results indicate that the aquifer is capable of storing approximately 95 million gallons (mg) of water, and the well should be capable of producing water at a rate of approximately 700 gpm for a period of at least 90 days. Detailed geologic and hydrogeologic information is presented in the technical memorandum included in Appendix C.

Pilot Test Approach

The approach of the pilot test program is to conduct injection, storage and recovery operations in a manner that allows the facility function and aquifer response to be evaluated during initial ASR operations. The pilot testing program will consist of a shakedown test and short duration recharge/pumping cycle followed by a full recharge-storage-recovery cycle. During the first short duration cycle, referred to as cycle 1, a relatively small volume of water will be stored to evaluate initial system operations and aquifer response. The first full cycle test, cycle 2, will more closely approximate full scale ASR operations, injecting approximately 95 mg of water over a 135-day period using an injection rate of approximately 500 gpm. The water will be stored for up to 60 days prior to a 90-day withdrawal period. Approximately 90 mg of water will be recovered at a rate of approximately 700 gpm.



SITE	LOCATION	
	NEAREST SECTION CORNER:	BEARING & DISTANCE:
SITE 1 SW 108TH AVENUE	T2S R1W SECTION 34 NE CORNER	S24°45'08"W 2,115'
SITE 2 NORWOOD	T2S R1W SECTION 35 SE CORNER	N31°32'49"W 2,230'
SITE 3 FROBASE	T3S R1W SECTION 1 NW CORNER	S30°06'05"E 1,457'
SITE 4 TUALATIN HIGH SCHOOL	T2S R1W SECTION 35 NE CORNER	S55°18'58"W 4,476'
SITE 5 ATFALATI PARK	T2S R1W SECTION 25 NE CORNER	S48°30'46"W 2,256

N

1000 500 0 1000 2000
1 Inch = 2000 Feet

Figure 1-1

CITY OF TUALATIN

ASR Limited License Application and Pilot Test Work Plan

ASR Pilot Program Study Area

December 2003

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Groundwater Solutions Inc.
3758 SE Milwaukie Ave. Portland, Oregon 97202
ph:503.239.8799 fx:503.239.8940 e:groundwatersolutions.com

G:\00\0500\203\CAD\00-0500-203-OR-FIGURE 1-1.dwg FIGURE 1-1 12/3/03 12:05 HCM

During the subsequent years, 2 through 5, injection, storage, and recovery rates and durations will be determined based upon the volume of water recovered the previous year. It is anticipated that the City will inject enough water each year to keep the storage zone "topped off" so that the maximum amount of stored water is available to the City. The City will then use the ASR system to meet peak demands.

Recharge water for this ASR project will be supplied from the City's supply connection to the City of Portland water supply system. It is envisioned that during full-scale ASR operation of the ASR Well No. 1 system, water will be injected at an estimated recharge rate of 500 gpm, resulting in storage of approximately 95 mg of water.

Long-Term ASR Development Plan

Should the pilot testing prove successful, the City of Tualatin will likely consider proceeding with implementation of an ASR expansion program to meet their ultimate goal of 5 mgd of supply capacity for peaking and emergency demand. It is anticipated that five ASR wells will be required to store and recover at capacities necessary to meet the City's goal. Two other sites were identified in the July 2001 Aquifer Storage and Recovery Feasibility Study as potential locations for exploratory well drilling and full-scale ASR production facilities. These sites are illustrated on Figure 1-1 and are referred to as the Norwood and Frobase sites. Two additional sites have been preliminarily identified for potential ASR development consideration. These sites are the Tualatin High School and Atfalati Park. After completion of the ASR Well No. 1 pilot testing, the City will evaluate these sites and identify the potential for ASR expansion to meet the ultimate goal of 5 mgd.

Summary

This document describes the City of Tualatin's ASR work program, summarizing work previously completed by the City, presenting the City's proposed pilot testing plan for ASR Well No. 1 and outlining the City's ultimate ASR program goals. This work plan is intended to fulfill the requirements of Oregon Administrative Rules Chapter 690-350. A series of Appendices (A through N) provide additional work plan supporting information.

SECTION 2

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SECTION 2

SECTION 2
PERMITS AND APPROVALS

General

This section identifies and describes the permits and approvals necessary for completion of the ASR pilot program and documents whether the permits and approvals have been obtained, requested or are not necessary for this project.

Source Water Rights

The City will use water from the City of Portland supplied through Tualatin's connection to the Washington County Supply Line for ASR injection water. A Water Right Holder Agreement letter has been obtained from the City of Portland and is included in Appendix D.

Land Use Approval

The City will obtain land use approvals to construct the well house and associated facilities on the site. As the site is within City limits, the approvals are issued by the City of Tualatin. Documentation demonstrating that land use approvals have been obtained is included in Appendix E.

Wastewater Discharge Approval

During the ASR pilot testing, some of the stored water will be pumped from the well and discharged to the City's stormwater system. This includes backflushing episodes when injection will be stopped and the well will be pumped for 15 to 20 minutes in order to remove sediment that may have entered the well during injection. The pumping discharge will be conveyed from the wellhead through buried piping to the existing stormwater system located adjacent to the facility and then to an existing detention pond. The discharge water will consist of either recharge water, i.e. disinfected surface water containing chlorine, native groundwater, or a mixture of the two. The City will review its current agreement with Clean Water Services of Washington County, holder of the National Pollutant Discharge Elimination System (NPDES) permit for discharge from the detention pond, to determine if the discharge conditions are acceptable. If required, approval for the discharge will be obtained from Clean Water Services.

Underground Injection Control (UIC) Registration

All ASR wells are required to be registered under the Oregon Department of Environmental Quality (DEQ) UIC program as a Class V injection well. Appendix F contains a completed UIC registration form. This form has been submitted to DEQ for review and approval.

Oregon Health Division Plan Review

The Department of Health Services (DHS) Drinking Water Program requires that plans for new sources, including wells, be reviewed and approved prior to construction. For new wells, DHS also requires submittal of as-builts, well test results, water quality results and plans for the design of wellhead improvements and connection to the water system prior to approving the use of the source. As such, the ASR well and wellhead design will be submitted to the DHS for plan review and approval prior to construction.

Summary

This section identified the permits and approvals necessary for completion of the ASR pilot program. Elements of this program will be reviewed by OWRD, DHS and DEQ. All necessary permits and approvals will be obtained prior to proceeding with construction of the pilot system.

SECTION 3

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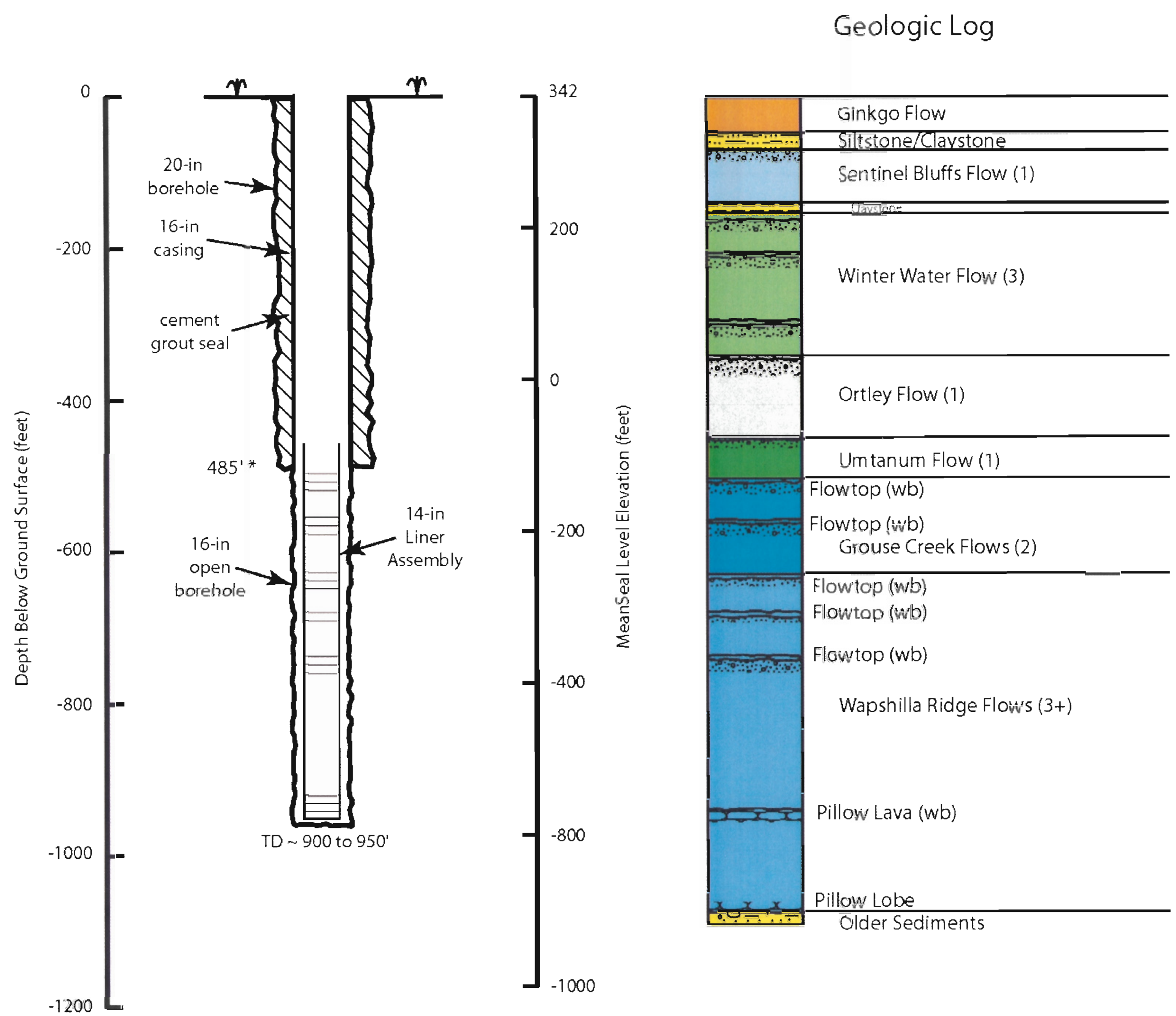
SECTION 3



Notes:

1. Geology from Beeson (2002)
2. wb = water bearing zone
3. * = depth of grout seal may be adjusted based on field observations made during drilling.

Figure 3-1

CITY OF TUALATIN

ASR Limited License Application and Pilot Test Work Plan

ASR Well No. 1 Schematic Design

December 2003

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1750 SE Milwaukie Ave. Portland, Oregon 97202 ph:503.239.8799 fx:503.239.8940 e:groundwatersolutions.com

SECTION 3
ASR FACILITY DESIGN CRITERIA

General

This section outlines the design criteria of the ASR Well No. 1 and associated wellhead facilities. These basic design criteria will be applied to each facility developed as part of the City's ASR program. As described in Section 1, it is anticipated that the City's will ultimately develop up to five ASR wells, producing a total of approximately 5 mgd for a 90 day period. Design parameters for the ASR well are presented below, along with key elements of the wellhead facility design.

ASR Well Design

General Design Parameters

The general considerations for the ASR well design are the casing depth, total depth of the well, use of a liner, and the potential for corrosion as it pertains to casing and liner materials and wall thicknesses.

ASR Well No. 1 Design

A discussion of ASR Well No. 1 design criteria is presented below. The design criteria elements listed below incorporate the target production capacity requirements with the hydrostratigraphy and aquifer test results from the exploratory well. Also presented are down well component requirements of an ASR system. The major features of the Tualatin ASR well design are presented in the following paragraph, and are illustrated on Figure 3-1.

The total approximate depth of ASR Well No. 1 will be between approximately 900 and 950 feet below ground surface (bgs). The well will have a 16-inch diameter production casing between the ground surface and a target depth of approximately 485 feet bgs. The production casing will be sealed along its full length with a grout seal in a 20-inch diameter boring. The lower borehole will extend from a depth of 485 feet to the total depth of between approximately 900 and 950 feet bgs. The lower borehole will be 16 inches in diameter. A 14-inch diameter screen liner assembly will be set in the lower borehole to prevent any potential for sloughing or collapse of the open borehole walls.

Key Design Issues

ASR Well No. 1 Seal Depth

The target seal depth for ASR Well No. 1 is approximately 485 feet bgs, or approximately 144 feet below mean sea level (msl). Approximately 190 wells that are completed within the upper 400 feet of basalt were identified within 1 mile of the ASR Well No. 1 site. Sixteen of these wells are completed between 400 and 480 feet bgs, and 7 wells were completed deeper than 480 feet bgs. Although total well depths do not necessarily equate to intersecting similar interflow zones due to variations in well surface elevations, the depths were used as a general guideline for evaluating the number of wells within various portions of the basalt aquifer. The ASR well seal depth is intended to minimize potential communication to the surrounding shallow basalt wells, and to maximize water production capabilities balanced against the available drawdown within the well. Based upon the test well drilling conditions, the final seal depth may vary between approximately 430 feet and 485 feet bgs, or approximately 85 to 144 feet below msl, depending upon the pressure and characteristics of water bearing interflow zones conditions encountered during drilling.

The selected seal depth is also intended to eliminate potential connection between the target injection zone and direct surface water connections. The nearby valleys have surface elevations ranging from approximately 150 to 250 feet above msl. Based upon the proposed seal depth, approximately 85 to 144 feet below msl, no natural discharge points associated with the target injection zone, such as springs or seeps, are expected.

Casing Material

Because of the large wetted length of the production casing during ASR operations, an assessment of corrosion potential will be conducted during the well design process to determine appropriate materials and wall thicknesses for the production casing and liner assemblies.

Wellhead Facility Design

The new ASR wellhead facility will include the following:

- Well house to protect the wellhead, pump, motor, mechanical and electrical systems
- Piping that conveys recharge water from the distribution system to the ASR pilot well
- Recharge loop, piping, valves, and controls at the wellhead that permit injection down the pump column
- Pump to waste piping that permits discharge of wastewater during startup and back flushing
- New pump, pump head, pump column and motor
- System controls and monitoring allowing automatic and manual operation with manual safety overrides
- Pressure transducer drop pipe and installation of a dedicated data logger system
- Secondary drop pipe for collecting manual water level measurements
- Bi-directional flow meter with totalizer connected to the City's telemetry system
- Sampling port for water quality sampling

The major features of the wellhead facility design are described in greater detail below:

- Well house structure. The structure will consist of a reinforced concrete floor and footings, concrete masonry units (CMU) walls with an exterior brick facing and wood frame roof structure with standing seam metal roofing. The footprint of the structure will be approximately 30 feet by 20 feet, or 600 square feet, with a separate interior room for disinfectant equipment. The facility will include appropriate building systems including lighting, heating and ventilation and fire and life safety. Noise abatement will be considered in pumping and mechanical system designs.

- Pumping system. The project will include furnishing and installing a line shaft vertical turbine-type well pump. Piping and valving including injection piping, isolation and control valves will be installed. Wellhead piping will be connected to the existing distribution system.

- Electrical power system and instrumentation and control system. Power supply to the station will be from the existing primary voltage electrical system on SW 108th Avenue. A pad mounted transformer will be installed on the site to provide 480 volt 3-phase service to the structure. A motor control center and associated electrical work will be installed inside the structure. Instrumentation and control systems improvements will be designed and provided by the City's current telemetry systems integrator.

- Disinfection system. Disinfection system facility will be included in the well house designs. Such system may include chlorination and ammoniation facilities.

- Site improvements. Site improvements will be provided including architectural site treatment as determined above, a driveway apron and access road to the structure, landscaping, site drainage, irrigation system, and other miscellaneous related facilities.

The wellhead facility conceptual design is included in Appendix G of this report.

Summary

This section presents the key elements of the well and wellhead facility design for ASR Well No. 1. The design of the well and wellhead will meet all applicable OWRD and DHS design standards. The final design of the well and wellhead will be submitted to the DHS for plan review prior to construction and DHS approval documentation will be forwarded to OWRD.

SECTION 4

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SECTION 4

SECTION 4
PILOT TEST PROGRAM

General

This section describes the pilot test program that will be used when developing and assessing Tualatin's ASR well sites. The purpose of the pilot test program is to confirm ASR feasibility for the target basalt aquifer and to develop criteria for full-scale ASR design and operation at the ASR Well No. 1 location and potential future ASR well locations. The full-scale operation objective for ASR Well No. 1 is storage of approximately 95 million gallons of water in the target basalt aquifer zone, followed by production of approximately 1 million gallons per day during the peak demand period of up to 90 days.

The overall pilot test program consists of two components:

- *Baseline Monitoring* – Includes a water level monitoring program prior to the start of ASR testing.

- *ASR Pilot Test Program* – Broken down into yearly testing programs:
  - Year 1 – Includes a shakedown test; an initial short duration injection and recovery cycle; and a full-scale injection, storage and recovery phase.
  - Years 2 through 5 – Injection, storage and recovery rates and duration will be determined on the basis of year one testing. Because all of the stored water may not be recovered each year, the subsequent year's injection volume may be reduced.

The pilot test program will be conducted at ASR Well No. 1 and at each future ASR well as they are developed during implementation of the full-scale program. The proposed pilot testing schedule for ASR Well No. 1 is presented in Appendix H and the preliminary pilot testing report outline is presented in Appendix I. Each component of the pilot test program is presented and discussed below.

Baseline Monitoring

The purpose of the baseline monitoring is to obtain background water level data for the pilot test well site and surrounding area. These data will be compared to data collected during pilot testing to evaluate the effects that ASR will have on the basalt aquifer system. Baseline monitoring will include the components discussed below.

Water Level Monitoring

A network of observation wells near to ASR Well No. 1 will be used to monitor groundwater levels in the basalt aquifer prior to the pilot test. The purpose of the baseline monitoring is to identify water level trends that could affect interpretation of the ASR pilot test results. Water level monitoring will be conducted at the observation points identified below.

Water Level Monitoring Network

Water well records from OWRD were reviewed to identify existing wells in the pilot test study area that could be used to evaluate background water levels and aquifer conditions during future ASR testing or full-scale operations. The well records reviewed for the ASR Well No. 1 pilot test program identified nearby wells within a radius of approximately 1 mile for the following 2 zones:

- Wells completed within the basalt formation interflow zones targeted for ASR direct injection at approximately 147 feet below msl
- Basalt formation wells completed above the target injection zones

Local wells have been selected for monitoring during testing and operation of ASR Well No. 1 from the OWRD records and are summarized in Table 4-1. The accessibility of several proposed monitoring wells is currently unknown. If proposed wells prove to be inaccessible, alternative wells will be selected and reviewed with OWRD.

The well log record review effort identified approximately 190 wells completed in the basalt formations above the target ASR well seal depth of approximately 480 feet bgs or an elevation of 147 feet below msl. Two shallow wells, those drilled to a depth of less than 480 feet bgs, were selected for monitoring. The first shallow basalt well is located on the ASR Well No. 1 property and a second is located on the adjacent property approximately 175 feet to the south of ASR Well No. 1. Water level data currently being collected at one additional shallow well, the Tualatin Valley Sportsman's Club well, will be obtained and reviewed as part of this monitoring program. Three existing wells completed in the basalt aquifer target injection zone that are located within approximately 1.25 miles of ASR Well No. 1 have been selected for monitoring. Wells included in the water level monitoring program include the following:

Shallow Basalt Wells

- Onsite shallow basalt well, OWRD No. Wash 3331
- Adjacent domestic well south of project site, OWRD No. unknown
- Tualatin Valley Sportsman's Club, OWRD No. Wash 1842

Target Zone Basalt Wells

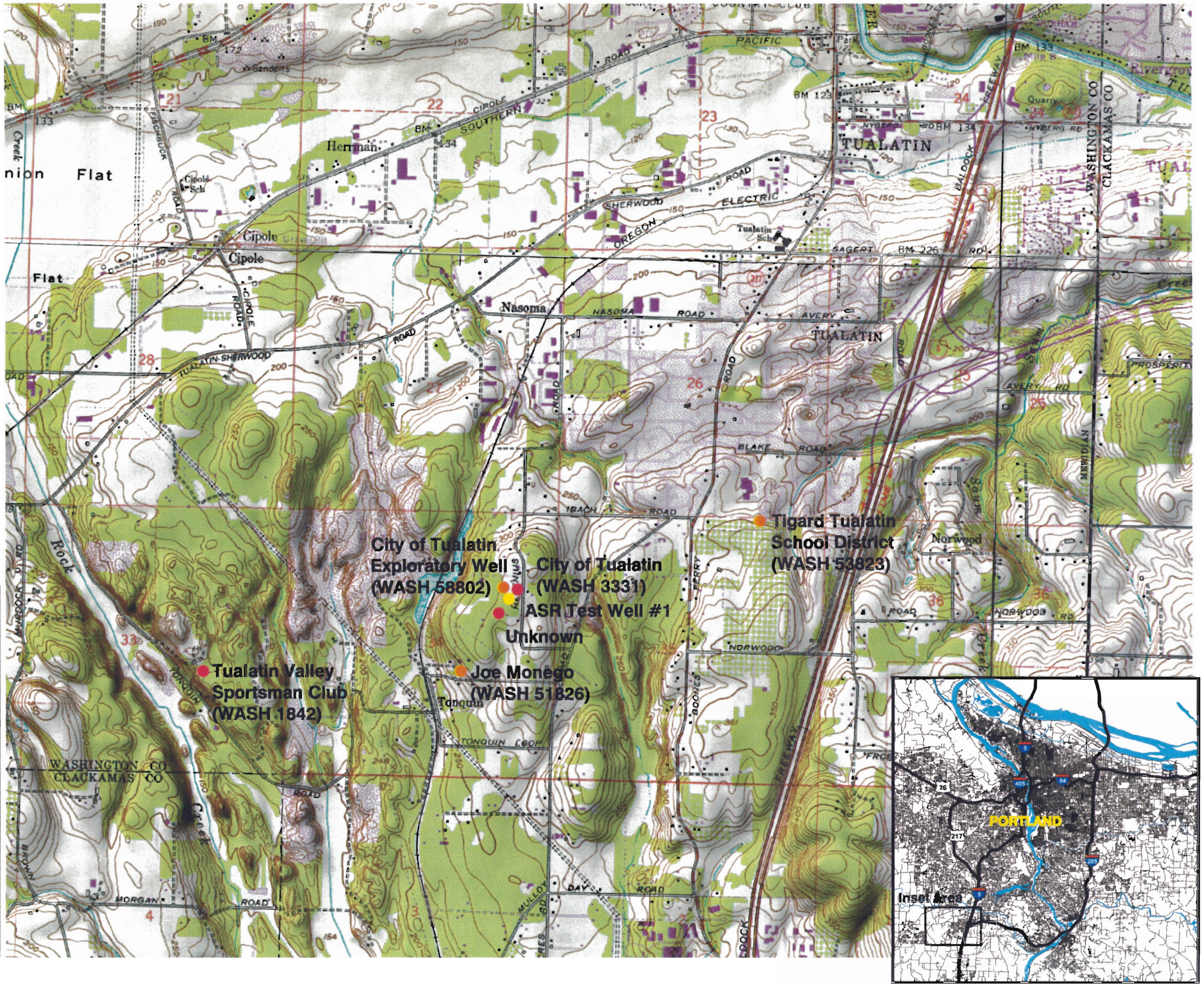
- ASR test well located onsite, OWRD No. Wash 58802
- Well located west of the site, OWRD No. Wash ~~51826~~ 58796
- Tualatin High School Basalt well located northeast of site, OWRD No. Wash 53823

530	549	Basalt, grey, hard
549	562	Basalt, black & red, medium-soft, broken, vesicular
562	608	Basalt, grey, medium-hard, fractured
608	626	Basalt, dark grey, medium-hard, fractured
626	641	Basalt, dark grey, medium, fractured
641	662	Basalt, dark grey, medium- hard, fractured
662	667	Basalt, dark grey, medium, fractured
667	675	Basalt, dark grey & red, soft, fractured, vesicular
675	690	Basalt, dark grey, medium-hard, fractured
690	735	Basalt, grey, hard, some fractures
735	755	Basalt, black, soft, broken
755	758	Basalt, black & red, soft, broken
758	855	Basalt, grey, hard, occasional fractures
855	834	Basalt, grey, hard, fractured, black
834	838	Basalt, grey, hard
838	843	Basalt, dark grey, hard, green fractures, black, fractured
843	855	Basalt, grey, hard, fractured
855	856	Basalt, grey, hard, highly fractured
856	864	Basalt, grey, hard, some black fractures & vesicules
864	876	Basalt, grey, hard, some fractures
876	881	Basalt, grey, hard
881	889	Basalt, grey, hard, w/white crystal fractures
889	910	Basalt, grey, hard
910	924	Basalt, grey, hard, some fractures
924	935	Basalt, black, soft, broken, vesicular
935	940	Basalt, black, soft, fractured, vesicular
940	965	Basalt, grey, medium, fractured, some vesicules
965	980	Basalt, grey-black, medium, fractured (green), some vesicules & pyrite
980	1032	Basalt, grey, medium, fractured, some vesicules & pyrite
1032	1041	Basalt, grey, medium, fractured
1041	1051	Basalt, grey, medium-hard, fractured, some vesicles
1051	1056	Basalt, grey, hard, some fractures
1056	1057	Basalt, black & blue & grey, soft, vesicular
1057	1058	Clay, grey & light green, firm, soft
1058	1062	Claystone, green & grey, firm, fractured with some basalt
1062	1064	Claystone, green & grey, firm with wood & some basalt
1064	1070	Claystone, green & grey, firm with cemented gravel & basalt

RECEIVED

SEP 0 6 2002

WATER RESOURCES DEPT.
SALEM, OREGON



LEGEND

- ASR Test Well
- ASR Target Zone Monitoring Well
- Shallow Basalt Monitoring Well

