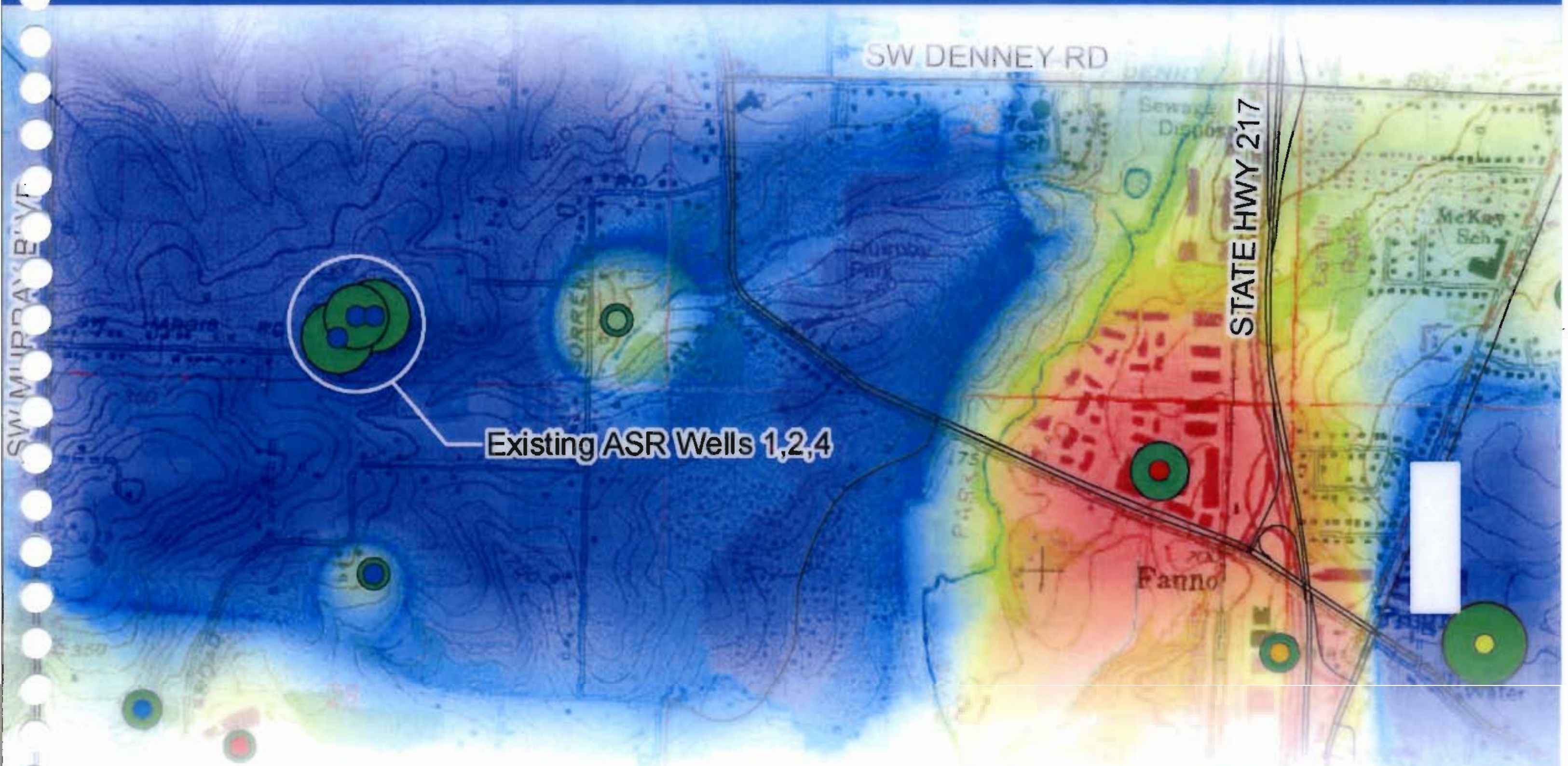
City of Beaverton - Year 2006 ASR Pilot Test Results

May 2007

Prepared for Oregon Water Resources Department



Prepared by

GSI Water Solutions, Inc.

55 SW Yamhill Street, Suite 400 Portland, OR 97204
P: 503.239.8799 F: 503.239.8940
info@gsiwatersolutions.com www.gsiwatersolutions.com

TECHNICAL MEMORANDUM

GSI Water Solutions, Inc.

City of Beaverton -Year 2006 ASR Pilot Test Results

PREPARED FOR: David Winship, PE - City of Beaverton
Rick Weaver - City of Beaverton

PREPARED BY: Larry Eaton, RG - GSI Water Solutions (GSI)
Jason Melady, RG - GSI

CC Donn Miller, RG - OWRD
Marc Norton, RG - OWRD
Dennis Nelson, RG - OHD
Rodney Weick, RG - DEQ

DATE: June 7, 2007

Introduction

The purpose of this technical memorandum is to present the results of the ninth aquifer storage and recovery (ASR) pilot test conducted by the City of Beaverton (City) during 2006. ASR pilot testing was conducted at the City's Sorrento Water Works Facility (Sorrento site) using two wells: ASR No. 1 (Hanson Road well) and ASR No. 2 (see Figure 1). The purpose of the pilot testing is to continue to test ASR feasibility for the basalt aquifer at this site and to evaluate the dynamic response to ASR activities.