N

1000 500 0 1000 2000
1 Inch = 2000 Feet

Figure 4-1

CITY OF TUALATIN

ASR Limited License Application and Pilot Test Work Plan

ASR Well No. 1 Pilot Testing Monitoring Well Location Map

December 2003

MSA

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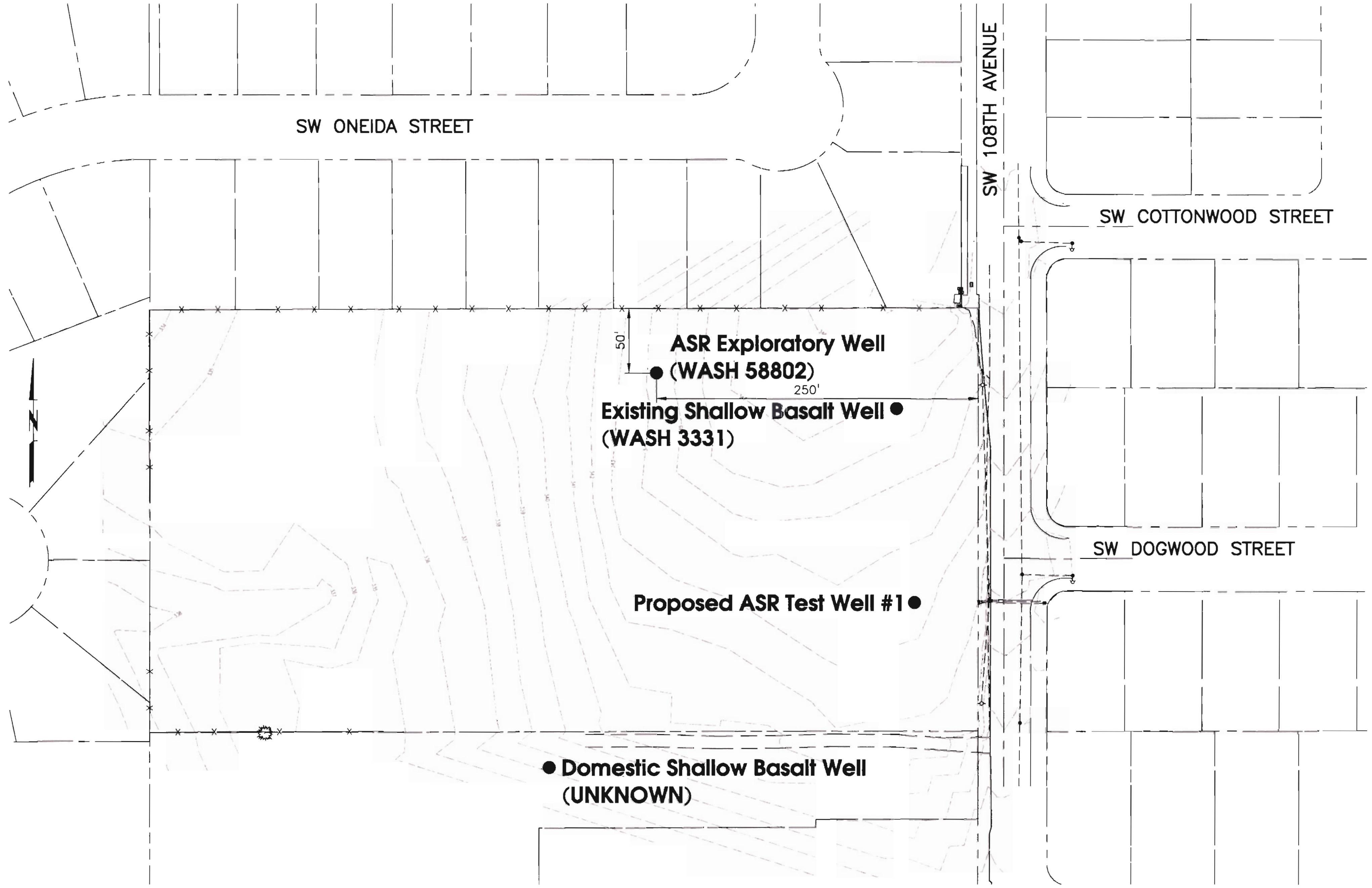
3758 SE Milwaukie Ave, Portland, Oregon 97202
ph:503.239.8799 fx:503.239.8940 e:groundwatersolutions.com

G:\00\0500\203\CAD\00-0500-203-OR-FIGURE 4-1.dwg FIGURE 4-1 11/26/03 09:13 HCM



SITE PLAN
SCALE: 1"=100'

Figure 4-2

CITY OF TUALATIN

ASR Limited License Application and Pilot Test Work Plan

ASR Well No. 1 Well Location Map

December 2003

MSA

Groundwater Solutions Inc.
3758 SE Milwaukie Ave. Portland, Oregon 97202
ph:503.239.8799 fx:503.239.8940 groundwatersolutions.com

G:\00\0500\203\CAD\00-0500-203-OR-FIGURE 4-2.dwg FIGURE 4-2 12/4/03 13:48 HCM

Table 4-1
ASR Well No. 1 Proposed Pilot Testing Monitoring Well Network

OWRD Well No.	Location	Owner	Total Depth (ft)	Diameter (in)	Pump Installed	Comments
ASR Target Zone Monitoring Wells (Approximately 500-1,000-foot depth)						
58802	T2S, R1W, 34, SE of NE 22675 SW 108th Avenue	City of Tualatin	1005	8	Yes	ASR test well
58796	T3S, R1W, 34, SE of NW 11150 Tonquin Loop	Joe Monego	560	4	?	Quarter-Quarter section location suspected to be incorrect based on well address. Will field verify.
53823	T2S, R1W, 35, NW of NE 22300 SW Boones Ferry Road	Tigard-Tualatin School District	627	8	Likely	
Shallow Basalt Monitoring Wells (completed above ASR Well No. 1 seal – less than 480-foot depth)						
3331	T2S, R1W, 34, SE of NE 22675 SW 108th Avenue	City of Tualatin	320	4	No	Existing domestic well located at ASR well site.
Unknown	T2S, R1W, 34, SE of NE	Domestic well located on property south of ASR well	?	?	?	
1842	T2S, R1W, 33, NW of SE	Tualatin Valley Sportsman Club	230	6	Yes	Others are collecting water levels here, and we will track their data to the extent possible.

The well locations and rationale for use are summarized in Table 4-1. The locations of the wells are shown in Figure 4-1 and 4-2. Well logs for these wells are provided in Appendix J. A nearby shallow basalt well will be monitored to determine the degree of hydraulic communication in the shallow basalt and the deeper interflow injection zones. This information will be used to assess if any head changes occur in the shallow zone during injection or pumping of the ASR well, and whether any potential adverse impacts on the shallower wells exists. Wells completed in the target injection zone portion of the basalt aquifer will be used to assess the amount and possible extent of head buildup during injection, drawdown during pumping, and to assess the potential for any adverse impacts on these and other deep wells.

Water levels in the ASR test well and the onsite shallow basalt well will be monitored with electronic data loggers. Manual water level measurements will be collected using an electronic water level sounder at the other monitoring locations. Measuring point elevations at the selected monitoring wells will be surveyed by City staff. Permission to use several of the wells will need to be confirmed with property owners. Additionally, appropriate access for water level measuring devices must be confirmed or obtained.

Baseline Monitoring Frequency

Baseline water level monitoring will be conducted for a minimum period of two weeks prior to the pilot test. Electronic measurements will be collected on a minimum of an hourly basis using transducers. Manual water level measurements will be collected using an electronic water level sounder on a daily basis. Water level monitoring during the pilot test is discussed in further detail below.

Source Water and Native Groundwater Quality

The ASR development regulations require that the source water and native groundwater be analyzed for EPA regulated constituents, DEQ water quality maximum measurable level (MML) constituents and the federal secondary maximum contaminant level (SMCL) constituents before pilot testing begins. In addition to the above-mentioned constituents, the groundwater must also be tested for selected general water quality parameters and common ions. These parameters are listed in the Summary of Native Groundwater and ASR Source Water Quality Testing tables included with this report in Appendix K.

The source water and groundwater quality were tested in the spring and summer of 2002 during the aquifer testing of the exploratory well at the site. Results of source water and native groundwater quality testing are presented in Appendix K and summarized below. The testing results indicate that both the source water and native groundwater quality meets all drinking water standards.

Source Water Quality

A source water sample was collected from the City of Tualatin's fire hydrant located at SW 108th Avenue and Dogwood Street during aquifer testing of the ASR test well. The source water quality evaluation and data is described in detail in the ASR Exploratory Well Testing and Evaluation Report prepared in November 2002. Testing results indicate that the source water quality was excellent with a low dissolved mineral content of 24 mg/L total dissolved solids (TDS) and only one constituent, total haloacetic acids, exceeding 50 percent of the EPA drinking water standards in the Safe Drinking Water Act (SDWA) rules.

Native Groundwater Quality

Testing of native groundwater quality was also completed during the exploration well aquifer test and is summarized in Appendix K. The native groundwater water quality evaluation is described in detail in the ASR Exploratory Well Testing and Evaluation Report prepared in November 2002. The report presents an assessment of the potential for chemical reactions between stored source water and native groundwater that could result in aquifer/well clogging or degradation of native groundwater quality. In addition, the report evaluates potential retreatment requirements. The results indicated that the native groundwater quality was good with a moderate amount of dissolved minerals recorded at 246 mg/L TDS and no constituents exceeding drinking water standards. The compound sodium is detected within the test well at a concentration of 26 mg/L which is slightly greater than the SMCL of 20 mg/L. The analysis concludes that no adverse chemical reactions are predicted to occur as a result of ASR operations. No additional samples of native groundwater quality will be collected during the baseline monitoring phase of the program.

Seep Monitoring

Natural discharge of groundwater from the basalt aquifer may occur as the pressure in the aquifer increases if there is a preferential pathway for groundwater to reach the ground surface. The proposed ASR well will be designed to seal off production zones in the aquifer down to an approximate elevation of 150 feet below msl. The nearby valleys have surface elevations ranging from approximately 150 to 250 feet above msl. Based upon the depth of the seal below the surrounding natural ground surface, no natural discharge points associated with the target ASR aquifer production zones within the basalt sequence, such as springs or seeps, are expected in the pilot test study area. Brief visual monitoring for seeps in slopes above low-lying areas near the ASR well sites will be conducted during the injection phase of pilot testing for further verification of this assumption.

ASR Pilot Test: Year 1

A discussion of the first year of pilot testing at the Tualatin ASR Well No. 1 site is presented below. The testing will consist of an initial shakedown test, and short duration injection and pumping cycle. This is referred to as cycle 1. Cycle 2 follows cycle 1 and is characterized

Table 5-1
Summary of Water Quality Sampling Program – Cycle 1 Testing Summary
(8 hours injection – 16 hours storage – 6 hours recovery)

Sample Location	Injection (8 hrs @ 500 gpm)					Storage (16 hrs)	Recovery (6 hrs @ 700 gpm)			
	Field Parameters	Geochemical Parameters	Turbidity	DBP	SDWA		Field Parameters	Geochemical Parameters	DBP	SDWA
Source Water	Prior to and end of injection	Prior to injection	Continuous	N/A	N/A	No scheduled sampling during storage	N/A	N/A	N/A	N/A
Pilot Test Well	Prior to injection	Prior to injection	N/A	N/A	N/A		At beginning, middle, and end	N/A	N/A	N/A

Notes:
1. See Appendix K for Field Parameters
2. See Geochemical, Metals, and Miscellaneous in Appendix K for Geochemcial Parameters
3. See Appendix K for Disinfection By-Products (DBP)
4. Safe Drinking Water Act (SDWA) Analytes include regulated and unregulated SOC's and VOC's, Bacteriological, and Radionuclides listed in Appendix K

Table 5-2
Summary of Water Quality Sampling Program – Cycle 2 Testing Summary
(135 days injection – 60 days storage – 90 days recovery)

Sample Location	Injection (135 days @ 500 gpm)					Storage (60 days)				Recovery (90 days @ 700 gpm)			
	Field Parameters	Geochemical Parameters	Turbidity	DBP	SDWA	Field Parameters	Geochemical Parameters	DBP	SDWA	Field Parameters	Geochemical Parameters	DBP	SDWA
Source Water	Days 1, 66, & 132	Days 1 & 132	Continuous	Days 1 & 132	--	--	--	--	--	--	--	--	--
Pilot Test Well	Prior to injection	Prior to injection	--	--	--	Days 15 & 45	Days 15 & 45	Days 15 & 45	Day 45	Days 19, 42, 71, & 90	Days 19, 42, 71, & 90	Days 19, 42, 71, & 90	Day 42

Notes:
1. See Appendix K for Field Parameters
2. See Geochemical, Metals, and Miscellaneous in Appendix K for Geochemcial Parameters
3. See Appendix K for Disinfection By-Products (DBP)
4. Safe Drinking Water Act (SDWA) Analytes include regulated and unregulated SOC's and VOC's, Bacteriological, and Radionuclides listed in Appendix K

by a full-scale ASR cycle consisting of recharge, storage, and recovery. Each cycle will be completed under controlled and monitored conditions. The test cycles and the monitoring plans for this initial ASR well are described in further detail below.

Cycle 1 Testing

The purpose of cycle 1 testing is to evaluate the injection system and well performance, and briefly examine the response of the aquifer system to injection. The data collected in this short cycle will provide the basis for predicting system performance during larger-scale ASR tests.

Prior to initiating the first recharge and recovery cycle, a shakedown test will be performed that will consist of starting injection to check the operation of the booster pump and controls, and to check well pump operation. Adjustments to the system will be made as necessary. After the shakedown period, a single injection-extraction cycle with a storage period of approximately 16 hours will be completed. Water will be injected into the well at an operation-scale rate of approximately 500 gpm for approximately 8 hours. The injected water will be stored overnight for approximately 16 hours and then recovered over a 6-hour period the next day with the intention of recovering 110 % of the injected volume at an estimated rate of 700 gpm. The recovered water will be discharged to the storm drain system located in SW 108th Avenue.

During cycle 1, water levels will be monitored at the same locations described in the baseline monitoring program. At monitoring locations equipped with electronic data loggers, water levels will be measured at the beginning of the injection and recovery phases at the frequencies identified in Table 4-2.

Table 4-2
Water Level Measurement Frequency Summary

Injection/Pumping Duration	Monitoring Frequency
First 5 minutes	30 seconds
5 – 30 minutes	1 minute
30 – 60 minutes	5 minutes
60 – 4 hours	15 minutes
4 hours - Completion	1 hour

At the other monitoring locations, manual measurements will be made on an hourly basis using a water level sounder. Water quality monitoring, sampling, and analysis procedures and frequency are described in Section 5, "Water Quality Monitoring Program," of this work plan.

Cycle 2 Testing

The purpose of cycle 2 testing is to evaluate the long-term aquifer response, well performance, and water quality conditions under operational-scale ASR conditions. Cycle 2 testing will consist of the following:

- A long-term injection period of 135 days, injecting approximately 95 mg at an estimated rate of approximately 500 gpm
- A 60-day storage period
- A step-rate pumping test followed by a 90-day recovery period with a goal or recovering approximately 90 mg at an estimated rate of up to approximately 700 gpm

The long-term injection period will be used to assess head buildup in the aquifer, water quality issues, the potential for loss of stored water, and injection well efficiency changes over time. The storage period will be used to determine if the quality of the stored water changes substantially during storage and the degree to which the head buildup is maintained. The step-rate pumping test will be performed at the start of the recovery phase. Results of the step test will be compared to the baseline step-rate test conducted as part of the feasibility study to assess changes in well efficiency following an ASR cycle. The recovery period will be used to estimate the amount of mixing and to identify changes in well performance and aquifer characteristics relative to the initial baseline pumping tests.

The recovered water will be pumped into the City's distribution system if water quality sampling conducted near the end of the storage phase indicates that the water meets all drinking water standards. Pumping to the distribution system will continue unless water quality parameters identified as part of the baseline monitoring and cycle 1 testing results indicate that the stored water quality does not meet aesthetic standards or drinking water standards, or until the target volume is recovered. If water quality data indicate the need to pump to waste, the remaining portion of the target recovery volume will be discharged to the stormwater drainage system in SW 108rd Avenue. Although not anticipated, it may be necessary during cycle 2 testing to pump a small portion of water, approximately 5 to 10 percent of the injected volume, or approximately 5 mg, to waste near the end of the recovery cycle. Up to 95 percent of the stored water under the Limited License will be recovered.

During cycle 2 testing, water levels will be monitored at the same locations described in the baseline monitoring program. Water levels will be measured at the same frequency used in cycle 1 testing. Water quality monitoring, sampling, and analysis procedures and frequency are described in Section 5, "Water Quality Monitoring Program," of this work plan.

Contingency Plan

In the event that the quality of the water being injected becomes impaired or the recovered water is unacceptable, all of the water injected into the aquifer will need to be recovered and pumped to the City's storm drainage system. The storm drainage system is adequately sized to dispose of the recovered water. The recovery flow rate will be controlled to prevent stressing of the stormwater facilities. On the basis of the water quality analysis conducted for the feasibility study, the likelihood of this situation occurring appears highly improbable.

ASR Testing: Years 2 through 5

Tualatin's full-scale ASR Program plans to potentially supply up to 5 mgd of stored water from as many as 5 wells. Following testing of ASR Well No. 1, the City will evaluate and consider the results and may begin developing the additional ASR wells as part of its ASR program.

The results of the year 1 cycle 1 and cycle 2 pilot testing, will be evaluated and used to optimize ASR Well No. 1 operations after the first year so that as much as 90 mg of stored water is available from this initial well to the City. Not all of the stored water may be recovered in any given year if there is insufficient demand for the water. The volume of water available for recovery that is remaining in the ASR storage account and carried over from year to year will be reduced by 5 percent each year that it is not recovered.

Ultimate ASR Well No. 1 storage volumes, injection and recovery rates, durations and schedules will be developed on the basis of the previous years results. The ASR operations plan for the following year will be submitted with each annual report. Any modifications to the sampling and monitoring plan will be submitted to OWRD for review and approval.

Limited License Duration

The City is seeking approval of a limited license for a duration of five (5) years.

Summary

This section describes the pilot test program that will be used when developing and assessing Tualatin's ASR well sites. The overall ASR pilot test program consists of two components, baseline monitoring and ASR pilot testing for year 1 and years 2 through 5. Based on the results of the year 1 pilot testing, the City will evaluate the potential for additional development of ASR and may proceed with the development of additional ASR well facilities as part of its ASR program.

SECTION 5

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SECTION 5

SECTION 5
WATER QUALITY MONITORING PROGRAM

General

This section outlines the pilot testing water quality monitoring program. This program is divided into two parts: monitoring during the year 1 pilot testing, and monitoring during years 2 through 5 of the pilot testing.

The purpose of the water quality monitoring program is as follows:

- Confirm that the recovered water meets Safe Drinking Water Act drinking water standards for:
  - Drinking water parameters
  - Aesthetics of the recovered water, taste and odor
  - Disinfection by-product monitoring

- Assess water quality compatibility with respect to:
  - Injection well clogging caused by particulates, or turbidity, air, biological activity, and chemical reactions
  - Mineral dissolution reactions in the aquifer that could affect recovered water quality
  - ASR well redevelopment criteria
  - Aquifer recovery efficiencies

The components of the water quality monitoring program for the pilot testing program are described in the following subsections. A discussion of the background native groundwater quality, source water quality, and predicted geochemistry resulting from mixing is presented in the Hydrogeological Summary Report included as Appendix C. Water quality data for the native groundwater and source water is presented in Appendix K.

Water Quality Monitoring: Year 1 Pilot Testing

Water quality samples will be collected during various portions of the injection, storage, and recovery periods throughout the duration of testing cycles 1 and 2. The water quality monitoring program for cycle 1 and cycle 2 of the pilot test is presented in Tables 5-1 and 5-2. The program has been designed to meet the objectives stated previously. A template that will be used for tracking the ASR testing program is presented in Appendix L.

Water Quality Monitoring Program: Pilot Testing, Years 2 through 5

An updated water quality monitoring program for years 2 through 5 will be developed and submitted to OWRD following collection and evaluation of year 1 data. It is anticipated that the water quality monitoring program for years 2 through 5 will follow a similar format as the cycle 2 monitoring program.

Summary

This section outlines the pilot testing water quality monitoring program. The water quality monitoring program will confirm that the recovered water meets Safe Drinking Water Act drinking water standards and assess water quality compatibility. Section 6 presents a Quality Assurance and Quality Control Plan to ensure that water quality monitoring data are valid representations of the water quality at the location sampled.

SECTION 6

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SECTION 6

SECTION 6
QUALITY ASSURANCE AND QUALITY CONTROL PLAN

General

This section presents a quality assurance and quality control (QA/QC) plan that describes water sampling QA/QC procedures that will be followed in the field during the City of Tualatin's ASR pilot testing program. The purpose of the QA/QC plan is to endeavor that collected water quality data are valid representations of the water quality at the sampling location. Under project management direction of MSA, Groundwater Solutions Inc. (GSI) staff and the City of Tualatin operations staff will collect the majority of the water quality data. GSI will provide training to City staff, where necessary, and periodically check field procedures and will review field and laboratory data for completeness and compliance with this plan.

QA/QC

QA/QC procedures that will be used in the field during the ASR pilot testing program include field equipment calibration, field record keeping, and chain-of-custody documentation. If lab testing results indicate that a parameter has an unexpectedly high concentration approaching the MCL or MML, injection or pumping will be stopped and the location will be re-sampled. Each element of the field QA/QC plan is described below.

Equipment Calibration

Field meters require calibration to provide accurate and precise measurement of field parameters. The field meters will be calibrated prior to each sampling event and subsequently operated in a manner consistent with the manufacturer's recommendations.

Record Keeping

The sampling technician will record field observations and measurements on the Water Sampling Field Form during sampling. A copy of the Water Sampling Field Form is included in Appendix M. The following information will be recorded on the form for each sampling point:

- Sampling time and date
- Name of person performing the sampling
- Location of sampling point
- Field parameter values for pH, temperature, and conductivity collected during sampling
- Appearance of sample
- Thermal and chemical preservation, if any

- Summary of field procedures

If groundwater samples are collected from wells, the following additional information will be recorded on the form:

- Depth to groundwater with reference to an established measuring point
- Field parameter values collected during purging intervals
- Purging time and volume of water purged

Sample Labels

A sample label will be secured to each water sample container. The following information will be included on the sample labels:

- Project name/number
- Sample Identification, such as well identification number and date
- Type of Sample, such as injection water/recovered water
- Name of person collecting the sample
- Date and time of sample collection
- Type of preservative, if any

Chain-of-Custody

A chain-of-custody form will be used to track and document possession of each sample and to specify the analyses requested. An example chain-of-custody form that will be used during the pilot testing program is included in Appendix N. The chain-of-custody record will be maintained according to the following procedure.

1. After collecting the samples, the sampling technician will complete the chain-of-custody form.
2. The chain-of-custody record will accompany the samples from the field to the laboratory.
3. Each individual having samples in his/her custody must ensure that the samples are not tampered with and that the chain-of-custody record is completed upon sample transfer.
4. A copy of the completed forms will be retained in the project files.

Laboratory Quality Assurance Program

Samples collected during the pilot testing program will be analyzed by an analytical laboratory certified by the Drinking Water Laboratory Certification Program (DWLCP) or the Oregon Environmental Laboratory Accreditation Program (OREALAP). DWLCP is in the process of being phased out and replaced by ORELAP, which is recognized by the U.S. Environmental Protection Agency's National Environmental Laboratory Accreditation

Program (NELAP) to accredit environmental testing laboratories to national standards as adopted by the National Environmental Laboratory Accreditation Conference (NELAC). The analytical laboratory will include analyses of trip blanks for volatile organic compound analyses, method blanks, spikes, duplicates, surrogates, and control samples in each analytical batch containing the Tualatin ASR samples or at a frequency of at least one in every 20 samples, depending upon the analysis being performed. The results from these procedures will be included with the Tualatin ASR sample results in an analytical laboratory report.

Summary

This section presents a QA/QC plan that describes water sampling QA/QC procedures that will be followed during the City of Tualatin ASR pilot testing program. A well documented QA/QC program with detailed field sampling and testing procedures will be implemented to provide valid representations of the water quality parameters at the sampling locations. Laboratory analysis will be performed at a laboratory certified to perform drinking water analyses.

APPENDIX

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APPENDIX

APPENDIX A

ASR License No. ____
(ASSIGNED AFTER FILING)

STATE OF OREGON
WATER RESOURCES DEPARTMENT
APPLICATION FOR LIMITED WATER USE LICENSE
FOR
AQUIFER STORAGE AND RECOVERY (ASR)

Applicant(s): City of Tualatin
Contact Person: Mike McKillip, P.E., City Engineer
Mailing Address: 18800 SW Martinazzi Avenue

Tualatin	Oregon	97062-7092	503.691.3030
City	State	Zip	Phone #

1. DATE(S) OF PRE-APPLICATION CONFERENCE(S): September 9, 2003

INFORMATION REGARDING ASR TESTING UNDER A LIMITED LICENSE

2. SOURCE OF INJECTION WATER for ASR: Bull Run Watershed
   a tributary of Sandy River

3. MAXIMUM DIVERSION RATE: 3,000 gpm (6.7 cfs)

4. MAXIMUM INJECTION RATE AT EACH WELL(S): 550 gpm (1.23 cfs)

5. MAXIMUM STORAGE VOLUME: 475 million gallons

6. MAXIMUM STORAGE DURATION: Typical: 2 months, possibly with year to year carryover

7. MAXIMUM WITHDRAWAL RATE AT EACH WELL(S): 700 gpm (1.56 cfs)

8. LICENSE TERM OR DURATION SOUGHT (5 year maximum): 5 years

9. PROPOSED USE OR DISPOSAL OF RECOVERED WATER: Initial recovery pumped to waste for short-term testing, long-term production water will be delivered to City water system.

10. IF CONTINGENCIES PRECLUDE THE USE IN ITEM 9, SPECIFY AN ALTERNATE USE OR DISPOSAL OF THE RECOVERED WATER: The water will be pumped to the storm drainage system in SW 108th Avenue.

-over-

INFORMATION REGARDING THE ULTIMATE ASR PROJECT

AS CURRENTLY ANTICIPATED

11. SOURCE OF INJECTION WATER for ASR: Bull Run Watershed
a tributary of Sandy River

12. MAXIMUM DIVERSION RATE: Approximately 3,000 gpm (6.7 cfs)

13. MAXIMUM INJECTION RATE AT EACH WELL(S): Approximately 550 gpm

14. MAXIMUM STORAGE VOLUME: 475 million gallons

15. MAXIMUM STORAGE DURATION: Typically 2 months, possibly with year to year carryover.

16. MAXIMUM WITHDRAWAL RATE AT EACH WELL(S): Approximately 700 gpm

NOTE: The materials required by rule for an ASR limited license are extensive. The items on this sheet consist of those outlined in OAR 690-350-020(2) and (3)(a)(A-E). Please consult the rule and provide as attachments to this form the other requirements in OAR 690-350-020(3)(a).

Signature of Applicant Michael A. McKillip Date 12/3/03

Title City Engineer

MSA

APPENDIX B

This page to be completed by the local Watermaster.

WATER AVAILABILITY STATEMENT

Name of Applicant: City of Tualatin Application 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:

   This well is proposed within the Sherwood-Dammasch-Wilsonville- Groundwater Limited Area. Source will be from injected water only as natural water from the basalt aquifer is closed for new appropriations.

2. Has the stream or basin that is the source for this application ever been regulated for minimum stream flows?

   ☐ Yes ☐ No

   If yes, please explain:

   N/A

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

   ☐ Yes ☐ No

   If yes, what are your observations for the stream?

   N/A

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

   ☑ Yes ☐ No

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

   Water source is from injection only.

5. Any other recommendations you would like to make?

Signature [signature] WM District #: 18 Date: October 28, 2003

MSA

APPENDIX C

Groundwater Solutions Inc.
3758 SE Milwaukie Ave. Portland, Oregon 97202
ph:503.239.8799 fx:503.239.8940 e:groundwatersolutions.com

Technical Memorandum

To: Brian Ginter and Chris Uber, P.E. – Murray Smith & Associates

CC: File

From: Walter Burt, R.G.

Date: December 4, 2003

Re: Hydrogeologic Summary Report
City of Tualatin Aquifer Storage and Recovery Program

REGISTERED PROFESSIONAL
OREGON
WALTER C BURT
G1402
GEOLOGIST
Expires 05/31/04

Introduction

This memorandum summarizes the hydrogeology in the vicinity of the City of Tualatin (City), Oregon and also presents the results of an evaluation of aquifer storage and recovery (ASR) feasibility conducted by the City. The purpose of this summary is to provide information in support of the City's application to the Oregon for an ASR Limited License, as required in Oregon Adminstrative Rules (OAR) 690-350-0020(3)(b)(C) and (3)(b)(G).

The City intends to develop an ASR system that could provide up to 5 million gallons per day (mgd) of water supply to the City from 5 wells during high water demand periods. Initially, the City will install a single ASR production well and conduct pilot testing to further assess feasibility and expansion potential. The City subsequently will expand the system in stages by adding wells based on the results of prior pilot testing. The following sections describe the hydrogeologic characterization work completed by the City of Tualatin to evaluate the feasibility of ASR, a conceptual hydrogeologic model of the City of Tualatin area, a description of the aquifer targeted for storage, and an assessment of potential impacts from implementation of an ASR system. The hydrogeologic conceptual model includes descriptions of the geologic setting, current knowledge of the hydrogeology of the aquifer targeted for ASR development and a summary of water quality in the target aquifer. The assessment of potential impacts from ASR includes a water quality compatibility assessment as well as an evaluation of potential impacts from head changes in the aquifer.

The overall area initially evaluated for ASR feasibility is shown in Figure 1. The area where the City intends to develop an ASR system is limited to the uplands generally south of downtown Tualatin.

ASR Feasibility Investigations

The City of Tualatin completed two phases of investigations between 2001 and 2003 to assess the feasibility of developing an ASR system to provide a source of water during peak demand periods. The initial phase included a review of available published and unpublished information describing the geology and hydrogeology in the vicinity of the City.

The second phase of the feasibility study involved drilling and testing a deep exploratory well (ASR Exploratory Well No. 1) to assess the suitability of the aquifer, evaluating water quality compatibility and assessing infrastructure requirements. The work completed as part of the second phase of the feasibility study included the following:

- Drilled a 1,070-foot deep exploratory borehole and completed the borehole as a 1,005-foot deep test well.
- Conducted a step-drawdown well test and a 5-day constant rate aquifer test
- Completed flow meter (spinner) logging of the lower borehole
- Sampled and analyzed a groundwater sample from the well and a sample of injection source water for water quality analysis of geochemical and both regulated and unregulated Safe Drinking Water Act (SDWA) parameters
- Completed an analysis of water quality compatibility issues for ASR
- Evaluated injection and recovery rates and storage volumes
- Evaluated permitting and infrastructure requirements

The results of these two investigations and other unpublished and published work in the area are summarized in the following sections of this document.

Geologic Setting

The City of Tualatin is located in an east-west trending valley bordered by hills to the south and to the north. The Tualatin River occupies the north side of the valley. Elevations within the City range from approximately 100 feet (MSL) in the vicinity of the Tualatin River to over 550 feet (MSL) in the hills just outside the southern and southeastern portions of the UGB. Figure 1 presents the generalized geology in the Tualatin area based on mapping and interpretations by Beeson and Others (1989), Madin (1990), Wilson (1997) and Burns and Others (1997). The predominant geologic units present in the area, from youngest (shallowest) to oldest (deepest), include relatively fine-grained unconsolidated sediments, basalt from the Columbia River Basalt Group (CRBG), and Eocene marine sediments. Descriptions of these units with regard to their general hydrogeologic characteristics are provided in this section. Figures 2 and 3 depict geologic cross-sections of the study area that show the relative positions of the geologic units described below.

Unconsolidated Sediments - Qtu

These materials consist of undifferentiated and unconsolidated sediments comprised of Pleistocene flood deposits overlying late Miocene and Pliocene fluvial and lacustrine deposits. These sediments consist predominately of fine-grained silt and clay with thin, discontinuous lenses of sand and gravel. The thickness of unconsolidated sediments overlying the CRBG is over 600 feet between downtown Tualatin and the north side of the Tualatin River. Water wells completed in the sediments tend to be considerably less productive than wells completed in the basalt. In addition, high iron and total dissolved solids concentrations have been noted in the sediments during drilling. For the purpose of this study, the sediments overlying the CRBG were not considered suitable for hosting an ASR system.

Columbia River Basalt Group - CRBG

The CRBG consists of a series of basalt lava flows originating from eastern Washington, Oregon and western Idaho that underlie a large area in the Willamette and Tualatin valleys. Overall, the CRBG is up to approximately 1,000 feet thick in the Willamette Valley, including in the vicinity of the Study Area.

The CRBG in the Tualatin area is represented by two distinct groups of flows comprising the Wanapum (Tcw) and the Grande Ronde (Tcg) formations. A brief description of the geologic nature of the two CRBG formations is provided below:

> **Wanapum Basalt Formation** (Tcw): The Wanapum Basalt Formation dates from approximately 15.3 million years ago during the middle Miocene. Three separate groups of flows comprise the three members of the Wanapum Basalt Formation. The Wanapum within the Study Area consists of flows of the Frenchman Springs Member, which is one of the three members comprising the formation.
>
> **Grande Ronde Formation** (Tcg): The Grande Ronde Formation dates from prior to approximately 15.6 million years ago during the early and middle Miocene. The Grande Ronde is by far the most voluminous of the CRBG formations and is predominant in the Tualatin Valley, including the study area. The Grande Ronde locally includes the following units that may include one or more separate basalt flows: Sentinel Bluffs, Winter Water, Ortley, Umtanum, Grouse Creek, Wapshilla Ridge and Mt. Horrible or Downey Gulch. ASR Exploratory Well No. 1 penetrated all but the Mt. Horrible or Downey Gulch units of the Grande Ronde Formation. The basalt flows of the Grande Ronde Formation host the most productive aquifer in the study area, and is the target aquifer for hosting an ASR system.

Marine Sediments - Tm

This unit consists of undifferentiated Eocene and Oligocene (greater than 23.7 million years ago) marine sediments (Burns and Others, 1997). The sediments typically consist of fine-grained silt and clay with some sand lenses. ASR Exploratory Well

No. 1 penetrated the marine sediments at a depth of approximately 1,060 feet bgs. Basaltic gravels encountered on top of the marine sediments may represent alluvial sediments deposited on the surface of the marine sediment unit during the period prior to emplacement of the CRBG basalt flows. The marine sediments typically do not host very productive aquifers. In deeper portions of the Tualatin basin and in faulted areas along the margin, the marine sediments often contain saline water. The water quality in some basalt wells in the region has been affected by saline water migrating up into the basalt where vertical pathways allow. Field and laboratory specific conductivity measurements obtained during drilling of ASR Exploratory Well No. 1 indicate an increase in specific conductivity of groundwater from 478 microsiemens per centimeter (μS/cm), at a depth of approximately 950 feet in the CRBG, to 2,380 μS/cm at a depth of 1,060 feet within the marine sediment. The marine sediment unit was not considered a candidate aquifer for development of ASR at the City, based on the relatively low permeability of the unit.

Structural Geology
The valley occupied by the Tualatin River and City of Tualatin is a fault-bounded structural basin bordered on three sides by basalt highlands. The faults bounding the valley have juxtaposed substantial thicknesses (over 600 feet) of CRBG section under the highlands against the alluvial and lacustrine sediments filling the valley. In addition, the faults have segmented the CRBG in the hills surrounding the City. Figure 1 shows the locations of published mapped or inferred faults. Figures 3 and 4 are geologic cross sections illustrating the relationship between geologic units and structures in the Tualatin area.

Geologic structures have an important influence on groundwater flow in the CRBG. Faults and folds influence groundwater flow by promoting and/or impeding both lateral and vertical flow. Faults may limit lateral transmission of water in the basalts that can effectively create "compartments" in aquifers in the CRBG. They also may promote preferential vertical flow of water, bringing deeper water up into shallower aquifers or transmitting of water into deeper aquifers. The character of faults in the CRBG depends on the degree of offset of the basalt flows, as well as healing by secondary minerals such as clays.

Hydrogeologic Setting

Hydrostratigraphy

ASR Exploratory Well No. 1 penetrated approximately 1,050 feet of CRBG consisting of 11 or 12 separate basalt flows. The CRBG stratigraphy at the exploratory well location is shown in Figure 4. The completed exploratory well was cased and sealed to a depth of 489 feet and is open to six water-bearing zones within the Grande Ronde Formation; five of these zones consist of the flow tops of two Grouse Creek and three Wapshilla Ridge basalt lava flows. The sixth zone is a pillow lava sequence within the Wapshilla Ridge Unit. The thickest of these zones are associated with the two Grouse Creek flows and the third Wapshilla Ridge flow. A seventh water-bearing zone, consisting of basalt pillow lobes overlying the alluvial gravel layer at the marine sediment contact, was penetrated at the base of the Wapshilla Ridge unit; however, this zone was subsequently sealed off because of the presence of poor quality water, as evidenced by high specific conductivity readings obtained while drilling. Downhole flow logging indicates that over 90 percent of the flow from the open interval in the Grande Ronde Formation at this location originates from the upper 5 interflow zones tested.

Hydrogeologic Characteristics of the CRBG

Groundwater in the basalt flows of the CRBG is predominantly derived from interflow zones, which represent the contact between individual basalt flows. These interflow zones commonly consist of a rubbly and porous zone formed by a flowtop breccia and chilled margin at the base of the overlying flow. At locations where surface water body (i.e., river or lakes) was present at the time of flow emplacement, pillow basalts zones are formed with a glassy matrix by the intrusion of the lava flow into the water. These interflow zones typically can easily transmit water laterally. Groundwater may also be produced from fractured zones in the more massive interior flows of the CRBG if sufficient structural deformation and fracturing has occurred.

The vertical hydraulic connectivity between basalt interflow zones of the CRBG in the vicinity of the Study Area is unknown. However, hydraulic communication between interflow zones is limited by dense flow interiors on a local scale, and may even be on a regional scale. Consequently, aquifers within the CRBG are commonly well confined at a local scale. However, vertical tectonic fracturing and thinning and pinching out of flows also may result in hydraulic connection between interflow zones, particularly over larger areas. Thus, aquifers within the CRBG may hydraulically exhibit leaky confining characteristics over larger areas and over longer time periods of observation.

The significance of the faults bordering and crosscutting the basalt highlands adjacent to Tualatin with regard to the hydraulic characteristics of the basalts is not known for certain at present. However, the faults bordering the hills juxtapose interflows of the CRBG with up to 600 or more feet of generally fine-grained, low permeability valley fill sediments. There is some evidence from aquifer testing at ASR Exploratory Well No. 1 and at the City of Tigard COT-1R and the City of Beaverton ASR-3 that the contact with the valley fill sediments may act as a negative (low flow) hydraulic boundary in the confined basalt aquifer interflow zones. Further discussion of this is provided later in this document.

Groundwater Levels

Spatial Groundwater Levels

Static groundwater levels obtained from well driller logs for wells completed in the CRBG indicate that the depth to water in basalt wells generally increases with increasing ground surface elevation; groundwater levels in basalt wells located to the south of downtown Tualatin range from approximately 50 to nearly 400 feet below ground surface depending on the ground surface elevation and depth of the well. Groundwater levels also vary with depth in the CRBG. The static water level for the lower CRBG measured in ASR Exploratory Well No. 1 in Summer 2002 was approximately 253 feet bgs. The corresponding static water level elevation for this deep CRBG water level is approximately 90 feet MSL. Groundwater levels measured in Summer 2002 in a shallow (320-foot deep) basalt domestic well near ASR Exploratory Well No. 1 were between approximately 190 and 210 feet bgs; the approximate corresponding groundwater elevations for these shallow CRBG water levels are 130 to 150 feet MSL, indicating an overall downward gradient from the shallow CRBG to the deep CRBG zones.

Temporal Groundwater Levels

Hydrographs for City of Sherwood wells and selected wells included in the Willamette Basin Study (USGS, 1999) were evaluated for seasonal and long-term temporal changes in groundwater levels. Groundwater levels in the basalt aquifers in the vicinity of Tualatin show both seasonal and long-term variability. Groundwater levels typically are at the lowest seasonal levels in the fall and highest levels in the late spring. The seasonal variability often reflects the effects of pumping during the dry season, and the effects of recovery from pumping and winter recharge to the aquifer.

Groundwater levels in the CRBG aquifer in the vicinity of Tualatin have generally exhibited long-term declines over the past 35 years or more. Groundwater levels in the City of Sherwood wells show annual declines of 2 to 5 feet per year, which is similar to what has been observed at City of Wilsonville wells prior to 2002. Hydrographs for other basalt wells, including wells on the south flanks the Bull Mountain show lesser declines (USGS, 1999). Water levels in many wells show water levels rebounded significantly in the 1980s and 1990s, though generally not to pre-1970s levels. The rebound may be a result of more precipitation after the droughts in the 1970s and as a result of less groundwater pumping as the rural areas have become urbanized. A rebound in water levels in the CRBG aquifer in the vicinity of the City of Wilsonville also has occurred since Wilsonville transitioned from using basalt groundwater wells to surface water from the Willamette River treatment plant in 2002.

Groundwater Flow

Groundwater flow is in part a function of the distribution of groundwater levels in the aquifer (hydraulic gradient) and the hydraulic parameters of the aquifer, including transmissivity and storativity. The horizontal gradient and groundwater flow direction in the CRBG has not been determined in the vicinity of the area under consideration by the City of Tualatin for development of an ASR system. Regional hydraulic gradients in the CRBG commonly range from 0.001 to 0.01. Groundwater flow in the CRBG in the Willamette Valley is typically toward the major drainages in the is anticipated to be toward the major drainages in the area, including the Tualatin River located to the north and east, and the Willamette River located to the south and east. The difference in groundwater levels between the shallow and deep CRBG wells indicates a downward vertical component of flow. This observation is consistent with those of Woodward, et al (1998).

The transmissivity of the CRBG aquifers in the Tualatin Valley ranges from several thousand gallons per day per foot (gpd/ft) to several hundred thousand gpd/ft. The transmissivity of the lower CRBG interflow zones is approximately 26,500 gpd/ft, based on results of the aquifer test conducted at ASR Exploratory Well No. 1 (Figure 5). This value of transmissivity is consistent with the range of transmissivities measured in other large production wells completed in the CRBG in the region.

Storativity estimates for CRBG aquifers range from 1×10^{-5} to 1×10^{-3} and are typical of confined aquifers. The relatively high values of transmissivity and low values of storativity indicate that the basalt will readily yield water to wells but drawdown effects will be transmitted over long distances, in certain cases for miles. In addition, the low storativity value indicates that the aquifer is vulnerable to overpumping that result in water level declines.

At least one negative flow boundary was observed during aquifer testing of ASR Exploratory Well No. 1. Potential geologic features that may correspond to the boundary include several faults cross-cutting the basalt highlands, as well as where faults bordering the valley have brought relatively low permeability sediments into contact with interflow zones of the lower CRBG. The time that the boundary effect was manifested during the aquifer test (approximately 700 minutes) is consistent with the estimated distance to contact between the basalt and valley-fill sediments. However, the boundary does not appear to significantly affect the feasibility of achieving target injection and pumping rates.

Water Quality

Water quality of both native groundwater and injection source water was assessed by obtaining a sample of groundwater from the exploratory well at the end of the 5-day aquifer test and from a hydrant near the exploratory well site. The samples were analyzed for regulated and unregulated constituents and geochemical parameters. The results from the water quality evaluation are summarized in Tables 1 and 2, and are discussed in the following sections

Native Groundwater Quality

General Chemistry

In general, the native groundwater quality is good with a moderate amount of dissolved minerals at 246 mg/L total dissolved solids (TDS). This is considerably lower than the TDS measured in the borehole prior to sealing off the lower 65 feet. At 116 mg/L, the water is considered hard relative to what most people consider hard (greater than 50 mg/L). The water has a slightly alkaline pH 7.76, relatively low temperature, and is considered to be slightly reduced, no color and can be considered to be moderately aggressive.

The water has a slightly mineralized taste and no discernable odor after the well was pumped for several days. The drilling contractor did note a slight hydrogen sulfide odor at times during drilling. A small amount of the mineral pyrite (iron sulfide) was observed within some interflow zones and so the odor is likely a result of oxygen being introduced into the subsurface during drilling that causes oxidation of the pyrite. It is not uncommon for water produced from basalt wells that have been pumped for a period of time to have hydrogen sulfide smell similar to a slight rotten egg smell. This is thought to be a result of exposing sulfide minerals in the basalt aquifer in the vicinity of the well to oxygen as the cone of depression develops due to pumping. In most cases, chlorination of the pumped water eliminates the odor if it develops.

Iron and manganese concentrations are often elevated in basalt groundwater; however, concentrations measured in the ASR exploratory well are below secondary drinking water standards and so these parameters should not impact taste or cause staining of laundry.

The groundwater has a low or not detected organic carbon content and so this water will likely have a low potential to promote the formation of disinfection by-products when chlorinated water is injected into the aquifer or when it is recovered and then rechlorinated.

Regulated Constituents
Parameters that have regulatory standards such as metals, nitrate, volatile organic compounds, and pesticides, that are indicative of contamination, were either not detected or were detected at levels below the applicable regulatory criteria. Unregulated organic parameters and total and fecal coliform also were not detected in the native groundwater sample.

Mineral Stability
A geochemical model (PHREEQC) was used to assess the equilibrium state of the native groundwater with respect to common minerals associated with basalt aquifers. The analysis is used to determine whether the water is undersaturated, supersaturated, or at equilibrium with a particular mineral in solution. Undersaturated means that there is a tendency for this water to dissolve minerals present in the subsurface. Supersaturation indicates the water has a tendency to precipitate the mineral. Equilibrium means that the water does not have a tendency to either dissolve or precipitate a mineral. Understanding the equilibrium state of the water helps to understand what will occur when recharge water and native groundwater are mixed.

Native basalt groundwater at the exploratory well is in equilibrium with respect to calcite (calcium carbonate) and dolomite (calcium magnesium carbonate). The model indicates that the groundwater is undersaturated with respect to iron oxyhydroxide, which means there is a tendency to dissolve this mineral. The low level of dissolved iron in the sample (0.1 mg/L) and the oxidation state of the water (Eh = 29 millivolts) indicates that iron oxyhydroxide is probably close to equilibrium and suggests that iron and therefore many other dissolved metals are not mobile in the groundwater system. Chrysotile (magnesium silicate) and siderite (iron carbonate) are undersaturated, meaning they have a tendency to dissolve. Because sulfate was not detected in the sample and the sample is not strongly reduced, it is inferred that there is not a substantial amount of sulfide mineral (pyrite) in the aquifer. The lack of dissolved aluminum in the water indicates that clay minerals in the aquifer (including kaolinite, montmorillonite, and illite) are insoluble and will tend to stay in solid form.

A Stiff and Piper diagram that illustrates the chemical signature of the basalt groundwater compared with the Tualatin City water is presented as Figure 6. These diagrams are commonly used to graphically illustrate the dominant cations and anions dissolved in the water and to aid in comparing two water samples. The basalt groundwater is a calcium-sodium-bicarbonate type water. As shown in the Stiff and Piper diagram, the native groundwater is significantly more mineralized than the recharge source water and has a different chemical signature based on the relative proportions of dissolved cations and anions. As discussed later in this report, it is anticipated that the recovered ASR water will be more like the recharge source water and so ASR will actually improve the water quality near the ASR well by reducing the concentration of dissolved ions

Recharge Source Water Quality

General Chemistry

The water sample collected from the distribution system near the ASR exploratory well from the fire hydrant located at SW 108th Avenue and Dogwood has excellent quality with a low dissolved mineral content or TDS of 24 mg/L that is typical of a surface water origin. The hardness is also quite low at 12 mg/L.

Metals that have regulatory standards were either not detected or were detected at levels below the applicable regulatory criteria. The total iron concentration is somewhat higher than expected at 0.14 mg/L; however, dissolved iron was not detected. This indicates that the measured iron concentration is likely derived from particulates in the distribution system.

The water has a slightly alkaline pH of 7.78 and is considered very oxidized. Because the alkalinity is low at 15 mg/L, the water has very little buffering capacity and so the pH can easily change in response to reactions and chemical changes in the distribution system. The concentration of total organic carbon is also considered low at 0.98 mg/L and so the formation potential for disinfection byproducts is expected to be low.

Suspended Sediment

Suspended solids were not detected in the distribution system water sample. Suspended solids in municipal drinking water systems most typically come from sediment present in pipes within the distribution system. Sediment can become mobile when there is a change in flow rate or direction, or a sudden change in system pressure. Sediment can also enter the system when water lines are repaired or when there is a change in how water is fed into the system from its original source. If suspended solids were present at high enough concentrations, they could potentially clog the ASR well during injection. This has been a problem at other ASR well sites in the area. Suspended solids content in the recharge water can increase suddenly and unexpectedly. Consequently, it is necessary to take preventative measures such as systematic distribution system flushing and to frequently monitor turbidity in the system so that a problem can be identified before it reaches the ASR well.

While recharge source water may be high quality, there may be fine-grained material in the water that may slowly clog an ASR well over time. For this reason, it is typical to monitor turbidity in the distribution system and to monitor well performance during injection so that the well can be back flushed and pumped to waste on a periodic basis to remove sediment from the well. The optimal back flushing frequency is typically established during the pilot testing phase of the project.

Mineral Stability

The geochemical modeling results show that the ASR source water sample collected at the SW 108th Avenue and Dogwood Street hydrant is undersaturated with respect to calcite and dolomite. This indicates that the water has a tendency to dissolve calcite and dolomite. The model indicates that the groundwater is oversaturated with respect to iron oxyhydroxide, which indicates that the water tends to precipitate iron hydroxide. The lack of dissolved iron in the sample and oxidized state of the source water indicates that iron oxyhydroxide is stable in the solid phase, probably within the distribution system.

Evaluation of Potential Impacts from ASR

The anticipated ASR pilot testing and operational scenario contemplated by the City of Tualatin is for injection and storage of approximately 95 mg at each ASR well site, which will allow for a recovery rate from each well of 1 mgd for 90 days. Potential impacts from ASR operations may result from piezometric head changes in the confined basalt aquifer and water quality changes or reactions in the aquifer due to the interaction of injection water, native groundwater and the aquifer matrix. In addition, other nearby wells could capture stored ASR water. Selection of the target ASR zones incorporated these factors as well as potential productivity of the interflow zones. As a result, the targeted ASR zones are deeper than the majority of the basalt wells in this area. This section summarizes the evaluation of the identified potential impacts from the ASR operations.

Impacts from Piezometric Head Changes

Piezometric head increases due to injection will be transmitted over relatively great distances in the target aquifer due to the relatively high transmissivity and low storativity values of the aquifer. The potential for these head increases to impact wells, create seeps or caused increased spring discharges in lowlying locations where the basalt interflow zones intersect the ground surface is assessed in this section.

It is important to note that injection at the exploratory well location will occur within basalt interflow zones that are below approximately elevation –150 feet MSL; thus, the potential for groundwater to discharge at the surface due to increased heads in the deep aquifer will depend on the degree of vertical continuity between the deeper and shallower CRBG units, as well as the geometry of the injection mound surrounding the ASR well. The data from the aquifer test of the exploratory well indicate that a strong connection does not exist between the deep and shallow zones at the site as water levels in a nearby shallow domestic well did not show a clear response to pumping; however, some vertical leakage is possible over the typical long-term cycles of injection and recovery. Based on previous experience with similar local conditions, it is anticipated that injection at this site is not likely to create surface discharge of groundwater based on the expected localized area with maximum injection heads and predicted rapid decrease in injection head with distance from the site. The potential for surface discharges will be of more concern as additional ASR sites are developed and the potential for recharge mound overlap increases. A preliminary analysis of potential head rises within the aquifer during injection by a 5-well ASR system is summarized below.

A preliminary estimate of the head rise in the basalt aquifer target interflow zones (below –150 feet MSL) adjacent to a single ASR well at the end of the 130-day injection period using the results of the exploratory well testing is approximately 60 feet, or approximately elevation 150 feet MSL. Head rises in wells completed within basalt interflow zones located above the target injection zones will likely be significantly lower, and is dependent upon the vertical leakage within the system., Based on analytical estimates of head increases using aquifer parameters from the exploratory well test and superposition, between 50 and 80 feet of interference at the end of an injection cycle from other ASR wells is possible at each well location, causing an estimated maximum piezometric head within the aquifer of approximately 230 feet MSL at the well locations. There are several locations within one-half mile of the area under consideration for implementation of ASR that have surface elevations less than 230 MSL including (1) the valley located to the west of ASR Exploratory Well No. 1, (1) the area north towards downtown, and (3) the Saum Creek drainage east of the I-5 freeway. However, the potential for the piezometric surface to reach this level is considered low, as piezometric surface elevations will decrease significantly with increasing distance from each ASR well. Estimates of increases in the piezometric surface at the valley located 2000 west of the exploratory well during injection range from 60 to 90 feet, or between approximately elevations 150 and 180 feet MSL, which is below ground surface.