Previous reports have outlined in more detail the City's ASR program, as well as previous pilot testing results. The reader is referred to a list of reports at the end of this technical memorandum that provides additional reference material for this project.

The City of Beaverton receives its water from the Joint Water Commission (JWC). The water then is stored in the basalt aquifer beneath the Sorrento site during the winter and spring months (December through June) when river flows are high. This stored water is recovered during the summer and fall months (July through October) to augment system capacity during peak demand periods or if necessary, during an emergency condition.

ASR pilot testing for the City is being conducted under ASR Limited License #002, issued by the Oregon Water Resources Department (OWRD). The limited license permits recovery of 95 percent of the stored water; however, because the City has a groundwater registration (GR-328), it has the option to use native groundwater, if necessary, after the ASR account has been depleted. ASR Limited License #002 was renewed in 2003 for another 5 years of testing, to allow the City additional time to evaluate the basalt aquifer and to determine whether the aquifer can host additional ASR wells before the City applies for a full-scale ASR operational permit from OWRD. The City intends to request another 5-year extension to ASR Limited License #002 on or before its expiration in July 2008.

Summary

During the 2006 recharge season, a total of 303.3 million gallons (MG) of treated drinking water were stored in the basalt aquifer beneath the Sorrento site using two City ASR wells: ASR No. 1 and ASR No. 2. When combined with the carryover storage volume of 145.4 MG from the previous ASR cycle (2004-2005), a total of 448.7 MG was available for recovery. A total of 265.2 MG of water were recovered, the bulk of which was recovered between late May and early September using the same two wells; resulting in 160.8 MG in carryover into Cycle 10 for the 2006-2007 ASR cycle ([[303.3 MG + 145.4 MG] X 0.95] - 265.2 MG = 160.8 MG) per Condition 12A of the City's limited license, which prescribes a 5-percent reduction in the amount of water that can be recovered and/or carried over each year.

The maximum head rise during injection in ASR No. 1 was 126 feet above the pre-injection static water level. The head rise during injection in ASR No. 1 was maintained below the base of the casing (surface seal), as required by Condition 11 of the City's limited license. The maximum head rise during injection in ASR No. 2 was 118 feet above the pre-injection static water level. A head rise in the ASR No. 4 observation well, which represents the response in the aquifer near the injection wells, was at least 114 feet above the pre-injection static water level (missing some data at extremes). A response was observed (approximately 22 ft head rise above pre-injection water level in 2006) in the State observation well (WASH 9205), which is completed in basin sediments. The State well shows that basin sediments south of the Sorrento site are in hydraulic connection with the basalt aquifer that is host to the City's ASR system.

Clogging near the boreholes was controlled by frequent back-flushing of the wells (about once every 3 weeks). In addition, no long-term decline in the static water level in the regional basalt aquifer caused by ASR activities was noted, which resulted in no appreciable net loss of stored water from the aquifer. The rising aquifer level appears to be correlated with near average precipitation during recent years, an overall decrease in native groundwater pumping by the City, and carryover storage being left in the aquifer. Because of the continued upward trend in the aquifer water level, the City intends to request a meeting with the OWRD regarding (1) relief of condition No. 12 of ASR Limited License #002 that requires retaining 5 percent of the injected water volume in the aquifer, and (2) the possibility of additional native groundwater production under the limited license beyond the City's existing water rights. This approach is similar to what the City of Tigard outlined in its 2006 annual report.

No water quality standard exceedances were noted. Finally, no adverse chemical reactions that could potentially clog the aquifer near the injection wells were observed in the data and the water quality remained excellent during the recovery phase. The City did not receive any complaints from area residents about the quality of the recovered water from its ASR system. Overall, the City's ASR system has been very successful and continues to play a key role in helping the City meet peak demands.

Year 2006 Description

Table 1 summarizes Year 2006 ASR activities at the Sorrento site. Table 2 provides a summary of ASR activities at the Sorrento site since ASR cycle testing began in 1999. Table 3 summarizes ASR injection/recovery rates and maximum and minimum water levels in ASR No. 1 and ASR No. 2, and ASR No. 4 observation well.

Table 1
Year 2006 ASR Pilot Operation (Cycle 9)
City of Beaverton

Well ID	Start/ End of Injection	Start/End of Storage	Start/End of Recovery	ASR Account Carryover[1] from Last Year	ASR Volume Injected - Cycle 9 (2006)	Total Storage Volume[3]	5% Reduction in Total Storage Volume[2,3]	ASR Volume Recovered	Total Recovered Volume	ASR Account Carryover[4] to Next Year
ASR No. 1	4-Jan-06 17-May-06	17-May-06 30-May-06	30-May-06 1-Sep-06	72.7 MG	117.5 MG	190.2 MG	180.7 MG	65.6 MG	65.6 MG	115.1 MG
ASR No. 2	4-Jan-06 17-May-06	17-May-06 5-June-06	5-June-06 17-Dec-06	72.7 MG	185.8 MG	258.2 MG	245.3 MG	199.6 MG	199.6 MG	45.7 MG
Totals				145.4 MG	303.3 MG	448.7 MG	426.3 MG	265.2 MG	265.2 MG	160.8 MG

MG = million gallons

[1]Carryover assumes the Sorrento Water Works Facility (ASR No. 1 and ASR No. 2) is treated collectively (see Table 2). Individual carryover is split between the two wells equally.