Locations within 1 mile to the west of the exploratory well site are less then elevation 200 feet MSL, particularly in the vicinity of the Morse Brothers Coffee Lake Quarry site. The bottoms of the quarry pits are below sea level but are above the interflow zones targeted for ASR at the initial pilot test site. A worst case scenario estimate, assuming the quarry intersected the target ASR interflow depths, the estimated increases in the piezometric head at the quarry from an ASR well at the initial pilot test site ranges between 15 and 20 feet. The water level elevation in the south pit of the quarry was approximately 80 feet MSL in May 2003 and the piezometric surface in a nearby well (Tricounty Gun Club Well – OWRD Well No. WASH 1847) was approximately 129 feet MSL in April 2003. As discussed above, injection in the target aquifer at the exploratory well site will occur below elevation –149 feet MSL. Consequently, the actual head rise experienced that the quarry locations will depend on the degree of vertical connection between the receiving interflows and the shallower CRBG units penetrated by the quarry, and likely will be significantly less than predicted for the deeper units.

Monitoring the potential for surface discharges and connectivity between the shallow and deeper basalt zones will be implemented during pilot testing, particularly as each additional ASR well is brought on line. The monitoring would include measuring water levels in the exploratory well, the onsite domestic well and possibly one or two other nearby shallow wells. Periodic visual surveys of potential seep areas also will be conducted prior to and during pilot testing. The actual head rise at the quarry and the resulting impacts of implementation of ASR will be assessed during pilot testing of the initial ASR well at the exploratory well site.

Capture of Stored Water by Other Wells

No large-capacity wells completed in the deep CRBG that could capture stored ASR water have been identified in the general vicinity of the exploratory well site. A majority of the basalt wells in this area are completed at depths shallower than the targeted ASR zones. The irrigation well(s) at the Tualatin High School are within the area where ASR will be implemented. This well only penetrates the upper portion of the target aquifer zones and is not expected to capture stored water, although it may affect water levels during injection and pumping. There several large-capacity wells within several miles of the exploratory well also could influence water levels, and thus could affect achievable ASR well injection and pumping rates. Water level recording instrumentation will be installed in the exploratory well to allow for assessment of long-term aquifer trends and effects from pumping distant production wells.

Water Quality Compatibility Evaluation

An analysis of water quality compatibility was performed for the ASR source water and native basalt groundwater produced from the exploratory well. The purpose of this assessment was to determine if chemical reactions could occur as a result of mixing the recharge source water with the native groundwater that might adversely affect ASR well performance, flow properties of the basalt aquifer, or recovered water quality. The evaluation was conducted by interpreting Stiff and Piper geochemical diagrams and by performing an analysis of the equilibrium status of a theoretical mixture of the source water and native groundwater using the PHREEQC geochemical model. The modeling was performed to predict possible geochemical effects, such as mineral precipitation or dissolution that might occur when the recharge water and native groundwater are mixed. The modeling was performed using a theoretical 50:50 mixture of native groundwater and injection source water. This is typically the worst-case mixing relationship that could produce adverse chemical reactions.

As the recharge water is introduced into the ASR well, some native basalt groundwater will be displaced and some will mix with the recharge water. The water quality immediately adjacent to the ASR well will be very similar to the recharge water. Near the outer limits of the recharge water bubble, the water quality will gradually become a mixture between recharge water and native groundwater. The pH in the mixed zone is predicted to remain slightly alkaline at a pH of 7.7. Outside the mixed zone further away from the ASR well, the water quality will be identical to native groundwater. Because most of the recharge water will be withdrawn soon after it is injected every year, it is anticipated that there will be no long-term change in water quality within the basalt aquifer.

Geochemical Modeling Results

Based on the available water chemistry data and geochemical modeling results using the PHREEQC model, the recharge source water and receiving native basalt groundwater appear to be chemically compatible and do not appear to present any fatal flaws for ASR development or use. When the relatively oxidized recharge water mixes with native groundwater in the aquifer near the ASR well, precipitation of calcite and dolomite that could clog the well is not predicted to occur. In fact, the geochemical modeling results indicate that there will be a slight potential for calcite and dolomite to dissolve, if present in the aquifer. This would result in a slight increase in the calcium and magnesium concentration in the recovered water. These minerals probably make up only a small percentage of the aquifer matrix and so this will likely not be a concern. The likely increase in calcium concentration is a few mg/L, but could be as much as 10 mg/L on the first recharge cycle, depending on how much carbonate is present in the aquifer. The recovered water chemistry should more closely resemble the recharge water chemistry with each subsequent ASR injection, storage and recovery cycle, particularly if additional recharge water is left in the aquifer from year to year.

The geochemical modeling indicates that iron oxyhydroxides are likely to precipitate when the two waters are mixed. Because the concentration of iron in both the source water and native groundwater is low, the mass of the iron hydroxides will likely be small and so it is anticipated that clogging will likely not be a significant problem. The results also indicate that manganese-containing minerals, if present in the aquifer, will have a tendency to dissolve, which could increase the concentration of dissolved manganese in the recovered water. Manganese is often associated in small quantities with other primary (pyrolusite) and secondary minerals (iron oxides) in basalt. It is anticipated that manganese dissolution will not be a significant concern because chemical testing conducted by Dr. Beeson on rock samples obtained while drilling the test well shows that there is a very low percentage of manganese-containing mineral present in the aquifer. In addition, manganese dissolution and precipitation rates are very slow in natural systems. While not a fatal flaw to ASR implementation, both iron and manganese concentrations should be monitored during the pilot study phase to confirm that these reactions are not significant.

Because iron and manganese precipitation and dissolution reactions are pH dependent, iron and manganese equilibrium, and hence the resultant concentration of dissolved iron and manganese in recovered water, can often times be managed through pH adjustment at the ASR wellhead. Well performance during injection should be monitored to determine if iron hydroxide precipitation (or sediment) is beginning to clog pore openings near the well. If this is observed, the well can be periodically back flushed to remove the material. Aggressive redevelopment that may involve pulling the pump and physically and chemically treating the well may also be needed periodically. If iron precipitation is found to be a problem during the pilot testing phase, consideration should be given to storing more water than is recovered each year so that the mixing zone where this reaction is most likely to occur is kept away from the ASR well. This should substantially reduce losses in well efficiency that might be caused by precipitation reactions.

If more than approximately 80 to 90 percent of the stored water is recovered, there will likely be a noticeable change in hardness and taste at locations closest to the ASR well source. This change is very gradual but may be noticed by industries relying on a constant water quality or by residents who notice water spots on windows. Leaving more stored water in the aquifer can minimize these affects.

Disinfection By-Products

Chloramines and disinfection byproducts will be introduced at the wellhead because the City of Tualatin water supply is derived from the City of Portland system. Residual chlorine concentrations will dissipate quickly, typically in a matter of hours, as the recharge water comes into contact with the aquifer matrix. Disinfection byproducts (DBPs) are produced as a result of chemical reactions between organic carbon and chlorine. Disinfection by-products include haloacetic acids (HAAs) and trihalomethanes (THMs). Because the TOC of the native groundwater is very low there is a lower potential for DBP formation after the chloraminated recharge water is introduced into the aquifer. It is anticipated that HAA concentrations will dissipate in at matter of days in the aquifer as a result of aerobic microbial degradation. THM concentrations may increase slightly after injection as a result of the reaction between the TOC present in the recharge water and chlorine; however, THM concentrations should decrease over a matter of weeks due to anaerobic microbial activity. Dilution caused by mixing between recharge water and native groundwater is also expected to reduce DBP concentrations. Detailed water quality testing results are documented in Appendix D.

Aquifers contain native populations of bacteria that can be affected by recharge activities. The potential water chemistry changes, if any, resulting from microbial activity cannot be predicted except in a general way. For example, if the aquifer is under reducing conditions, the microbial population will be a suite of anaerobic forms and many cannot survive the oxidized recharge water. Assuming that there is no iron sulfide present, there is usually little change in the recovered water chemistry resulting from this scenario. An aquifer under oxidizing conditions that is recharged with water containing a chloramine disinfectant, which will be the case here, can promote growth of aerobic bacteria present in the aquifer after the chlorine component is consumed because the bacteria will receive a nutrient in the form of ammonium that can boost their growth. Such a boost in growth is almost always accompanied by an increase in carbon dioxide. The increase in carbon dioxide will initially form carbonic acid, a weak acid that will react with, and be neutralized by, minerals in the aquifer. The chemical reaction increases the TDS and can potentially precipitate calcium carbonate resulting in recovered water chemistry with slightly higher TDS but lower calcium than that of the recharge water. Increased biological activity could also produce biomass that may reduce the permeability of the aquifer over the long term. Based on previous experience, it is anticipated that this issue is not a fatal flaw; however, recovered water quality should be monitored during any pilot program to assess the degree to which the ammonium is stimulating bacterial growth and affecting recovered water quality.

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Table 1
Summary of Native Groundwater and ASR Source Water Quality Testing
City of Tualatin Aquifer Storage and Recovery Program

		Analyte	Lowest Regulatory Standard	Units	Regulatory Criteria	MDL	*Native Groundwater* ASR Exploratory Well No. 1	*Source Water* 108th and Dogwood Hydrant/City of Portland Water Quality Analysis
						Date	08-Aug-02	August 8, 2002/ 2001
Bacteriological		Fecal Coliforms/E.Coli					Absent	Absent
		Total Coliform	<1/100 ML	CFU/100 ml	MML		Absent	Absent
Disinfection By-Products								
	THM	Chloroform (Trichloromethane)	None	mg/L	URC	0.0005	ND	
	THM	Bromodichloromethane	None	mg/L	None	0.0005	ND	
	THM	Dibromochloromethane	None	mg/L	None	0.0005	ND	
	THM	Bromoform (Tribromomethane)	None	mg/L	URC	0.0005	ND	
		Total Trihalomethanes	0.08	mg/L	MCL	--	0	0.022 *
	HAA	Monochloroacetic Acid	None	mg/L	None	0.002	ND	
	HAA	Dichloroacetic Acid	None	mg/L	None	0.001	ND	
	HAA	Trichloroacetic Acid	None	mg/L	None	0.001	ND	
	HAA	Monobromoacetic Acid	None	mg/L	None	0.001	ND	
	HAA	Dibromoacetic Acid	None	mg/L	None	0.001	ND	
		Total Haloacetic Acids	0.06	mg/L	MCL	--	0	0.034 *
		Chlorite [1]	1	mg/L	MCL	NT	NT***	NT***
		Bromate [1]	0.01	mg/L	MCL	NT	NT***	NT***
Field Parameters		Temperature	None	Celsius	None	NA	15.3	20.4
		Conductivity	None	mS/cm	None	NA	432	41
		Dissolved Oxygen	None	mg/L	None	NA	0	9.71
		pH	6 - 8.5	Units	SMCL	NA	7.76	7.78
		Turbidity	1	NTU	MCL, MML	NA	11.5	-2
		ORP	None	mV	None	NA	-171	407
Geochemical		Bicarbonate	None	mg/L	None	2	109	15
		Calcium	None	mg/L	None	0.1	27.1	2.5
		Carbonate	None	mg/L	None	2	ND	ND
		Chloride	250	mg/L	SMCL	1	43	2
		Hardness (as CaCO3)	250	mg/L	SMCL	4	116	12
		Magnesium	None	mg/L	None	0.05	10.27	0.57
		Nitrate as N	10	mg/L	MML	0.5	ND	0
		Nitrite as N	1	mg/L	MCL	0.01	ND	0.03
		Total Nitrate-Nitrite	10	mg/L	MML	--	ND	0.03
		Potassium	None	mg/L	None	0.1	2.2	0.2
		Silica	None	mg/L	None	0.2	47.5	10.6
		Sodium	20	mg/L	URC, SMCL	0.05	26.76	3.82
		Sulfate	250	mg/L	URC, SMCL	5	ND	ND
		Total Alkalinity	250	mg/L	SMCL	2	109	15
		Total Dissolved Solid	500	mg/L	SMCL	0.7	246	24
		Total Organic Carbon	None	mg/L	None	0.5	ND	0.98
		Total Suspended Solids	None	mg/L	None	2	ND	ND
Metals		Aluminum	0.05	mg/L	SMCL	0.05	ND	ND
		Antimony	0.006	mg/L	MCL	0.001	ND	ND
		Arsenic	0.05	mg/L	MCL, MML	0.002	ND	ND
		Barium	1	mg/L	MCL, MML	0.05	ND	ND
		Beryllium	0.004	mg/L	MCL	0.0005	ND	ND
		Cadmium	0.005	mg/L	MCL, MML	0.001	ND	ND
		Chromium	0.05	mg/L	MCL, MML	0.002	ND	ND
		Copper	1.3	mg/L	MCL	0.005	ND	ND
		Iron (Total)	None	mg/L	None	0.05	0.11	0.14
		Iron (Dissolved)	0.3	mg/L	SMCL	0.05	0.1	ND
		Lead	0.015	mg/L	MCL, MML	0.001	ND	ND
		Manganese (Total)	None	mg/L	None	0.002	0.017	0.022
		Manganese (Dissolved)	0.05	mg/L	SMCL	0.002	0.017	0.002
		Mercury	0.002	mg/L	MCL, MML	0.0004	ND	ND
		Nickel	0.1	mg/L	MCL	0.004	ND	ND
		Selenium	0.01	mg/L	MCL, MML	0.002	ND	ND
		Silver	0.05	mg/L	MML, SMCL	0.005	ND	ND
		Thallium	0.002	mg/L	MCL	0.0006	ND	ND
		Zinc	5	mg/L	SMCL	0.01	0.01	ND
Miscellaneous		Odor	3	TON	SMCL	1 ton	1	NT
		Color	15	ACU	SMCL	5 color units	ND	5 *
		Methylene Blue Active Substance	0.5	mg/L	SMCL	0.05	ND	NT
		Corrosivity (Langelier Saturation Index)	Non-Corrosive	mg/L	SMCL	--	-0.92**	NT
		Cyanide (as free cyanide)	0.2	mg/l	MCL	--	ND****	ND
		Fluoride	2	mg/L	MCL, MML, SMCL	0.5	ND	ND *
Radionuclides		Combined Radium 226/228 [1]	5	pCi/L	MCL	NT	NT***	NT***
		Uranium [1]	0.03	mg.L	MCL	NT	NT***	NT***
		Gross Alpha	15	pCi/L	MCL	1.79	ND	ND *
		Beta/Photon emitters [2]	4	mrem/yr	MCL	NA	NA	NA
		Gross Beta	50	pCi/L	MML	2.83	ND	ND *
		I - 131 [3]	3	pCi/L	MML	--	NA	NA
		Sr-90 [3]	8	pCi/L	MML	--	NA	NA
		Tritium [3]	20	pCi/L	MML	--	NA	NA

Table 1

Summary of Native Groundwater and ASR Source Water Quality Testing

City of Tualatin Aquifer Storage and Recovery Program

	Analyte	Lowest Regulatory Standard	Units	Regulatory Criteria	MDL	Native Groundwater ASR Exploratory Well No. 1	Source Water 108th and Dogwood Hydrant/City of Portland Water Quality Analysis
					Date	08-Aug-02	August 8, 2002/ 2001
Synthetic Organic Compounds (SOCs)							
Regulated SOCs	2,4,5-TP (Silvex)	0.01	mg/L	MCL, MML	0.0004	ND	ND **
	2,4-D	0.07	mg/L	MCL, MML	0.0002	ND	ND **
	Alachlor (Lasso)	0.002	mg/L	MCL, MML	0.0004	ND	ND **
	Atrazine	0.003	mg/L	MCL, MML	0.0002	ND	ND **
	Benzo(a)Pyrene	0.0002	mg/L	MCL	0.00004	ND	ND **
	BHC-gamma (Lindane)	0.0002	mg/L	MCL, MML	0.00002	ND	ND **
	Carbofuran	0.04	mg/L	MCL	0.001	ND	ND **
	Chlordane	0.002	mg/L	MCL	0.0004	ND	ND **
	Dalapon	0.2	mg/L	MCL	0.002	ND	ND **
	Di(2-ethylhexyl)adipate *(adipates)*	0.4	mg/L	MCL	0.001	ND	ND **
	Di(2-ethylhexyl)phthalate *(phthalates)*	0.006	mg/L	MCL, MML	0.001	ND	ND **
	Dibromochloropropane (DBCP)	0.0002	mg/L	MCL	0.00002	ND	ND **
	Dinoseb	0.007	mg/L	MCL	0.0004	ND	ND **
	Diquat	0.02	mg/L	MCL	0.0004	ND	ND **
	Ethylene Dibromide (EDB)	0.00005	mg/L	MCL, MML	0.00001	ND	ND **
	Endothall	0.1	mg/L	MCL	0.01	ND	ND **
	Endrin	0.0002	mg/L	MCL, MML	0.00002	ND	ND **
	Glyphosate	0.7	mg/L	MCL, MML	0.01	ND	ND **
	Heptachlor	0.0004	mg/L	MCL, MML	0.00004	ND	ND **
	Heptachlor Epoxide	0.0002	mg/L	MCL, MML	0.00002	ND	ND **
	Hexachlorobenzene (HCB)	0.001	mg/L	MCL, MML	0.0001	ND	ND **
	Hexachlorocyclopentadiene	0.05	mg/L	MCL, MML	0.0002	ND	ND **
	Methoxychlor	0.04	mg/L	MCL, MML	0.0002	ND	ND **
	Polychlorinated Biphenyls (PCBs)	0.0005	mg/L	MCL, MML	0.0002	ND	ND **
	Pentachlorophenol	0.001	mg/L	MCL, MML	0.00008	ND	ND **
	Picloram	0.5	mg/L	MCL, MML	0.0002	ND	ND **
	Simazine	0.004	mg/L	MCL, MML	0.0001	ND	ND **
	Toxaphene	0.003	mg/L	MCL, MML	0.001	ND	ND **
	Vydate (Oxamyl)	0.2	mg/L	MCL	0.002	ND	ND **
Volatile Organic Compounds (VOCs)							
Regulated VOCs	1,1,1-Trichloroethane	0.2	mg/L	MCL, MML	0.0005	ND	ND **
	1,1,2-Trichloroethane	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	1,1-Dichloroethylene	0.007	mg/L	MCL, MML	0.0005	ND	ND **
	1,2,4-Trichlorobenzene	0.07	mg/L	MCL, MML	0.0005	ND	ND **
	1,2-Dichlorobenzene (o)	0.6	mg/L	MCL, MML	0.0005	ND	ND **
	1,2-Dichloroethane (EDC)	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	1,2-Dichloropropane	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	1,4-Dichlorobenzene (p)	0.075	mg/L	MCL, MML	0.0005	ND	ND **
	Benzene	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Carbon Tetrachloride	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Chlorobenzene	0.1	mg/L	MCL, MML	0.0005	ND	ND **
	cis-1,2-Dichloroethylene	0.07	mg/L	MCL, MML	0.0005	ND	ND **
	Ethylbenzene	0.7	mg/L	MCL, MML	0.0005	ND	ND **
	Dichloromethane (methylene chloride)	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Styrene	0.1	mg/L	MCL, MML	0.0005	ND	ND **
	Tetrachloroethylene	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Toluene	1	mg/L	MCL, MML	0.0005	ND	ND **
	trans-1,2-Dichloroethylene	0.1	mg/L	MCL, MML	0.0005	ND	ND **
	Trichloroethylene	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Vinyl chloride	0.002	mg/L	MCL, MML	0.0005	ND	ND **
	Total Xylenes	10	mg/L	MCL, MML	0.0005	ND	ND **

NOTES:

mg/L = milligram per liter
MDL = Method Detection Limit
ND = Not detected at concentrations greater than the MDL
NT = Analyte not tested
NA = not applicable
MCL = Federal maximum contmainant level for drinking water
MML = DEQ's maximum measurable levels for groundwater
SMCL = Federal secondary maximum contaminant levels for drinking water
UCMR = EPA unregulated contaminant monitoring regulations for drinking water
Samples are unfiltered unless noted (i.e., dissolved)
1 = Chlorite, Bromate, Combined Radium 226/228 and Uranium required after December 2003
2 = Only need to analyze for if in a vunerable area (i.e., near man-made radioactive sources, such as nuclear facilities - only selected systems along Columbia River currently classified as vunerable 11/03)
3 = These are only analyzed if Gross Alpha or Beta exceed an MML or MCL

1 = These are only analyzed if Gross Alpha or Beta exceed an MML or MCL
* = Analysis by the City of Portland of samples collected in March 2002
** = Analysis by the City of Portland of samples collected from Bull Run water between September 11, 1996 and June 16, 2002. Samples from individual Portland groundwater sources are not representative of ASR source water and so were not included.
*** Chlorite, Bromate, Combined Radium 226/228 and Uranium required after December 2003 and will be collected in future
**** Cyanide result from City of Sherwood Well # 6, (approximately 1.9 miles west of ASR # 1 within the same production zone). Tualatin will collect a sample from new well after drilling to verify these results.

Table 2

Summary of Native Groundwater and ASR Source Water Quality Testing - *Former* Unregulated Contaminants List

City of Tualatin Aquifer Storage and Recovery Program

	Analyte	Lowest Regulatory Standard	Units	Regulatory Criteria	MDL	*Native Groundwater* ASR Exploratory Well No. 1	*Source Water* 108th and Dogwood Hydrant/City of Portland Water Quality Analysis
					Date	08-Aug-02	August 8, 2002 March-April 2002
Unregulated Contaminants (UCMR) [4]							
	2,4-Dinitrotoluene	None	mg/L	None	0.002	NT	ND
	2,6-Dinitrotoluene	None	mg/L	None	0.002	NT	ND
	Acetochlor	None	mg/L	None	0.002	NT	ND
	DCPA mono- and di-acid degradate	None	mg/L	None	0.001	NT	ND
	4,4-DDE	None	mg/L	None	0.0008	NT	ND
	EPTC	None	mg/L	None	0.001	NT	ND
	Molinate	None	mg/L	None	0.0009	NT	ND
	Methyl-tert-butylether (MTBE)	None	mg/L	None	0.005	ND	ND
	Nitrobenzene	None	mg/L	None	0.01	NT	ND
	Perchlorate	None	mg/L	None	0.004	NT	ND
	Terbacil	None	mg/L	None	0.002	NT	ND
Synthetic Organic Compounds (SOCs)							
Unregulated SOCs	3-Hydroxycarbofuran	None	mg/L	None	0.004	ND	ND **
	Aldicarb	None	mg/L	None	0.002	ND	ND **
	Aldicarb Sulfone	None	mg/L	None	0.001	ND	ND **
	Aldicarb Sulfoxide	None	mg/L	None	0.003	ND	ND **
	Aldrin	None	mg/L	None	0.0001	ND	ND **
	Benzyl Butylphthalate	None	mg/L	None	0.001	ND	ND **
	Butachlor	None	mg/L	None	0.001	ND	ND **
	Carbaryl	None	mg/L	None	0.004	ND	ND **
	Di-n-Butylphthalate	None	mg/L	None	0.001	ND	ND **
	Dicamba	None	mg/L	None	0.0005	ND	ND **
	Dieldrin	None	mg/L	None	0.00001	ND	ND **
	Diethylphthalate	None	mg/L	None	0.001	ND	ND **
	Dimethylphthalate	None	mg/L	None	0.001	ND	ND **
	Di-n-octylphthalate	None	mg/L	None	0.001	ND	ND **
	Methomyl	None	mg/L	None	0.004	ND	ND **
	Metolachlor	None	mg/L	None	0.002	ND	ND **
	Metribuzin	None	mg/L	None	0.001	ND	ND **
	Propachlor	None	mg/L	None	0.001	ND	ND **
Volatile Organic Compounds (VOCs)							
Unregulated VOCs	1,1,1,2-Tetrachloroethane	None	mg/L	None	0.0005	ND	ND **
	1,1,2,2-Tetrachloroethane	None	mg/L	None	0.0005	ND	ND **
	1,1-Dichloroethane	None	mg/L	None	0.0005	ND	ND **
	1,1-Dichloropropene	None	mg/L	None	0.0005	ND	ND **
	1,2,3-Trichlorobenzene	None	mg/L	None	0.0005	ND	ND **
	1,2,3-Trichloropropane	None	mg/L	None	0.0005	ND	ND **
	1,2,4-Trimethylbenzene	None	mg/L	None	0.0005	ND	ND **
	1,3,5-Trimethylbenzene	None	mg/L	None	0.0005	ND	ND **
	1,3-Dichloropropane	None	mg/L	None	0.0005	ND	ND **
	2,2-Dichloropropane	None	mg/L	None	0.0005	ND	ND **
	Bromobenzene	None	mg/L	None	0.0005	ND	ND **
	Bromochloromethane	None	mg/L	None	0.0005	ND	ND **
	Bromodichloromethane	None	mg/L	None	0.0005	ND	ND **
	Bromoform	None	mg/L	None	0.0005	ND	ND **
	Bromomethane	None	mg/L	None	0.0005	ND	ND **
	Chloroethane	None	mg/L	None	0.0005	ND	ND **
	Chloroform	None	mg/L	None	0.0005	ND	ND **
	Dibromochloromethane	None	mg/L	None	0.0005	ND	ND **
	Dibromomethane	None	mg/L	None	0.0005	ND	ND **
	Dichlorodifluoromethane	None	mg/L	None	0.0005	ND	ND **
	Fluorotrichloromethane	None	mg/L	None	0.0005	ND	ND **
	Hexachlorobetadiene	None	mg/L	None	0.0005	ND	ND **
	Isopropylbenzene	None	mg/L	None	0.0005	ND	ND **
	m-Dichlorobenzene	None	mg/L	None	0.0005	ND	ND **
	Methyl-tert-butylether (MTBE)	None	mg/L	None	0.0005	ND	ND **
	Napthalene	None	mg/L	None	0.001	ND	ND **
	n-Butylbenzene	None	mg/L	None	0.0005	ND	ND **
	o-Chlorotoluene	None	mg/L	None	0.0005	ND	ND **
	p-Chlorotoluene	None	mg/L	None	0.0005	ND	ND **
	p-Isopropyltoluene	None	mg/L	None	0.0005	ND	ND **
	sec-Butylbenzene	None	mg/L	None	0.0005	ND	ND **
	tert-Butylbenzene	None	mg/L	None	0.0005	ND	ND **

NOTES:

mg/L = milligram per liter

MDL = Method Detection Limit

ND = Not detected at concentrations greater than the MDL

NT = Analyte not tested

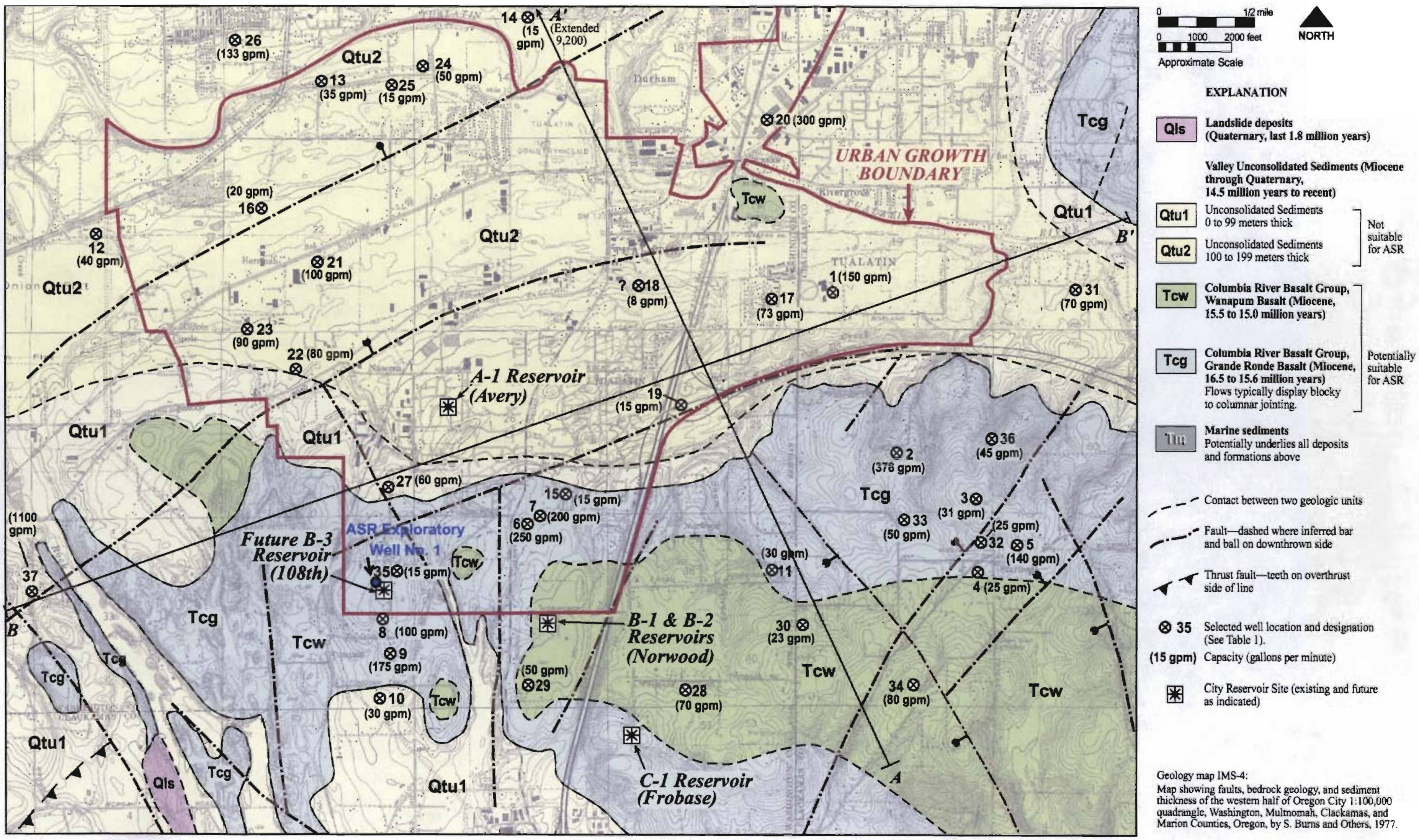
MCL = Federal maximum contmainant level for drinking water

MML = DEQ's maximum measurable levels for groundwater

4 = UCMR List 1 compounds required through December 2003, but not required after that time.Sample results from City of Portland 12/16/02 sample event, however all event were ND.

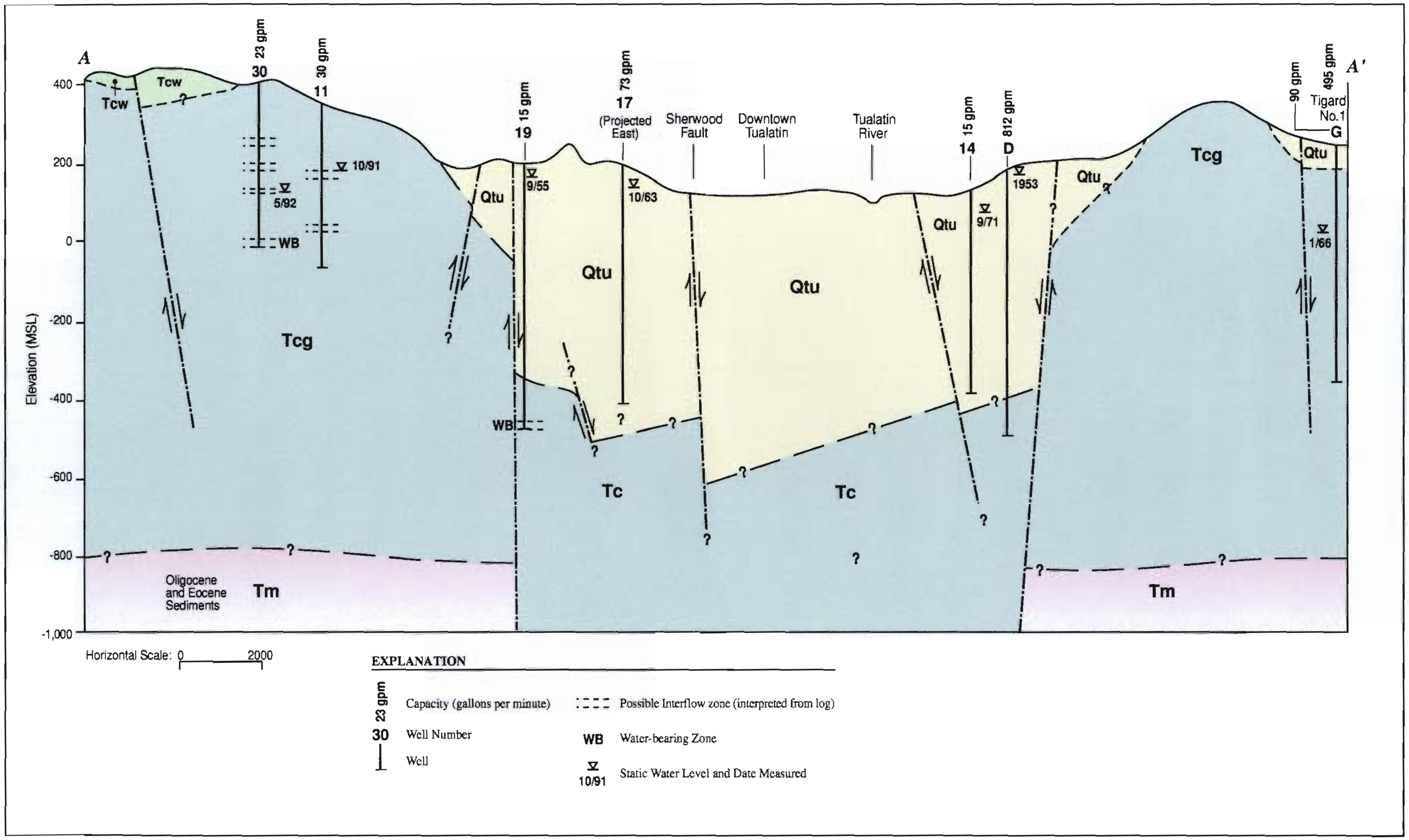
URC = Oregon Health Division unregulated contaminants for drinking water

** = Analysis by the City of Portland of samples collected from Bull Run water between September 11, 1996 and June 16, 2002. Samples from individual Portland groundwater sources are not representative of ASR source water and so were not included.



Groundwater Solutions Inc.

Figure 1
Study Area Geology and Well Locations
City of Tualatin ASR Project

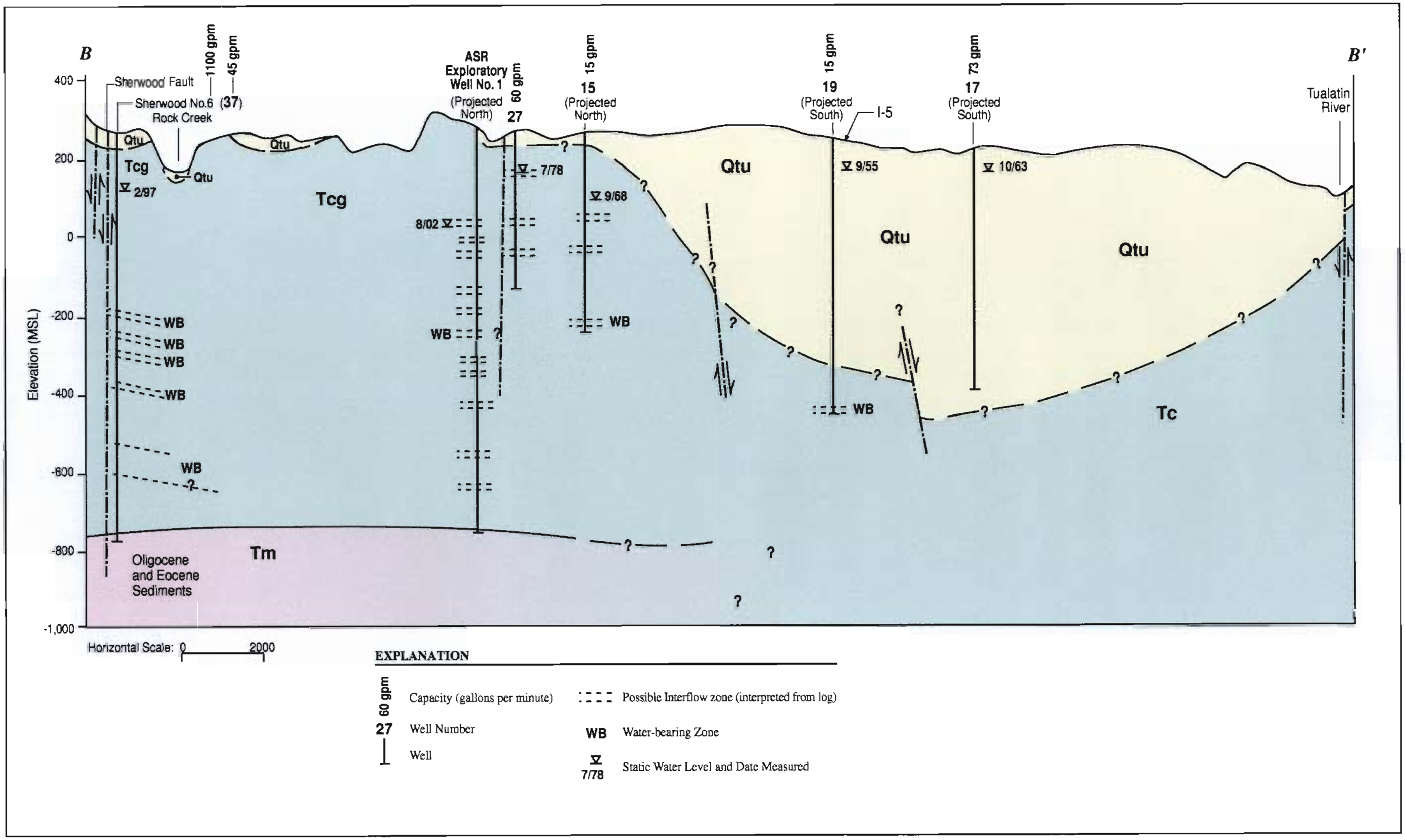


Groundwater Solutions Inc.

FIGURE 2

Cross Section A to A'

CITY OF TUALATIN ASR PROJECT

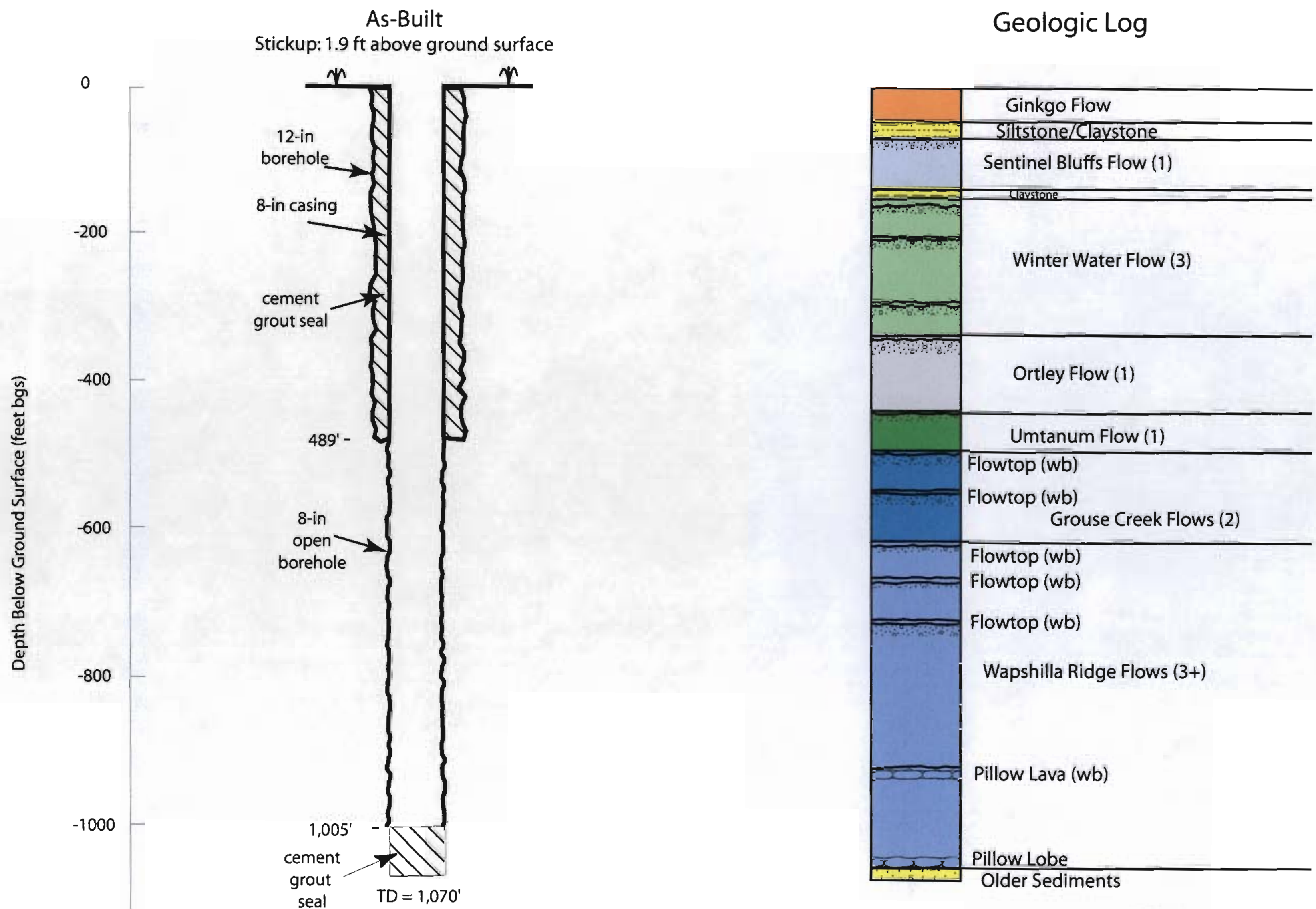


Groundwater Solutions inc.

FIGURE 3

Cross Section B to B'

CITY OF TUALATIN ASR PROJECT



Note: Geology from Beeson (2002)
wb = water bearing zone

Figure 4
Tualatin ASR Exploratory Well
AS-Built and Geologic Log

Groundwater Solutions Inc.

file path: Projects\116 - Tualatin\003\Permiting\gw_characterizationreport\as_built.pdf

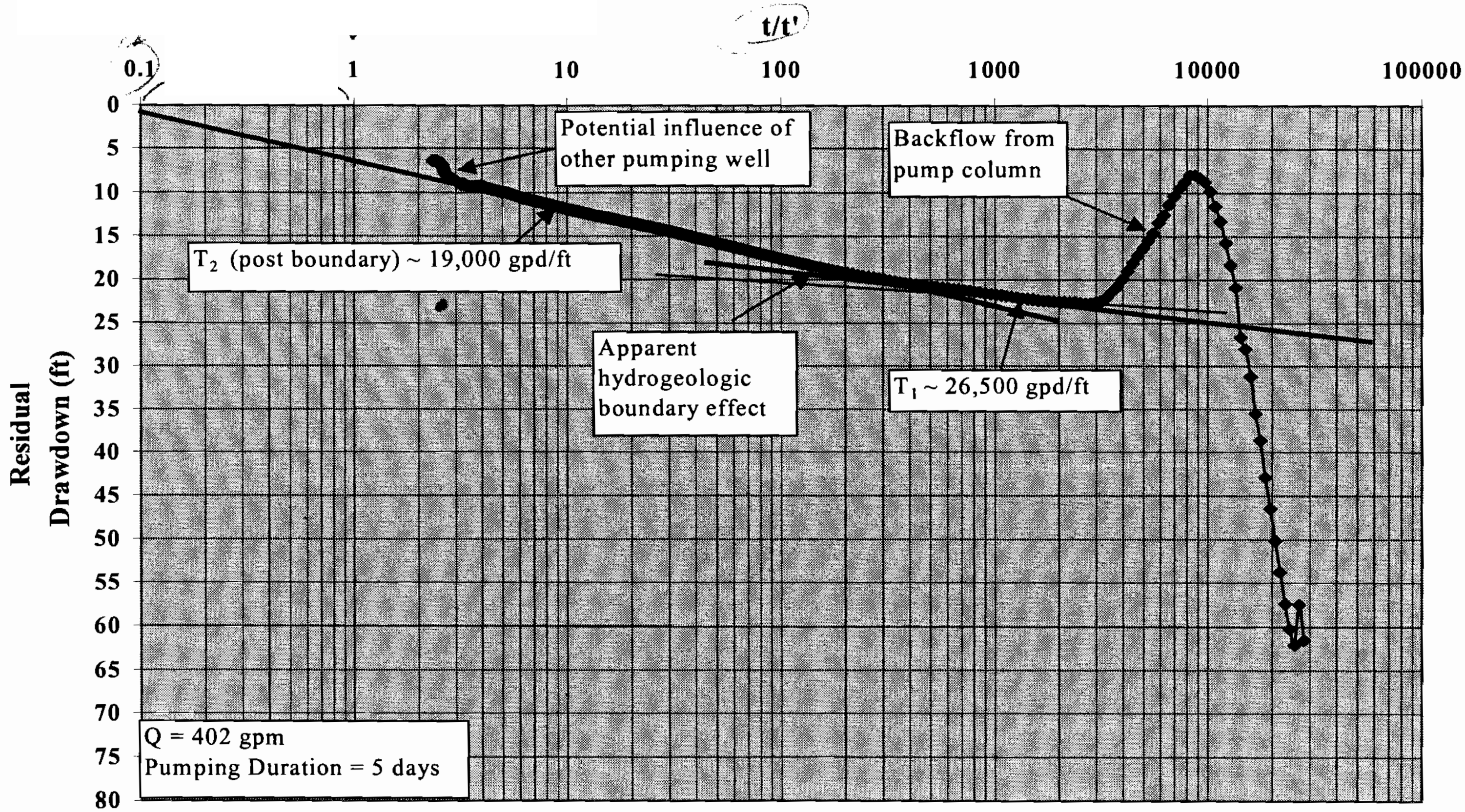


Figure 5
Recovery Plot
ASR Exploratory Well Constant Rate Aquifer Test

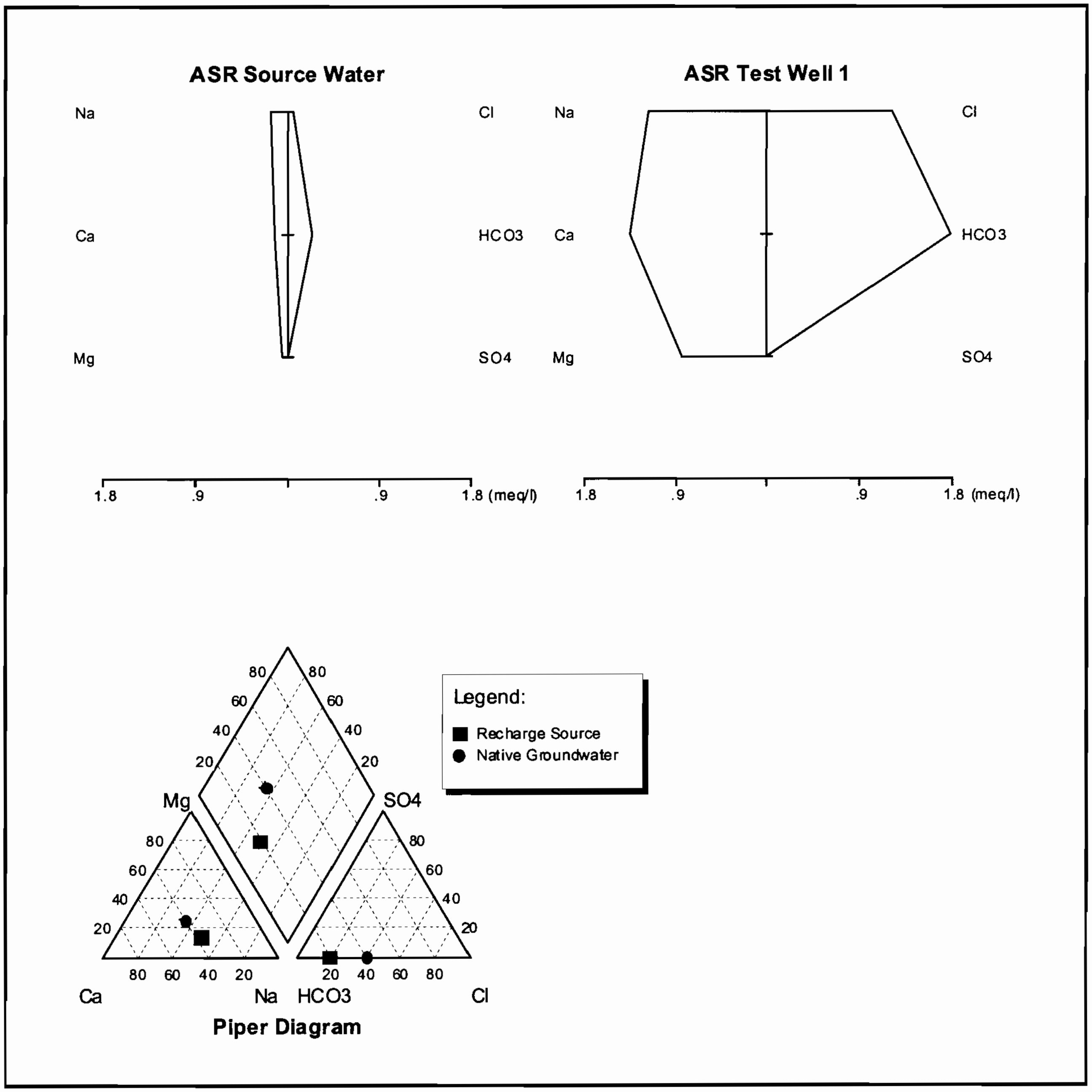


Figure 6
Stiff and Piper Diagram
Tualatin ASR Exploratory Well

MSA

APPENDIX D

CITY OF
PORTLAND, OREGON
BUREAU OF WATER WORKS

Dan Saltzman, Commissioner
Morteza Anoushiravani, P.E., Administrator
1120 SW 5th Avenue
Portland, Oregon 97204
Information (503) 823-7404
Fax (503) 823-6133
TDD (503) 823-6868

CITY OF TUALATIN
RECEIVED
NOV 2 6 2003
ENGINEERING &
BUILDING DEPARTMENT

November 20, 2003

Mr. Mike McKillip
City of Tualatin
18880 SW Martinazzi
Tualatin, OR 97062

Subject: Availability of Bull Run Water for ASR Pilot Testing

Dear Mike,

Confirming your conversation with Mark Knudson last week, we are pleased to make available water from our Bull Run supply for your use as part of your proposed pilot study of aquifer storage and recovery. Anne Conway of our Finance staff will be following up with you in the next few days regarding the cost structure for this proposed use.

Please do not hesitate to contact Mark at 503-823-7499 if you have any questions.

Sincerely,

Mort Anoushiravani, P.E.
Administrator

c: Mark Knudson
Anne Conway

MSA

APPENDIX E

City of Tualatin
18880 SW Martinazzi Avenue
Tualatin, Oregon 97062-7092
Main 503.692.2000
TDD 503.692.0574

December 1, 2003

Mr. Michael A. McKillip
City Engineer
City of Tualatin
18880 SW Martinazzi Avenue
Tualatin, Oregon 97062

Re: City of Tualatin – Proposed ASR Well No. 1 Site

Dear Mike:

The purpose of this letter is to document that the City of Tualatin has issued required land use approvals for the development of an Aquifer Storage and Recovery (ASR) facility at 22675 SW 108th Avenue. The construction of the pump house will require Architectural Review. This review will be limited to the architectural features of the building.

The subject property is owned by the City of Tualatin and is the planned site of the City's future B-3 reservoirs. The City drilled an exploratory well on this site in 2002. The property is located in an area zoned for low density residential development (RL Planning District). A conditional use permit allowing city water facilities and a City park on the property was granted on January 28, 2002 (CUP 01-06, Resolution No. 3941-02).

Please do not hesitate to contact me if you need any additional information in this regard. Thank you.

Sincerely,

William A. Harper, AICP
Associate Planner

MSA

APPENDIX F

MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
121 S.W. Salmon, Suite 900 Portland, Oregon 97204-2919 PHONE 503.225.9010 FAX 503.225.9022

00-0500.104
December 5, 2003

Ms. Barbara Priest
UIC Program Coordinator
Oregon DEQ – Water Quality Division
811 SW Sixth Ave.
Portland, OR 97204

Re: City of Tualatin – Aquifer Storage and Recovery (ASR) Well No. 1
Underground Injection Control (UIC) Registration

Dear Ms. Priest: .

On behalf of the City of Tualatin, please find enclosed the completed Underground Injection Control Registration Forms for the City of Tualatin Aquifer Storage and Recovery Well No. 1. This information was previously submitted in draft form under the reference number 11919. Currently, the City of Tualatin is in the process of obtaining a limited water use license with the Oregon Water Resources Department (OWRD) for the pilot testing of the proposed ASR Well No. 1. As requested, this letter includes a brief project summary and a vicinity map to supplement the UIC Registration Forms.

The intended location of the proposed City of Tualatin ASR Well No. 1 is near the intersection of SW 108th Avenue and Dogwood Street in Tualatin, Oregon, as shown on the attached site map. The proposed injection water source is the City of Portland's Bull Run Watershed Water Supply System via the Washington County Supply Line. Since Tualatin does not hold a water right for the injection water, an agreement has been obtained from the City of Portland for use of water for ASR testing. The proposed pilot testing schedule for water use will begin in January 2005 and completion is expected in November 2005.

During the pilot testing, approximately 500 gallons per minute (gpm) will be injected into the well. An anticipated maximum volume of approximately 95 million gallons (mg) of injected water will be stored for a minimum period of approximately 30 days. After the storage period, the water will be recovered and pumped into the City of Tualatin's water distribution system. The anticipated maximum withdrawal rate of the recovered water will be approximately 700 gpm. The recovered water will only enter the City's distribution system when water quality testing indicates that the water meets applicable drinking water standards.

The water will be injected into the well from the City's distribution system and recovered by a deep well vertical turbine pump. The injection and discharge piping will be connected to the distribution system.

If pilot testing is successful, the injection water source, the maximum injection rate, and the maximum withdrawal rate for full-scale ASR production at ASR Well No. 1 will be similar to that used during the pilot testing. It is anticipated that the injected storage volume capacity will support an approximate 90-day production period and recover approximately 90 mg of the stored water. The recovered water will be used during peak use demand periods, typically anticipated to occur during the summer months.

It is our intent to register the Tualatin ASR Well No. 1 as a Class V injection well through the Department of Environmental Quality. Please use the project summary and attached location map to assist in this registration process.

Thank you for your time and assistance with this process. If you have any questions regarding the project, please do not hesitate to contact me at (503)225-9010. If I am not available please ask for Brian Ginter. Thank you.

Sincerely,

MURRAY, SMITH & ASSOCIATES, INC.

Chris H. Uber, P.E.
Vice President

CHU:ces

Enclosures

cc: Michael McKillip, City of Tualatin
Walter Burt, Groundwater Solutions Inc.
Donn Miller, Oregon Water Resources Department

DEQ USE ONLY
Registration #:
File #:
Mail ID #2/#9:
DOC Conf.:
Notes:

UNDERGROUND INJECTION CONTROL REGISTRATION

General, Industrial and Commercial

DEQ

Oregon Department of Environmental Quality

(see pp. 3 - 4 for detailed instructions)

DEQ USE ONLY
Received:
☐ IND ☐ DOM ☐ UIC:
Notes:

A. FACILITY NAME, LOCATION & CONTACT

1. Facility's Legal Name: City of Tualatin ASR Well No. 1
2. Common Name: ASR Well No. 1
3. Facility Physical Address: 22675 SW 108th Ave.
   City, State, Zip Code: Tualatin, OR 97062
4. Facility Mailing Address: 18880 SW Martinazzi Ave.
   City, State, Zip Code: Tualatin, OR 97062-7092
5. Latitude: N45 degrees 21 minutes 22 seconds Longitude: W122 degrees 47 minutes 19 seconds
6. Facility Contact Name: Mike McKillip, P.E., City Engineer
   Contact Telephone #: 503.691.3030
   Fax #: 503.692.5421
7. Responsible Official Name: Mike McKillip, P.E., City Engineer
   Address: 18880 SW Martinazzi Ave.
   City, State, Zip Code: Tualatin, OR 97062-7092

B. FACILITY DESCRIPTION (ATTACH DOCUMENTS AS NEEDED)

1. SIC code: or NAICS code: Secondary SIC/NAICS code:
2. Briefly describe the nature of business at this facility: Aquifer Storage and Recovery for Municipal Drinking Water System
3. Briefly describe the types of materials, products, and wastes handled at the facility. Attach a list of the soluble compounds from the MSDS sheets or a copy of the Fire Marshall's survey. Note if you qualify as a small quantity generator or large. Attach and sign the UIC no-exposure certification form:
   Drinking Water
4. Land use zoning of facility: ☐ Industrial ☐ Commercial ☐ Residential ☒ Other: Public
5. Drinking water source: Monthly average usage (gal./day): N/A ☐ Public water ☐ Private Well
6. Process water source: Monthly average usage (gal./day): N/A ☐ Public water ☐ Private Well ☐ Recycled or Reclaimed
7. Depth to winter high water table: ____ feet If not available, average depth to groundwater: 258 feet Attach nearest well log. ☒ Attached
8. Indicate if present: ☐ UIC spill prevention/response plan ☐ Employee training on spill plan ☐ Plug(s) or block(s) for UIC system
   ☐ Spill clean up supplies, describe: ☐ Containment facilities, describe:
   ☐ Maintenance program and schedule for UIC system(s) (please attach) ☐ Existing soil/groundwater contamination (brownfield)
   ☐ Stormwater management plan (due 3/02) ☐ Steep slopes/hazard area ☐ Floodplain/sensitive groundwater area ☐ Monitoring plan
9. Describe stormwater, process, or wastewater discharge systems used on site and estimate the number of each: N/A
10. Does an adequate confinement barrier or filtration medium (pre-treatment) exist at the site to protect groundwater? N/A
    ☐ Yes ☐ No ☐ Do Not Know If "YES," attach relevant documentation, such as a vulnerability report form from the Oregon Health Division.
11. Is connection to or construction of a surface discharging storm sewer or sanitary sewer available? ☐ YES ☐ NO
    If "NO," briefly explain or attach relevant documentation: N/A
12. List any other DEQ or public agency permits applied for or issued to this facility: OWRD Limited License No. 10 (Proposed)

C. 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.

Mike McKillip, P.E.
Name of Legally Authorized Representative (Type or Print)

City Engineer
Title

Michael A. McKillip
Signature of Legally Authorized Representative

12/3/03
Date

UIC REGISTRATION FOR GENERAL, INDUSTRIAL, & COMMERCIAL SYSTEMS

Oregon Department of Environmental Quality

(See pp. 3-4 for detailed instructions)

D. UNDERGROUND INJECTION CONTROL INFORMATION

EPA Well Types

5A19 -Cooling Water Return	[5R21 - Aquifer Recharge]	5W12 Water Treatment Plant Effluent	5X26 Aquifer Remediation
5D2 --Stormwater	5W9 - Untreated Sewage	5W20 Industrial Process Water	5X27 Other Wells
5D4 -Industrial Storm Runoff	5W10 Cesspool	5W31 Septic System (well disposal)	5X28 Motor Vehicle Waste
5G30 Special Drainage Water	5W11 Septic System (gen)	5W32 Septic System (drainfield)	5X29 Abandoned Drinking Well
5A5 -Electric Power Generator	5A6 - Geothermal Heat	5A7 -- Closed Loop Heat Pump Return	5D3 - Drill Hole

Complete the information requested below for each UIC system that is at the facility. Attach additional copies of this sheet if necessary. Also attach a facility map that clearly identifies the location of each UIC by name or number.

UIC SYSTEM # or NAME: ASR Well No. 1 **INSTALLATION YEAR:** ______

1. Latitude: N45 degrees 21 minutes 22 seconds
   Longitude: W122 degrees 47 minutes 19 seconds
2. Type: ☐ Dry well/sump ☒ Drill hole ☐ Other: ______
   ☐ Drainfield ☐ Infiltration trench / basin (circle one)
3. Waste type discharged: Drinking Water
   Discharge rate: 550 gpm Discharge volume: 95MG/yr.
4. Distance to nearest: Domestic/public water well: 0
   Wetland: 850' Other surface water(s): 700'
   Attach a well log for the nearest water well.
5. Status: (see instructions for status definition)
   ☒ Planning stage ☐ Under construction ☐ Active
   ☐ Not in use ☐ Temporarily Abandoned
   ☐ Located in a delineated source water area
   ☐ Permanently Abandoned/Decomissioned (date & method): ______
6. Characteristics:
   Depth: ~900 ft Diameter: ~2 ft
   Design drainage rate: N/A
   Size of impervious area drained: N/A
   Type of treatment prior to discharge: N/A

UIC SYSTEM # or NAME: ______ **INSTALLATION YEAR:** ______

1. Latitude: ____ degrees ____ minutes ____ seconds
   Longitude: ____ degrees ____ minutes ____ seconds
2. Type: ☐ Dry well/sump ☐ Drill hole ☐ Other: ______
   ☐ Drainfield ☐ Infiltration trench / basin (circle one)
3. Waste type discharged: ______
   Discharge rate: ______ Discharge volume: ______
4. Distance to nearest: Domestic/public water well: ______
   Wetland: ____ Other surface water(s): ______
   Attach a well log for the nearest water well.
5. Status: (see instructions for status definition)
   ☐ Planning stage ☐ Under construction ☐ Active
   ☐ Not in use ☐ Temporarily Abandoned
   ☐ Located in a delineated source water area
   ☐ Permanently Abandoned/Decomissioned (date & method): ______
6. Characteristics:
   Depth: ____ ft Diameter: ____ ft
   Design drainage rate: ______
   Size of impervious area drained: ______
   Type of treatment prior to discharge: ______

UIC SYSTEM # or NAME: ______ **INSTALLATION YEAR:** ______

1. Latitude: ____ degrees ____ minutes ____ seconds
   Longitude: ____ degrees ____ minutes ____ seconds
2. Type: ☐ Dry well/sump ☐ Drill hole ☐ Other: ______
   ☐ Drainfield ☐ Infiltration trench / basin (circle one)
3. Waste type discharged: ______
   Discharge rate: ______ Discharge volume: ______
4. Distance to nearest: Domestic/public water well: ______
   Wetland: ____ Other surface water(s): ______
   Attach a well log for the nearest water well.
5. Status: (see instructions for status definition)
   ☐ Planning stage ☐ Under construction ☐ Active
   ☐ Not in use ☐ Temporarily Abandoned
   ☐ Located in a delineated source water area
   ☐ Permanently Abandoned/Decomissioned (date & method): ______
6. Characteristics:
   Depth: ____ ft Diameter: ____ ft
   Design drainage rate: ______
   Size of impervious area drained: ______
   Type of treatment prior to discharge: ______

To expedite the registration of your facility, please fill out this form in its entirety.

Use this form to register underground injection control (UIC) systems
Common UIC systems include dry wells, sumps, drain holes, infiltration trenches, or infiltration basins.

A. FACILITY NAME, LOCATION & CONTACT

1. Enter the **legal** Oregon corporate name (i.e., Acme Products, Inc.) or the name of the **legal** representative of the company if the company operates under an assumed business name (i.e., John Smith, dba Acme Products). The name must be a legal, active name registered with the Oregon Department of Commerce, Corporation Division (503) 378-4752, unless otherwise exempted by the Department of Commerce regulations.
2. Enter the common name of this facility if different than the legal name.
3. Enter the physical location of the facility (not mailing address), including city, state, and zip code.
4. Enter the mailing address of the facility if different from the physical location.
5. Enter the latitude and longitude of the approximate center of the facility or site in degrees/minutes/seconds. Latitude and longitude can be obtained from United States Geological Survey (USGS) quadrangle or topographic maps by calling 1-888 ASK-USGS, or by accessing MapBlast's web site at http://www.mapblast.com/mblast/mAdr.mb. DEQ also has instructions for obtaining latitude and longitude from maps at http://waterquality.deq.state.or.us/wq/wqpermit/LatLongInstr.pdf or by calling the number at the end of these instructions.
6. Enter the name, telephone and fax number of the facility contact; this would be the person to call in case there are any questions about this registration.
7. Enter the name and mailing address of the responsible official or organization for this facility, if different from #4..

B. FACILITY DESCRIPTION

1. Enter the Standard Industrial Classification (SIC) four-digit code **or** North American Industry Classification System five or six-digit code (NAICS) for the facility. These codes are used to describe the primary activity at the facility that generates the most money and may be found on fire marshal reports, insurance papers, or tax forms. The NAICS codes replaced the SIC system in 1997, however, it is usually easy to convert between the two systems so either code is acceptable. SIC or NAICS information is also available from the U.S. Census Bureau at 1-888-756-2427 or at http://www.naics.com/search.htm. Include a secondary code if applicable.
2. Briefly describe the nature of business at the facility. For example, "retail clothing store," "gasoline service station with repair shop," "retail and wholesale cabinet store with cabinet manufacturing," or "rental service store for home, yard, and contractor equipment with in-house maintenance shop."
3. Briefly describe the types of materials, products, and wastes handled at the facility. For example, from a service station one might expect "new and used gasoline, diesel, transmission oil, brake fluid, antifreeze, solvents and tires; general cleaners (409, Simple Green, etc.); office wastes; and general garbage." Submit a list of the water-soluble compounds from the MSDS sheets or a copy of the Oregon State Fire Marshal survey.
4. Indicate if the facility is located on property that is zoned for industrial, commercial, residential, or some other use.
5. Estimate the monthly average usage of drinking water in gallons per day and indicate the source.
6. Estimate the monthly average usage of water for processing or manufacturing purposes and indicate the source.
7. Provide the depth in feet to the winter high water table. If that information is unavailable or unknown, provide the average depth to groundwater in feet from your well log. If you do not have your well log, you may be able to access it through the Oregon Water Resources Department (WRD) web site at http://www.wrd.state.or.us/groundwater/index.shtml, or by calling (503) 378-8455. The Natural Resource Conservation Service in your area may also have this information.
8. Check the appropriate boxes to provide information about the facility's ability to prevent spills or leaks of materials that may enter any drainage system, as well as your employee's ability to respond to spills or leaks when they occur. DEQ recommends that facilities have a written spill prevention and response plan and training on the plan so employees will know what to do in case of a spill. In addition, a way to plug or block the UIC drainage system (dry well, sump, drain hole, infiltration trench, etc.) in the event of a spill is highly recommended. It is also suggested that an adequate supply of appropriate spill containment and clean up material be maintained on site; containment facilities should be used for the storage of materials that could easily drain into the UIC system in the event of a leak or spill. Specify what type of maintenance is performed on the UIC system and the frequency of such maintenance. If no maintenance occurs, indicate as such. Stormwater plans are required to be developed and kept on site. Note if the site has had past contamination problems, is located on steep slopes, in a floodplain (e.g., flooded in 1996), a groundwater management area, or in a known hazard area (mapped by Oregon Department of Geology, USGS and others). The hazard data should be available at your local planning agency or the Oregon Department of Geology, (503) 731-4100. Contact Mark Nelson at DEQ for clean-up site information, (503) 229-6852.
9. Describe how stormwater, process, or wastewater discharge is handled; e.g. Holding Tank, Settling Basin, Wet or Dry Vault, Catch Basin, Dry Well/Sump, Stormwater Drain, Floor Drains, Sand/grit or oil/water separator, Cesspool, Detention Pond or Lagoon, Septic System, etc. In addition, estimate the number of each.
10. Indicate if an adequate confinement barrier or filtration medium exists at the facility site to protect the local groundwater. You may wish to contact a registered geologist, cite US Geological Service report, Water Resources Department study, or the Oregon Health Division (OHD) Vulnerability Studies, (541) 726-2587 (you will need information on township, range and section). Some examples of situations where the groundwater may not be protected include: dry wells that are drilled into or very near the groundwater table, areas where the soils are very porous so that drainage into a dry well or sump is quickly discharged to groundwater without contaminants being reduced by natural degradation (e.g., biological activity, soil attenuation), etc.
11. Indicate if connection to or construction of surface discharging system. If it is not feasible, explain why. For example, "there is no city sewer available to connect to," "the city's surface drainage system is filled to capacity and they will not allow connection," etc.
12. In order for DEQ to coordinate with other DEQ offices and public agencies, list all permits applied for or issued to this facility.

C. SIGNATURE OF LEGALLY AUTHORIZED REPRESENTATIVE

The signature of a legally authorized representative must be provided in order to process this registration.

Definition of Legally Authorized Representative:
Please also provide the information requested in brackets [ ]

- **Corporation** — president, secretary, treasurer, vice-president, or any person who performs principal business functions; or a manager of one or more facilities that is authorized in accordance to corporate procedure to sign such documents
- **Partnership** — General partner *[list of general partners, their addresses and telephone numbers]*
- **Sole Proprietorship** — Owner(s) *[each owner must sign the application]*
- **City, County, State, Federal, or other Public Facility** — Principal executive officer or ranking elected official
- **Limited Liability Company** — Member *[articles of organization]*
- **Trusts** — Acting trustee *[list of trustees, their addresses and telephone numbers]*

D. UNDERGROUND INJECTION CONTROL (UIC) INFORMATION

Please submit a facility map that clearly identifies the location of each UIC system (specific point of discharge or injection, e.g. dry well, sump, drain hole, infiltration trench, etc.) by number or name.

For each UIC system, provide the number or name and its installation date. The installation date will be on your well log or permit. Your city or county building department may also have this information for your site. If the installation date is not known, provide the Oregon Resources Department (WRD) card number and/or the well identification number, or estimate when the UIC system was installed. Also, for each UIC system provide the following:

1. Enter the latitude and longitude of the injection system site in degrees/minutes/seconds (GPS data is acceptable). Latitude and longitude can be obtained from United States Geological Survey (USGS) quadrangle or topographic maps by calling 1-888 ASK-USGS, or by accessing MapBlast's web site at http://www.mapblast.com/mblast/mAdr.mb. DEQ also has instructions for obtaining latitude and longitude from maps at http://waterquality.deq.state.or.us/wq/wqpermit/LatLongInstr.pdf or http://wqmaps.deq.state.or.us/scripts/esrimap.dll?name=llid2&cmd=map (click on the pencil icon next to the word "Locate").
2. Type of UIC system (listed on DEQ's UIC webpage). Stormwater systems can be 5D2 (regular), 5D3 (drillhole) or 5D4 (industrial).
3. Where the drainage into the UIC system is coming from. **Please note**: You may need to document no toxic exposure.
4. Estimated distance in feet of the UIC system to the nearest domestic or public water supply well, wetland, and other surface water. This information is used by DEQ to evaluate the risk to sensitive sites that could be impacted by accidental spills or contaminated storm water drainage. Attach a well log for the nearest water well.
5. Whether the UIC system is being planned, under construction, active, inactive, temporarily abandoned, or permanently abandoned (closed or decommissioned). A UIC system is considered "temporarily abandoned" when it is taken out of service but still exists. Owners of temporarily abandoned UICs intend to bring them back into service at a future date. A watertight cap or seal that prevents any materials from entering the UIC must cover temporarily abandoned UICs. A UIC is considered "permanently abandoned" when it is completely filled so that movement of water within the UIC is permanently stopped. With the exception of hand-dug UIC systems, a licensed water well constructor, or the landowner under a Landowner's Water Well Permit, must perform a permanent abandonment. Please see Oregon Administrative Rule (OAR) 690-220-0005 or visit WRD's web page for the rule at http://arcweb.sos.state.or.us/rules/OARS_600/OAR_690/690_220.html. WRD has also developed a well guide that may be of use: *A Consumer's Guide to Water Well Construction, Maintenance and Abandonment* available at http://www.wrd.state.or.us/publication/wellcon99/index.shtml#abandoning. You may also contact WRD at (503) 378-8455. If the UIC system has been permanently abandoned/decommissioned, provide the date and method of closure. If you are planning to decommission the system, submit a *DEQ Pre-Closure Notification Form* 30 days before proposed closure.
6. The following design characteristics:
   - Depth and diameter in feet
   - Design drainage rate if known
   - Size of the impervious area in square feet drained by the UIC system. An impervious area is an area that does not allow rain to soak into the ground. It includes paved areas, concrete pads, buildings, and compacted areas such as graveled or dirt roads. For example, if the UIC system is used for roof drainage, estimate the square footage of the building the roof drain serves.
   - Type of treatment prior to subsurface discharge or BMPs to protect groundwater. For storm drainage systems, this could be a grassy swale, "stormceptor"-type pretreatment devices, catch basin inserts, or other pre-treatment design. It does not include the rocks inside a dry well. If there is no treatment prior to the UIC system, write "no treatment." Please visit DEQ's UIC webpage for more information about pretreatment systems under Stormwater Guidelines.
7. Call Oregon Health Division (OHD) at (541) 726-2587 to determine if your UIC is in a delineated 2-year time of travel area of a public water system.

REGISTRATION SUBMITTAL AND QUESTIONS

Send the registration form to the DEQ Water Quality Division:

DEQ Water Quality Division, 811 SW 6th Avenue, Portland, OR 97204
For questions, contact Barbara Priest at (503) 229-5945,
or at 1-800-452-4011 (toll-free, inside Oregon), TTY (503) 229-6993; Fax: (503) 229-6037.
Or visit the DEQ UIC webpage: http://www.deq.state.or.us/wq/groundwa/uichome.htm

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 57935

(START CARD) # 143357

(1) OWNER:
Well Number ______

Name City of Tualatin

Address 18880 SW Martinazzi

City Tualatin State OR Zip 97062

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

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

☑ Other Reverse Circulation Rotary

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

☐ Thermal ☐ Injection ☐ Livestock ☑ Other ASR explor.

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Well 1005 ft.

Explosives used ☐ Yes ☑ No Type ______ Amount ______

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
12	0	34	cement	0	486	129 sks
10	34	489				
8	489	1070				

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:	8	+2	486	1/4	☑	☐	☑	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) 486–488

(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
100	11		1 hr.
250	30		2nd hr
350	49		3rd hr

Temperature of water approx 55F 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 high TDS

Depth of strata: 1056 to bottom

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

Township 2 S Range 1 W WM.

Section 34 SE 1/4 NE 1/4

Tax Lot 5500 Lot ______ Block ______ Subdivision ______

Street Address of Well (or nearest address) 22675 SW 108th Avenue Tualatin, OR 97062

(10) STATIC WATER LEVEL:
258 ft. below land surface. Date 8/19/02

Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found 245

From	To	Estimated Flow Rate	SWL
245	258	20	NM
296	317	20	NM
331	356	150	NM
434	444	100	NM
also see (12)			

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
SEE ATTACHED FORMATION LOG			
additional water bearing zones (11):	Est. Locations		
	490	505	see (10)
	540	562	see (10)
	626	641	see (10)
Estimated Flow Rate: see (8)	667	675	see (10)
	735	758	see (10)
	855	864	see (10)
	924	940	see (10)
NM	1056	1057+	NM
Bottom of well was abandoned by pumping			
32 sacks cement grout from bottom up to			
1005'.			

Date started 5/15/02 Completed 8/19/02

(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 1367

Signed [signature] Date 9/5/02

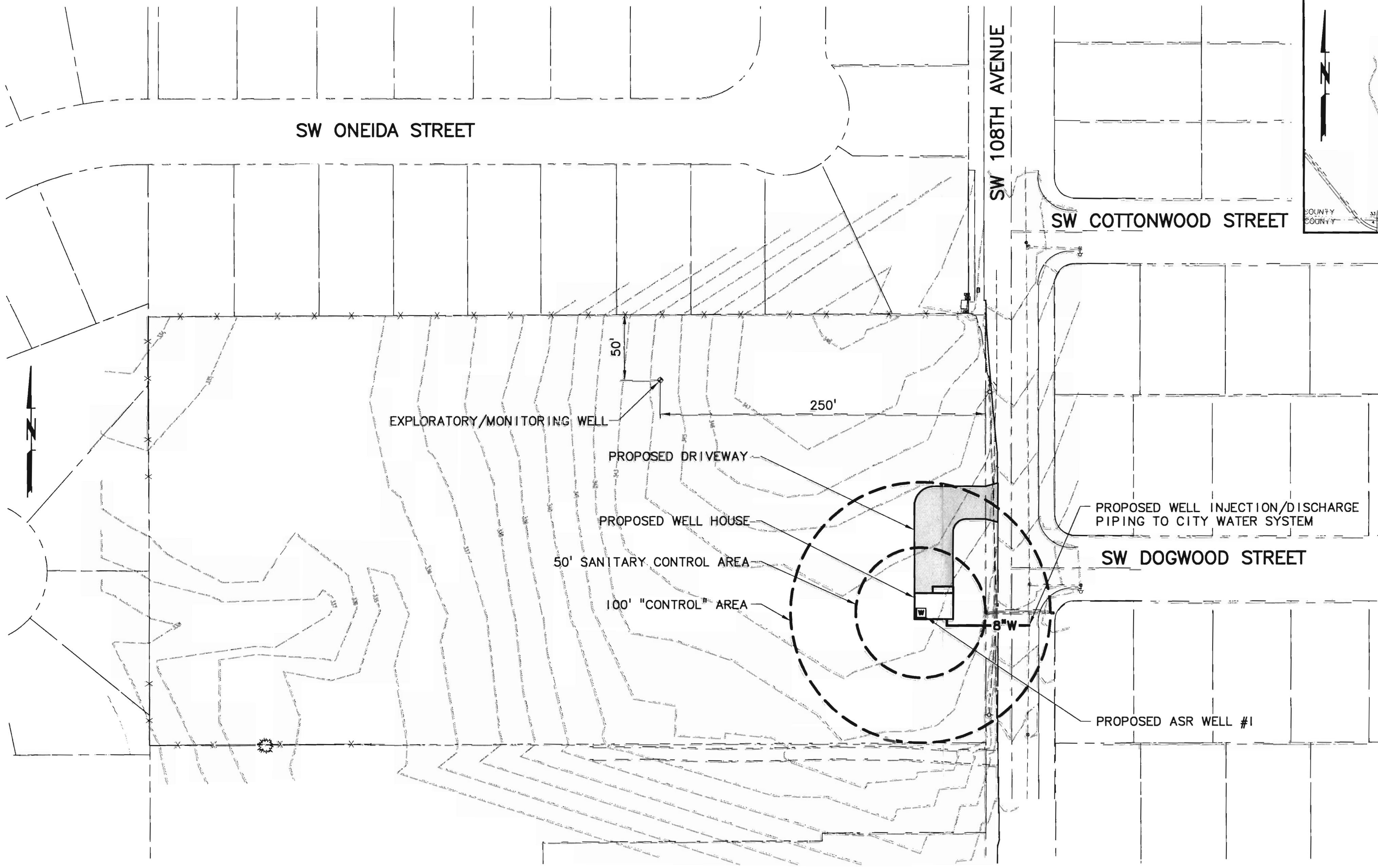
(bonded) Water Well Constructor Certification:

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 649

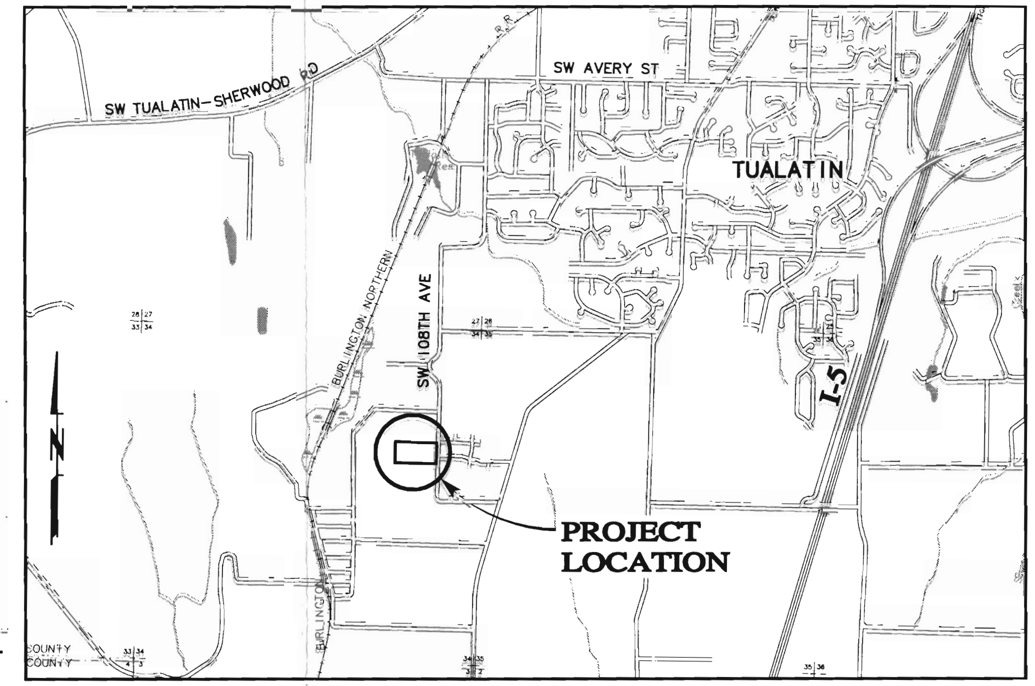
Signed Stephen Schneider Date 9/5/02

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



SITE PLAN

SCALE: 1"=100'



VICINITY MAP

SCALE: 1"=3000'

NO.	DATE	BY	REVISION

NOTICE: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

BMC/CES DESIGNED
DKH DRAWN
JSJ CHECKED

PRELIMINARY ONLY
DO NOT USE FOR CONSTRUCTION
DECEMBER 2003
MURRAY, SMITH & ASSOCIATES INC.
Engineers/Planners

MSA Murray, Smith & Associates, Inc.
Engineers/Planners
121 S.W. Salmon, Suite 900
Portland, Oregon 97204
Phone 503-225-9010
Fax 503-225-9022

CITY OF TUALATIN

AQUIFER STORAGE AND RECOVERY PRODUCTION WELL

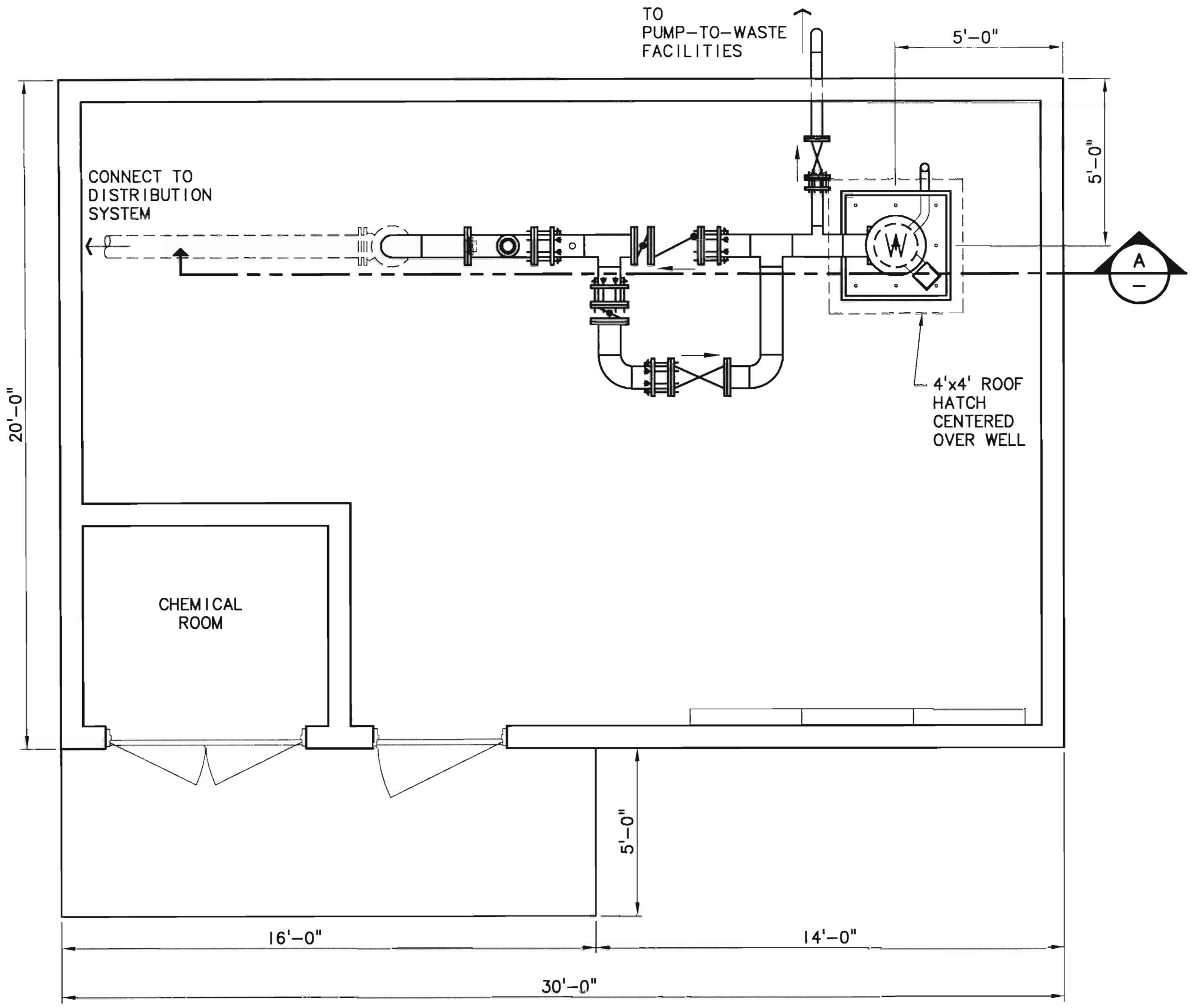
PRELIMINARY SITE PLAN AND VICINITY MAP

SHEET 1

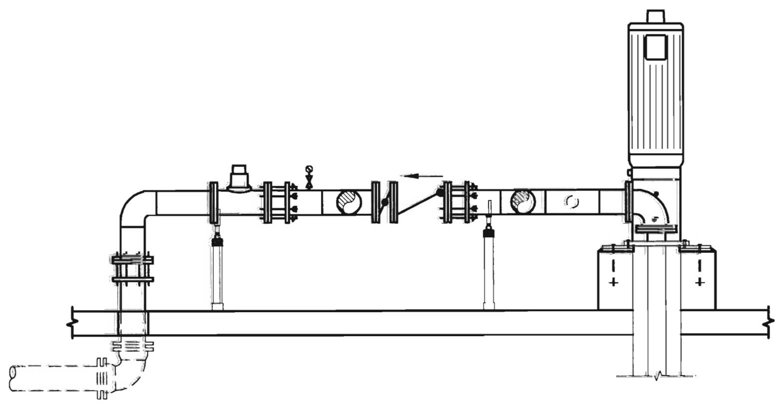
PROJECT NO.: 00-0500.203 | SCALE: AS SHOWN | DATE: DECEMBER 2003

G:\00\0500\203\CAD\00-0500-203-OR-FIGURE 1.dwg FIGURE 1 12/4/03 13:36 (HCM)

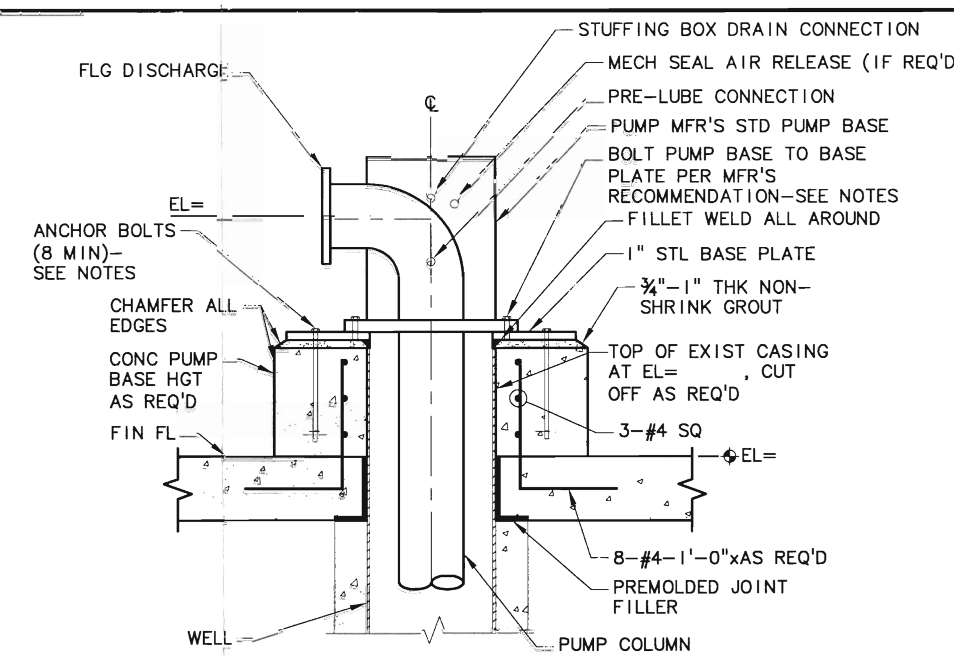
APPENDIX G



WELL HOUSE FLOOR PLAN
SCALE: 3/8"=1'-0"



SECTION (A)
SCALE: 3/8"=1'-0"



NOTES:

1. COMPLY WITH ALL REQUIREMENTS OF OREGON WATER RESOURCES DEPARTMENT FOR WORK ON EXISTING WELL.

2. FURNISH AND INSTALL BRASS OR COPPER FITTINGS, PIPING AND VALVING AS REQUIRED TO PROVIDE AIR RELEASE AND DRAIN. TYPICAL EACH PUMP.

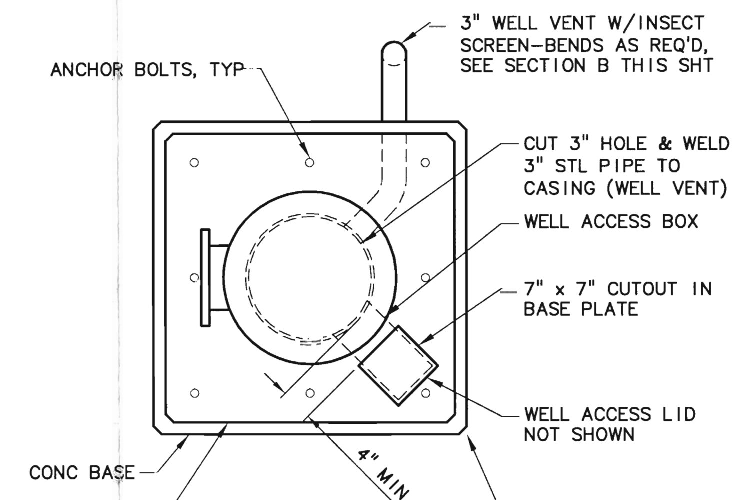
3. ROUTE AIR RELEASE AND DRAIN PIPING TO TRENCH DRAIN. HOLD OUTLET PIPING 6-INCHES OFF FLOOR.

4. ANCHOR BOLTS TO BE 7/8" MINIMUM GALVANIZED STEEL WITH HEX NUTS (8 REQUIRED). LENGTH AND EMBED PER MANUFACTURER REQUIREMENTS.

5. PUMP BASE BOLTS TO BE HEX HEAD BOLTS WITH LOCK WASHER, LENGTH AS REQUIRED.

6. WELL VENT AND WELL ACCESS PORTS NOT SHOWN FOR CLARITY. SEE PLAN VIEW OF PUMP BASE, DETAIL 2 THIS SHEET.

DEEP WELL VERTICAL TURBINE PUMP BASE DETAIL (1)
SCALE: 1"=1'-0"



PLAN VIEW – PUMP BASE (2)
SCALE: 1"=1'-0"

NO.	DATE	BY	REVISION

NOTICE: 0 ½ 1 — IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

CES — DESIGNED
MBE/DKH — DRAWN
JSJ — CHECKED

PRELIMINARY ONLY
DO NOT USE FOR CONSTRUCTION
DECEMBER 2003
MURRAY, SMITH & ASSOCIATES INC. Engineers/Planners

MSA Murray, Smith & Associates, Inc. Engineers/Planners
121 S.W. Salmon, Suite 900
Portland, Oregon 97204
Phone 503-225-9010
Fax 503-225-9022

CITY OF TUALATIN

AQUIFER STORAGE AND RECOVERY PRODUCTION WELL

PRELIMINARY MECHANICAL PLAN AND SECTIONS

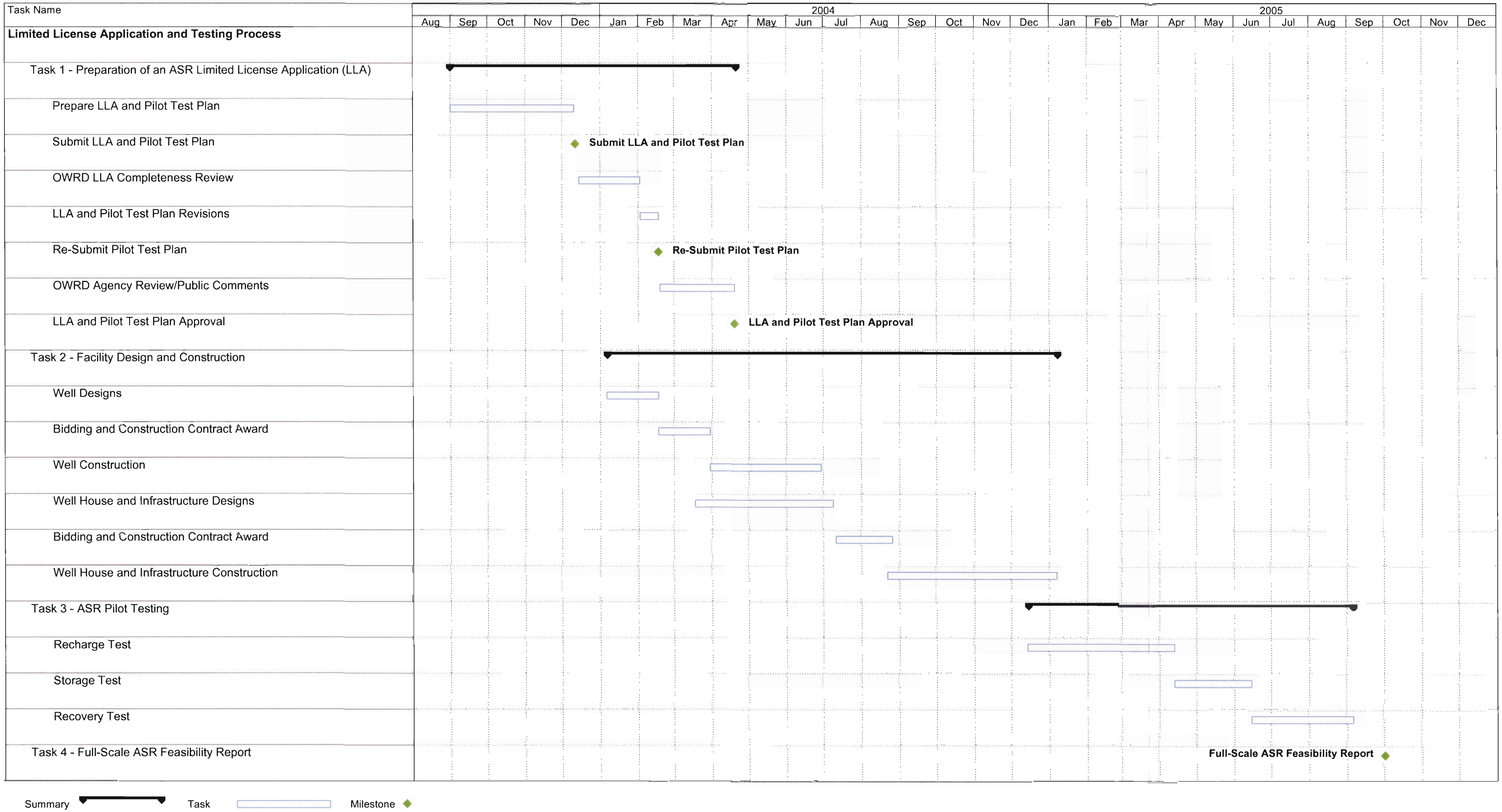
SHEET 2

PROJECT NO.: 00-0500.203 | SCALE: AS SHOWN | DATE: DECEMBER 2003

MSA

APPENDIX H

City of Tualatin ASR Well No. 1
ASR Limited License Application and Pilot Test Program
Project Schedule



APPENDIX I

APPENDIX I
PILOT TEST REPORT OUTLINE

The following is an outline of the pilot test report that will be submitted at the conclusion of Year 1 pilot testing:

Executive Summary

Section 1 – Introduction

Project Description
Existing Site Conditions

Section 2 – Pilot Test Results

ASR Injection and Pumping Rates and Volumes
  Stored Water
  Native Groundwater
Injection and Pumping Efficiency

Section 3 – Water Quality Monitoring

Injected water quality
Recovered water quality
Chemical Reactions

Section 4 – Water Level Monitoring and Aquifer Response

Data Collection
Results

Section 5 – Pilot Testing Conclusions

Section 6 – Proposed ASR Operations Plan for Year 2 through 5

MSA

APPENDIX J

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the STATE ENGINEER, SALEM, OREGON 97310 within 30 days from the date of well completion.

Wash 1842

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

RECEIVED MAR 2 1973 STATE ENGINEER SALEM OREGON

State Well No. 2S/1W-33 db
State Permit No.

(1) OWNER:
Name Tualatin Valley Sportsman Club
Address P.O Box Sherwood, Ore.

(2) TYPE OF WORK (check):
New Well ☐ Deepening ☒ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☒ Driven ☐
Cable ☐ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) CASING INSTALLED: Threaded ☐ Welded ☐
" Diam. from ft. to ft. Gage
" Diam. from Deepening ft. Gage
" Diam. from ft. to ft. Gage

(6) PERFORATIONS: Perforated? ☐ Yes ☒ No.
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? Operator
Yield: 52 gal./min. with 167 ft. drawdown after 2 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 52 Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Well seal—Material used Deepening
Well sealed from land surface to ft.
Diameter of well bore to bottom of seal in.
Diameter of well bore below seal in.
Number of sacks of cement used in well seal sacks
Number of sacks of bentonite used in well seal sacks
Brand name of bentonite
Number of pounds of bentonite per 100 gallons of water lbs./100 gals.
Was a drive shoe used? ☐ Yes ☐ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County Wash. Driller's well number 319
NW ¼ SE ¼ Section 33 T. 2S R. 1W W.M.
Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.
Depth at which water was first found 218-222 ft.
Static level 63 ft. below land surface. Date 2-9-73
Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing 6"
Depth drilled 121 ft. Depth of completed well 230 ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. *Report each change in position of Static Water Level and indicate principal water-bearing strata.*

MATERIAL	From	To	SWL
Hard Gray Basalt	109	114	
Gray + Brown Broken Basalt	114	122	
Hard Gray Basalt	122	157	
Gray & Brown Broken Basalt	157	168	
Hard Gray Basalt	168	218	
Gray Porous Basalt (water)	218	222	63
Hard Gray Basalt	222	230	

Work started 2-9 19 73 Completed 2-9 19 73
Date well drilling machine moved off of well 2-10 19 73

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] Raymond A. Borchers Date 2-10, 19 73
(Drilling Machine Operator)
Drilling Machine Operator's License No. 305

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name Ray Borchers - Well Drilling
(Person, firm or corporation) (Type or print)
Address Rt 3 Box 271A Sherwood, Ore.
[Signed] Raymond A. Borchers
(Water Well Contractor)
Contractor's License No. 404 Date 2-10, 19 73

(USE ADDITIONAL SHEETS IF NECESSARY)

SP*45656-119

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

RECEIVED
AUG 10 1993
WATER RESOURCES DEPT.
SALEM, OREGON

Wash 333

2S/1W/34ad

(START CARD) # 52439

(1) OWNER:
Well Number

Name: City of Tualatin
Address: 18880 SW Martinazzi Ave.
City: Tualatin State: OR Zip: 97062

(2) TYPE OF WORK:
[X] New Well [ ] Deepen [ ] Recondition [ ] Abandon

(3) DRILL METHOD:
[X] Rotary Air [ ] Rotary Mud [ ] Cable
[ ] Other

(4) PROPOSED USE:
[X] Domestic [ ] Community [ ] Industrial [ ] Irrigation
[ ] Thermal [ ] Injection [ ] Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval [ ] Yes [X] No Depth of Completed Well 320 ft.
Explosives used [ ] Yes [X] No Type ______ Amount ______

HOLE Diameter	From	To	SEAL Material	From	To	Amount sacks or pounds
8	0	54	cement	0	54	15 sks
6	54	320				

How was seal placed: Method [ ] A [X] 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:	6	+1	54	.250	[X]	[ ]	[X]	[ ]
					[ ]	[ ]	[ ]	[ ]
					[ ]	[ ]	[ ]	[ ]
					[ ]	[ ]	[ ]	[ ]
Liner:	4	0	320	cl 160	[ ]	[X]	[X]	[ ]
					[ ]	[ ]	[ ]	[ ]

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
[X] Perforations Method skilsaw
[ ] Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
220	280	.1x6	150			[ ]	[X]
300	320	.1x6	100			[ ]	[X]
						[ ]	[ ]
						[ ]	[ ]
						[ ]	[ ]

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

Yield gal/min	Drawdown	Drill stem at	Time
15		320	1 hr.

Temperature of Water ~55°F 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 Washington Latitude ______ Longitude ______
Township 2S N or S. Range 1W E or W. WM.
Section 34 SE ¼ of NE ¼
Tax Lot 1001 Lot — Block ______ Subdivision ______
Street Address of Well (or nearest address) 22675 SW 108th Tualatin, OR 97062

(10) STATIC WATER LEVEL:
127 ft. below land surface. Date 7/30/93
Artesian pressure ______ lb. per square inch. Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found approx. 40

From	To	Estimated Flow Rate	SWL
SWL	320	see (8)	see (10)

(12) WELL LOG:
Ground elevation approx. 340

Material	From	To	SWL
Top soil	0	3	
Clay, brown	3	32	
SS, gray, frac	32	39	
Basalt, brn, frac, some ves	39	45	
Basalt, gray, hard	45	65	
Basalt, gray & brn, med, frac	65	69	
Basalt, red, soft, ves, bkn, cinder	69	77	
Basalt, gray & brn, med, ves	77	84	
Basalt, gray-blk & brn, med-hd, frac	84	140	
Basalt, red, med, frac, cindery	140	147	
Basalt, gray & blk, frac	147	158	
Basalt, red & brn, bkn, ves	158	171	
Bslt, gry&red&brn, med-soft, v. frac	171	185	
Basalt, gray, hard	185	209	
Basalt, brn & red, bkn, ves, sft	209	230	
Basalt, gray, med-hd, some frac	230	254	
Basalt, blk & gray, med, v.frac	254	265	
Basalt, dk gray, some frac	265	303	
Basalt, dk red, bkn, ves	303	315	
Basalt, dk gray, some frac	315	320	

Date started 7/27/93 Completed 7/30/93

(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 well construction standards. Materials used and information reported above are true to my best knowledge and belief.

Signed Donald D. Davis WWC Number 1085
Date 8/2/93

(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 well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 649
Signed Stephen Schneider Date 8/2/93

Wash
53823

Well ID# L14892

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

(START CARD) # 102386

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

(1) OWNER: Well Number
Name Tigard-Tualatin School District 23J
Address 13137 SW Pacific Hwy
City Tigard State OR Zip 97223

(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 627 ft.
Explosives used ☐ Yes ☒ No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
8	400	627	NOT CHANGED			

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:	NOT CHANGED				☐	☐	☐	☐
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
200+		627	1 hr.
200		527	1 hr.
180		427	0.75 hr.
150		327	0.75 hr.

Temperature of water ~55°F 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 Wash Latitude Longitude
Township 2S N or S Range 1W E or W. WM.
Section 35 NW 1/4 NE 1/4
Tax Lot 700 Lot Block Subdivision
Street Address of Well (or nearest address) 22300 SW Boones Ferry Rd. Tualatin, OR. 97062

(10) STATIC WATER LEVEL:
174 ft. below land surface. Date 7/17/98
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:

Depth at which water was first found 421

From	To	Estimated Flow Rate	SWL
421	436	~100	see(10)
518	575	~100+	see(10)

(12) WELL LOG:
Ground Elevation ~300'

Material	From	To	SWL
Basalt, grey & red, ves	400	406	
Basalt, grey, hard	406	421	
Basalt, black, bkn, ves	421	427	
Basalt, black-red, bkn, ves	427	436	
Basalt, grey, hd,occ.frac/ves	436	518	
Basalt, black,bkn, soft	518	521	
Sandstone, grey, hd, frac	521	526	
Basalt, blk, ves, soft	526	530	
Basalt, grey, m-h, some ves	530	542	
Basalt, grey w/brn, bkn, ves, med	542	550	
Basalt, grey, frac, m-h	550	555	
Basalt, blk & red, bkn,w/grn c.s.	555	575	
Basalt, grey, frac, m-h			

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AUG 04 1998
WATER RESOURCES DEPT.
SALEM, OREGON

Date started 6/24/98 Completed 7/14/98

(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 1578
Signed Date 7/30/98

(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 649
Signed Date 7/30/98

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

RECEIVED WASH 58796

AUG 26 2002

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 40825
START CARD # 113713

(1) LAND OWNER Well Number ______
Name Joe Monego
Address 17865 Sarah Hill Lane
City Lake Oswego State OR Zip 97035

(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 554 ft.
Explosives used ☐ Yes ☒ No Type ______ Amount ______

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
10	0	19	Bentonite	0	19	10
6	19	560				

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☒ Other Bentonite poked + probed
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:	6	+1	19	.250	☒	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:	4	-3	554	160	☐	☒	☐	☐
					☐	☐	☐	☐

Drive Shoe used ☐ Inside ☐ Outside ☐ None
Final location of shoe(s) 19

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

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
354	554	3/16	94	4		☐	☒
						☐	☐
						☐	☐
						☐	☐

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

Yield gal/min	Drawdown	Drill stem at	Time
30	unable	560	1 hr.

Temperature of water 55° 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 Wash Latitude ______ Longitude ______
Township 3 N or S (S) Range 1 E or W (W) WM.
Section 34 SE 1/4 NW 1/4
Tax Lot 100 Lot ______ Block ______ Subdivision ______
Street Address of Well (or nearest address) 11150 Tonquin Loop

(10) STATIC WATER LEVEL:
184 ft. below land surface. Date 8-9-02
Artesian pressure ______ lb. per square inch Date ______

(11) WATER BEARING ZONES:
Depth at which water was first found 460

From	To	Estimated Flow Rate	SWL
460	560	30+	184

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
Top soil	0	2	
Basalt gray brown soft	2	8	
" brown med	8	25	
" gray brown med hard	25	34	
" brown med	34	47	
Conglomerate brown med	47	55	
Basalt gray hard	55	71	
" red soft	71	93	
Conglomerate brown med	93	114	
Basalt brown med	114	135	
Conglomerate gray soft	135	142	
Basalt brown soft	142	162	
" gray hard	162	280	184
" brown soft	280	330	
" gray hard	330	384	
" brown med	384	460	
" gray hard porous	460	560	

Date started Aug 2, 2002 Completed Aug 10, 2002

(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 1229
Signed [signature] Date 8-11-02

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RECEIVED AUG 2 6 2002 WATER RESOURCES DEPT. SALEM, OREGON

WASH 58796

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 40825
START CARD # 113713

(1) LAND OWNER Well Number
Name Joe Monego
Address 17865 South Hill Lane
City Lake Oswego State OR Zip 97035

(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 554 ft.
Explosives used ☐ Yes ☒ No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
10	0	19	Bentonite	0	19	10
6	19	560				

How was seal placed: Method ☐A ☐B ☐C ☐D ☐E
☒ Other Bentonite poked + probed
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:	6	+1	19	.250	☒	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:	4	-3	~~554~~	160	☐	☒	☐	☐
					☐	☐	☐	☐

Drive Shoe used ☐ Inside ☐ Outside ☐ None
Final location of shoe(s) 19

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

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
354	554	3/16	94	4		☐	☒
						☐	☐
						☐	☐
						☐	☐

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

Yield gal/min	Drawdown	Drill stem at	Time
30	unable	560	1 hr.

Temperature of water 55° 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 Wash Latitude Longitude
Township 2 N or S Range 1 E or W WM.
Section 34 SE 1/4 NW 1/4
Tax Lot 100 Lot Block Subdivision
Street Address of Well (or nearest address) 11150 Tonquin Loop

(10) STATIC WATER LEVEL:
184 ft. below land surface. Date 8-9-02
Artesian pressure lb. per square inch Date

(11) WATER BEARING ZONES:
Depth at which water was first found 460

From	To	Estimated Flow Rate	SWL
460	560	30+	184

(12) WELL LOG:
Ground Elevation

Material	From	To	SWL
Top soil	0	2	
Basalt gray brown soft	2	8	
" brown med	8	25	
" gray brown med hard	25	34	
" brown med	34	47	
Conglomerate brown med	47	55	
Basalt gray hard	55	71	
" red soft	71	93	
Conglomerate brown med	93	114	
Basalt brown med	114	135	
Conglomerate gray soft	135	142	
Basalt brown soft	142	162	
" gray hard	162	290	184
" brown soft	290	330	
" gray hard	330	384	
" brown med	384	460	
" gray hard porous	460	560	

Date started Aug 2, 2002 Completed Aug 10, 2002

(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 1229
Signed [signature] Date 8-11-02

ORIGINAL – WATER RESOURCES DEPARTMENT FIRST COPY – CONSTRUCTOR SECOND COPY – CUSTOMER

WASH 58802

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 57935
(START CARD) # 143357

(1) OWNER: Well Number ____
Name City of Tualatin
Address 18880 SW Martinazzi
City Tualatin State OR Zip 97062

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

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

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

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Well 1005 ft.
Explosives used ☐ Yes ☑ No Type ____ Amount ____

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
12	0	34	cement	0	486	129 sks
10	34	489				
8	489	1070				

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:	8	+2	486	1/4	☑	☐	☑	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) 486–488

(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
100	11		1 hr.
250	30		2nd hr
350	49		3rd hr

Temperature of water approx 55F 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 high TDS
Depth of strata: 1056 to bottom

(9) LOCATION OF WELL by legal description:
County Washington Latitude ____ Longitude ____
Township 2 S Range 1 W WM.
Section 34 SE 1/4 NE 1/4
Tax Lot 5500 Lot ____ Block ____ Subdivision ____
Street Address of Well (or nearest address) 22675 SW 108th Avenue
Tualatin, OR 97062

(10) STATIC WATER LEVEL:
258 ft. below land surface. Date 8/19/02
Artesian pressure ____ lb. per square inch. Date ____

(11) WATER BEARING ZONES:
Depth at which water was first found 245

From	To	Estimated Flow Rate	SWL
245	258	20	NM
296	317	20	NM
331	356	150	NM
434	444	100	NM
also see (12)			

(12) WELL LOG:
Ground Elevation ____

Material	From	To	SWL
SEE ATTACHED FORMATION LOG			
additional water bearing zones (11):	Est. Locations		
	490	505	see (10)
	540	562	see (10)
	626	641	see (10)
Estimated Flow Rate: see (8)	667	875	see (10)
	735	758	see (10)
	855	864	see (10)
	924	940	see (10)
NM	1056	1057+	NM
Bottom of well was abandoned by pumping			
32 sacks cement grout from bottom up to	RECEIVED		
1005'.			
	SEP 0 6 2002		
	WATER RESOURCES DEPT. SALEM, OREGON		

Date started 5/15/02 Completed 8/19/02

(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 1367
Signed ____ Date 9/5/02

(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 649
Signed Stephen Schmaltz Date 9/5/02

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

City of Tualatin - Well Log

by Schneider Drilling Co.

Start Card # 143357 Label #L57935

FM	TO	DESCRIPTION
0	1	Topsoil
1	10	Clay, brown, medium-soft
10	20	Clay, brown, medium w/claystone, brown
20	33	Claystone, brown, medium-hard, fractured
33	38	Basalt, black, medium, fractured
38	49	Basalt, brown & grey, medium, fractured w/clay
49	59	Basalt, grey, medium w/claystone
59	71	Basalt, black, medium, fractured, w/vesicules
71	101	Basalt, grey, hard, w/fractures
101	144	Basalt, dark grey, hard, w/fractures & vesicules
144	149	Basalt, red, soft, broken
149	153	Basalt, black & red, medium-soft, fractured, vesicular
153	160	Basalt, black, medium-soft, fractured, vesicular
160	170	Basalt, black & brown, medium, fractured, w/vesicules
170	186	Basalt, dark grey, medium-hard, fractured, w/vesicules
186	190	Basalt, dark grey, medium, fractured, vesicular w/claystone
190	204	Basalt, dark grey, medium-hard, fractured
204	219	Basalt, black & red, medium-soft, fractured, vesicular
219	245	Basalt, grey, hard, w/fractures
245	258	Basalt, dark grey, brown, medium-soft, fractured w/claystone
258	263	Basalt, dark grey, hard, fractures
263	273	Basalt, black & red, medium, fractured, vesicular
273	296	Basalt, grey, hard, some fractures
296	317	Basalt, brown, soft, broken, vesicular
317	331	Basalt, grey, hard, some fractures
331	356	Basalt, brown, soft, broken, vesicular
356	369	Basalt, dark grey, medium-hard, fractured
369	434	Basalt, dark grey, hard, some fractures
434	444	Basalt, black, soft, broken, w/ some claystone
444	454	Basalt, black, medium, fractured
454	490	Basalt, grey, hard, some fractures
490	505	Basalt, black, soft, vesicular, broken
505	530	Basalt, dark grey, medium-hard, some fractures & claytone

RECEIVED
SEP 0 6 2002
WATER RESOURCES DEPT.
SALEM, OREGON

MSA

APPENDIX K

Summary of Native Groundwater and ASR Source Water Quality Testing
Tualatin ASR Limited License Permit

	Analyte	Lowest Regulatory Standard	Units	Regulatory Criteria	MDL	*Native Groundwater* ASR Exploratory Well No. 1	*Source Water* 108th and Dogwood Hydrant/City of Portland Water Quality Analysis
					Date	8-Aug-02	August 8, 2002/ 2001
Bacteriological	Fecal Coliforms/E.Coli					Absent	Absent
	Total Coliform	<1/100 ML	CFU/100 ml	MML		Absent	Absent
Disinfection By-Products	Chloroform (Trichloromethane)	None	mg/L	URC	0.0005	ND	
	Bromodichloromethane	None	mg/L	None	0.0005	ND	
	Dibromochloromethane	None	mg/L	None	0.0005	ND	
	Bromoform (Tribromomethane)	None	mg/L	URC	0.0005	ND	
	Total Trihalomethanes	0.08	mg/L	MCL	--	0	0.022 *
	Monochloroacetic Acid	None	mg/L	None	0.002	ND	
	Dichloroacetic Acid	None	mg/L	None	0.001	ND	
	Trichloroacetic Acid	None	mg/L	None	0.001	ND	
	Monobromoacetic Acid	None	mg/L	None	0.001	ND	
	Dibromoacetic Acid	None	mg/L	None	0.001	ND	
	Total Haloacetic Acids	0.06	mg/L	MCL	--	0	0.034 *
	Chlorite [1]	1	mg/L	MCL	NT	NT***	NT***
	Bromate [1]	0.01	mg/L	MCL	NT	NT***	NT***
Field Parameters	Temperature	None	Celsius	None	NA	15.3	20.4
	Conductivity	None	mS/cm	None	NA	432	41
	Dissolved Oxygen	None	mg/L	None	NA	0	9.71
	pH	6 - 8.5	Units	SMCL	NA	7.76	7.78
	Turbidity	1	NTU	MCL, MML	NA	11.5	-2
	ORP	None	mV	None	NA	-171	407
Geochemical	Bicarbonate	None	mg/L	None	2	109	15
	Calcium	None	mg/L	None	0.1	27.1	2.5
	Carbonate	None	mg/L	None	2	ND	ND
	Chloride	250	mg/L	SMCL	1	43	2
	Hardness (as CaCO3)	250	mg/L	SMCL	4	116	12
	Magnesium	None	mg/L	None	0.05	10.27	0.57
	Nitrate as N	10	mg/L	MML	0.5	ND	0
	Nitrite as N	1	mg/L	MCL	0.01	ND	0.03
	Total Nitrate-Nitrite	10	mg/L	MML	--	ND	0.03
	Potassium	None	mg/L	None	0.1	2.2	0.2
	Silica	None	mg/L	None	0.2	47.5	10.6
	Sodium	20	mg/L	URC, SMCL	0.05	26.76	3.82
	Sulfate	250	mg/L	URC, SMCL	5	ND	ND
	Total Alkalinity	250	mg/L	SMCL	2	109	15
	Total Dissolved Solid	500	mg/L	SMCL	0.7	246	24
	Total Organic Carbon	None	mg/L	None	0.5	ND	0.98
	Total Suspended Solids	None	mg/L	None	2	ND	ND
Metals	Aluminum	0.05	mg/L	SMCL	0.05	ND	ND
	Antimony	0.006	mg/L	MCL	0.001	ND	ND
	Arsenic	0.05	mg/L	MCL, MML	0.002	ND	ND
	Barium	1	mg/L	MCL, MML	0.05	ND	ND
	Beryllium	0.004	mg/L	MCL	0.0005	ND	ND
	Cadmium	0.005	mg/L	MCL, MML	0.001	ND	ND
	Chromium	0.05	mg/L	MCL, MML	0.002	ND	ND
	Copper	1.3	mg/L	MCL	0.005	ND	ND
	Iron (Total)	None	mg/L	None	0.05	0.11	0.14
	Iron (Dissolved)	0.3	mg/L	SMCL	0.05	0.1	ND
	Lead	0.015	mg/L	MCL, MML	0.001	ND	ND
	Manganese (Total)	None	mg/L	None	0.002	0.017	0.022
	Manganese (Dissolved)	0.05	mg/L	SMCL	0.002	0.017	0.002
	Mercury	0.002	mg/L	MCL, MML	0.0004	ND	ND
	Nickel	0.1	mg/L	MCL	0.004	ND	ND
	Selenium	0.01	mg/L	MCL, MML	0.002	ND	ND
	Silver	0.05	mg/L	MML, SMCL	0.005	ND	ND
	Thallium	0.002	mg/L	MCL	0.0006	ND	ND
	Zinc	5	mg/L	SMCL	0.01	0.01	ND
Miscellaneous	Odor	3	TON	SMCL	1 ton	1	NT
	Color	15	ACU	SMCL	5 color units	ND	5 *
	Methylene Blue Active Substance	0.5	mg/L	SMCL	0.05	ND	NT
	Corrosivity (Langelier Saturation Index)	Non-Corrosive	mg/L	SMCL	--	-0.92**	NT
	Cyanide (as free cyanide)	0.2	mg/l	MCL	--	ND****	ND
	Fluoride	2	mg/L	MCL, MML, SMCL	0.5	ND	ND *
Radionuclides	Combined Radium 226/228 [1]	5	pCi/L	MCL	NT	NT***	NT***
	Uranium [1]	0.03	mg.L	MCL	NT	NT***	NT***
	Gross Alpha	15	pCi/L	MCL	1.79	ND	ND *
	Beta/Photon emitters [2]	4	mrem/yr	MCL	NA	NA	NA
	Gross Beta	50	pCi/L	MML	2.83	ND	ND *
	I - 131 [3]	3	pCi/L	MML	--	NA	NA
	Sr-90 [3]	8	pCi/L	MML	--	NA	NA
	Tritium [3]	20	pCi/L	MML	--	NA	NA
Synthetic Organic Compounds (SOCs) Regulated SOCs	2,4,5-TP (Silvex)	0.01	mg/L	MCL, MML	0.0004	ND	ND **
	2,4-D	0.07	mg/L	MCL, MML	0.0002	ND	ND **
	Alachlor (Lasso)	0.002	mg/L	MCL, MML	0.0004	ND	ND **
	Atrazine	0.003	mg/L	MCL, MML	0.0002	ND	ND **
	Benzo(a)Pyrene	0.0002	mg/L	MCL	0.00004	ND	ND **
	BHC-gamma (Lindane)	0.0002	mg/L	MCL, MML	0.00002	ND	ND **
	Carbofuran	0.04	mg/L	MCL	0.001	ND	ND **
	Chlordane	0.002	mg/L	MCL	0.0004	ND	ND **
	Dalapon	0.2	mg/L	MCL	0.002	ND	ND **
	Di(2-ethylhexyl)adipate *(adipates)*	0.4	mg/L	MCL	0.001	ND	ND **
	Di(2-ethylhexyl)phthalate *(phthalates)*	0.006	mg/L	MCL, MML	0.001	ND	ND **
	Dibromochloropropane (DBCP)	0.0002	mg/L	MCL	0.00002	ND	ND **
	Dinoseb	0.007	mg/L	MCL	0.0004	ND	ND **
	Diquat	0.02	mg/L	MCL	0.0004	ND	ND **

Summary of Native Groundwater and ASR Source Water Quality Testing
Tualatin ASR Limited License Permit

	Analyte	Lowest Regulatory Standard	Units	Regulatory Criteria	MDL	*Native Groundwater* ASR Exploratory Well No. 1	*Source Water* 108th and Dogwood Hydrant/City of Portland Water Quality Analysis
					Date	8-Aug-02	August 8, 2002/ 2001
	Ethylene Dibromide (EDB)	0.00005	mg/L	MCL, MML	0.00001	ND	ND **
	Endothall	0.1	mg/L	MCL	0.01	ND	ND **
	Endrin	0.0002	mg/L	MCL, MML	0.00002	ND	ND **
	Glyphosate	0.7	mg/L	MCL, MML	0.01	ND	ND **
	Heptachlor	0.0004	mg/L	MCL, MML	0.00004	ND	ND **
	Heptachlor Epoxide	0.0002	mg/L	MCL, MML	0.00002	ND	ND **
	Hexachlorobenzene (HCB)	0.001	mg/L	MCL, MML	0.0001	ND	ND **
	Hexachlorocyclopentadiene	0.05	mg/L	MCL, MML	0.0002	ND	ND **
	Methoxychlor	0.04	mg/L	MCL, MML	0.0002	ND	ND **
	Polychlorinated Biphenyls (PCBs)	0.0005	mg/L	MCL, MML	0.0002	ND	ND **
	Pentachlorophenol	0.001	mg/L	MCL, MML	0.00008	ND	ND **
	Picloram	0.5	mg/L	MCL, MML	0.0002	ND	ND **
	Simazine	0.004	mg/L	MCL, MML	0.0001	ND	ND **
	Toxaphene	0.003	mg/L	MCL, MML	0.001	ND	ND **
	Vydate (Oxamyl)	0.2	mg/L	MCL	0.002	ND	ND **
Volatile Organic Compounds (VOCs) Regulated VOCs	1,1,1-Trichloroethane	0.2	mg/L	MCL, MML	0.0005	ND	ND **
	1,1,2-Trichloroethane	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	1,1-Dichloroethylene	0.007	mg/L	MCL, MML	0.0005	ND	ND **
	1,2,4-Trichlorobenzene	0.07	mg/L	MCL, MML	0.0005	ND	ND **
	1,2-Dichlorobenzene (o)	0.6	mg/L	MCL, MML	0.0005	ND	ND **
	1,2-Dichloroethane (EDC)	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	1,2-Dichloropropane	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	1,4-Dichlorobenzene (p)	0.075	mg/L	MCL, MML	0.0005	ND	ND **
	Benzene	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Carbon Tetrachloride	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Chlorobenzene	0.1	mg/L	MCL, MML	0.0005	ND	ND **
	cis-1,2-Dichloroethylene	0.07	mg/L	MCL, MML	0.0005	ND	ND **
	Ethylbenzene	0.7	mg/L	MCL, MML	0.0005	ND	ND **
	Dichloromethane (methylene chloride)	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Styrene	0.1	mg/L	MCL, MML	0.0005	ND	ND **
	Tetrachloroethylene	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Toluene	1	mg/L	MCL, MML	0.0005	ND	ND **
	trans-1,2-Dichloroethylene	0.1	mg/L	MCL, MML	0.0005	ND	ND **
	Trichloroethylene	0.005	mg/L	MCL, MML	0.0005	ND	ND **
	Vinyl chloride	0.002	mg/L	MCL, MML	0.0005	ND	ND **
	Total Xylenes	10	mg/L	MCL, MML	0.0005	ND	ND **

NOTES:

mg/L = milligram per liter
MDL = Method Detection Limit
ND = Not detected at concentrations greater than the MDL
NT = Analyte not tested
NA = not applicable
MCL = Federal maximum contmainant level for drinking water
MML = DEQ's maximum measurable levels for groundwater
SMCL = Federal secondary maximum contaminant levels for drinking water
UCMR = EPA unregulated contaminant monitoring regulations for drinking water
Samples are unfiltered unless noted (i.e., dissolved)
1 = Chlorite, Bromate, Combined Radium 226/228 and Uranium required after December 2003
2 = Only need to analyze for if in a vunerable area (i.e., near man-made radioactive sources, such as nuclear facilities - only selected systems along Columbia River currently classified as vunerable 11/03)
3 = These are only analyzed if Gross Alpha or Beta exceed an MML or MCL

1 = These are only analyzed if Gross Alpha or Beta exceed an MML or MCL
* = Analysis by the City of Portland of samples collected in March 2002
** = Analysis by the City of Portland of samples collected from Bull Run water between September 11, 1996 and June 16, 2002. Samples from individual Portland groundwater sources are not representative of ASR source water and so were not included.
*** Chlorite, Bromate, Combined Radium 226/228 and Uranium required after December 2003 and will be collected in future
**** Cyanide result from City of Sherwood Well # 6, (approximately 1.9 miles west of ASR # 1 within the same production zone). Tualatin will collect a sample from new well after drilling to verify these results.

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APPENDIX L

YEAR 2004-2005 – Tualatin ASR Well No. 11 - Sampling Schedule

Input Values in Yellow Cells				
Expected AVERAGE Injection Rate:	**500**	(gpm)		
Expected AVERAGE Recovery Rate:	**700**	(gpm)		
Expected Injection Start Date	**Wednesday 12/22/2004 12:00 PM**			
Expected Injection End Date	**Tuesday 5/3/05 10:40 AM**			
Expected Elapsed Injection Days		**132**	days	
Expected Elapsed Injection Hours		**3167**	hours	
		95,000,000	gallons injected at injection rate	
Total Planned Injection Volume (MG)		**95.0**	MG	95.0 Stored Vol. MG
Expected Storage Start Date	**Tuesday 5/3/05 10:40 AM**			
Expected Storage End Date	**Saturday 7/2/05 10:40 AM**			
Expected Elapsed Storage Days		**60**	days	
Expected Elapsed Storage Hours		**1440**	hours	
Total Planned Recovery Volume		**90.25**	Assume 95%	Recovered
Expected Recovery Start Date	**Saturday 7/2/05 10:40 AM**			
Expected Days Required to Recover 100% of Injection Volume	**Tuesday 10/4/05 4:34 PM**	**94**	days	
Expected Days Required to Recover Planned Volume	**Thursday 9/29/05 11:28 PM**	**90**	Assumes single-batch recovery	

Water Quality Monitoring Program

Water Type	Progress Point	Date	Elapsed Days	Analysis	Sample ID	Date Collected	Bottles Verified	Comments
Baseline Groundwater								
GW	-	Wednesday 12/15/04 12:00 PM	-	FP, GC, DBP, SDWA, UCMR, & Radon	TASR1-C1GW			
Injection Period								
Source	0%	Wednesday 12/22/04 12:00 PM	0	FP, GC, & DBP	TASR1-C2SW-1			
Source	50%	Saturday 2/26/05 11:20 AM	66	FP only	TASR1-C2SW-2			
Source	100%	Tuesday 5/3/05 10:40 AM	132	FP, GC, & DBP	TASR1-C2SW-3			
Storage Period								
Stored	25%	Wednesday 5/18/05 10:40 AM	15	FP, GC, & DBP	TASR1-C2T-1			
Stored	75%	Friday 6/17/05 10:40 AM	45	FP, GC, DBP, SDWA, UCMR, & Radon	TASR1-C2T-2			
Recovery Period								
Recovered	20%	Thursday 7/21/05 7:02 AM	19	FP, GC, & DBP	TASR1-C2R-1			
Recovered	45%	Saturday 8/13/05 8:31 PM	42	FP, GC, DBP, SDWA, UCMR, & Radon	TASR1-C2R-2			
Recovered	75%	Sunday 9/11/05 3:05 AM	71	FP, GC & DBP	TASR1-C2R-3			
Recovered	95%	Thursday 9/29/05 11:28 PM	90	FP, GC & DBP	TASR1-C2R-4			

Notes:

FP = Field Parameters
GC = Geochemical Parameters
DBP = Disinfection By-Products
SDWA = Safe Drinking Water Act Parameters (DHS, DEQ MML, Federal SMCL)
UCMR = EPA Unregulated Contaminant Monitoring Regulations parameters
Radon = Radon in drinking water analysis, SM 7500 or EPA 913.0

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APPENDIX M

GROUNDWATER SAMPLING FIELD FORM

Project Name________________________________Project Number ____________________________

Well No. ___________ Sampled By _________________ Date __/__/___ Casing Diameter____"

Well Depth _____' Water Level / Time ____'/____:____ TOC Elev. _______' Water Elev.______'

Well Volume / Purge Volume _________/_________gal. Total Purge Time ____________________

Well Recharge fast - mod - slow Purge Method _______________ Sample Method ______________

Sample Time ____:_____ Sample pH / Temp./Cond. _______/_______/_______

Lab Analysis ____________________________ Laboratory _________________________

Initial Purge Sample ____

Final Purge Sample ____

Time	Volume (gallons)	Temp (deg C)	pH	Conductivity (ms/cm)	Remarks
RPD (Last 3)					

APPENDIX N

MWH Laboratories
A Division of MWH Americas, Inc.

750 Royal Oaks Drive, Suite 100
Monrovia, California 91016-3629
Tel: 626 386 1100
Fax: 626 386 1101
1 800 566 LABS (1 800 566 5227)

CHAIN OF CUSTODY RECORD

MWH LABS USE ONLY:

LOGIN COMMENTS: ______________________	**SAMPLES CHECKED AGAINST COC BY:** __________
______________________	**SAMPLES LOGGED IN BY:** __________
SAMPLE TEMP WHEN REC'D AT LAB: ______ (Compliance: 4 +/- 2°C)	**SAMPLES REC'D DAY OF COLLECTION?** ☐ (check for yes)
CONDITION OF BLUE ICE: FROZEN ___ **PARTIALLY FROZEN** ___ **THAWED** ___	

TO BE COMPLETED BY SAMPLER:

COMPANY, UTILITY or PROJECT:	**SYSTEM #:**	**COMPLIANCE SAMPLES** ☐ - Requires state forms ☐ *(check for yes)* **NON-COMPLIANCE SAMPLES** ☐ *(check for yes)* **REGULATION INVOLVED:** (eg. SDWA, Phase V, NPDES, FDA,...) Type of samples (circle one): ROUTINE SPECIAL CONFIRMATION
MWH LABS CLIENT CODE:	**P.O.# / PROJECT JOB #:**	***SEE ATTACHED BOTTLE ORDER FOR ANALYSES*** ☐ (check for yes), ***OR*** **list ANALYSES REQUIRED (enter number of bottles sent for each test for each sample)**
SAMPLER PRINTED NAME AND SIGNATURE:	**TAT requested: rush by adv notice only** STD___ 1 wk ___ 3 day __ 2 day___ 1 day __	

SAMPLE DATE	SAMPLE TIME	STATION # or LOCATION	SITE NAME OR SAMPLE I.D.	MATRIX *	GRAB	COMP															SAMPLER COMMENTS

*** MATRIX TYPES:**

RSW = Raw Surface Water	CFW = Chlor(am)inated Finished Water	CWW = Chlorinated Waste Water	BW = Bottled Water	SO = Soil
RGW = Raw Ground Water	FW = Other Finished Water	WW = Other Waste Water	SW = Storm Water	SL = Sludge

	SIGNATURE	PRINT NAME	COMPANY/TITLE	DATE	TIME
RELINQUISHED BY:					
RECEIVED BY:					
RELINQUISHED BY:					
RECEIVED BY:					

C-O-C# ________

PAGE _____ OF _____