[2]Based on Condition No. 12 in Limited License #002, where 95 percent of stored water shall be recovered.

[3]Total storage volume includes Carryover from last year's ASR cycle and ASR volume stored this year.

[4]ASR Account Carryover to 2006-2007 is the difference between 95 percent of the total storage volume (carryover + injected volume) and the total recovered volume ([448.4 * 0.95 MG] - 265.2 MG =160.8 MG).

Table 2
Year 1999 - 2006 ASR Cycle Testing
City of Beaverton

Cycle Test	Wells	Year	Injection Period	ASR Volume Injected	ASR Volume Stored with Carryover	ASR Volume Recovered[1]	Native GW Recovered	Total Recovery	ASR[2,3,4] Account Carryover
Cycle 1	ASR No.1	1999	2 days	1.7 MG	1.7 MG	1.7 MG	None	1.7 MG	None
Cycle 2	ASR No.1	1999	30 days	34.5 MG	34.5 MG	32.7 MG	37.3 MG	70 MG	None
Cycle 3	ASR No.1	2000	65 days	74.7 MG	74.7 MG	70.9MG	27.1 MG	98 MG	None
Cycle 4	ASR No.1 and ASR No.2	2001	4 months	159.1 MG	159.1 MG	151.2 MG	99.8 MG	251 MG	None
Cycle 5	ASR No.1 and ASR No.2	2002	5.5 months	310.5 MG	310.5 MG	294.9 MG	106.3 MG	401.2 MG	None
Cycle 6	ASR No.1 and ASR No.2	2003	5.75 months	394.6 MG	394.6 MG	364.9 MG	49.2 MG	414.1 MG	10.0 MG
Cycle 7	ASR No.1 and ASR No 2	2004	5 months	444.3 MG	454.3 MG	202.6 MG	None	202.6 MG	229.0 MG
Cycle 8	ASR No.1 and ASR No.2	2005	2.6 months	209.5 MG	438.5 MG	270.9 MG	None	270.9 MG	145.7 MG
Cycle 9	ASR No.1 and ASR No.2	2006	4.4 months	303.3 MG	448.7 MG	265.2 MG	None	265.2 MG	160.8 MG
			Totals	1,932.2 MG	2,316.9 MG	1655.0 MG	319.7 MG	1974.7 MG	

[1] Up to 95 percent of the stored ASR water can be recovered; however, the City has in the past continued to pump native groundwater using ASR No. 1 and/or ASR No. 2 under its existing water right.

[2]Based on Condition No. 12 of Limited License #002, where 95 percent of the stored water can be recovered.

[3]Carryover assumes the Sorrento Water Works Facility (ASR No. 1 and ASR No. 2) is treated collectively.

[4]ASR Account Carryover to2006- 2007 is the difference between 95 percent of the total stored volume in 2006 and the 265.2 MG recovered in 2006 ([448.4 MG * 0.95] - 265.2 MG = 160.8 MG).

MG = million gallons

Table 3 - Year 2006 - ASR Injection and ASR No. 4 Observation Well

Well ID	Maximum Head Rise Above SWL Year 2006	Maximum Drawdown Below SWL Year 2006	Comments
ASR No. 1 Avg. Injection = 618 gpm Avg. Recovery = 617 gpm	126 ft (75 ft bgs)	36 ft (237 ft bgs)	Head rise stayed below casing (surface seal). Drawdown was 63 feet above pump intake.
ASR No. 2 Avg. Injection = 972 gpm Avg. Recovery= 1,441 gpm[1]	118 ft (90 ft bgs)	50 ft (258 ft bgs)	Head rise was 90 feet below ground surface and drawdown was 76.3 feet above pump intake
ASR No. 4 Obs	114 ft	0.0 ft	Water level in this observation well reflect what is occurring in the aquifer at this site.

SWL = pre-injection year 2006 static water level
gpm = gallons per minute
[1] As presented in the ASR No. 4 Work Plan dated November 15, 2005, the City requested the Limited License #002 be modified to allow the City to pump its ASR wells up to 3 mgd.

Water Level Monitoring

To monitor the dynamic response of the aquifer to ASR operation, a network of monitoring wells was established in the preliminary phase of the project and it has been maintained for the past 6 years. The network was modified in 2001 when new wells were added (e.g., Maverick Street) and others were dropped from the network based on a detailed review of the data (e.g., Blomquist). Wells that were monitored during year the 2006 ASR program are listed below. Figure 1 shows the location of the monitoring wells relative to the Sorrento site.

- ASR No. 1 – City telemetry system
- ASR No. 2 – City telemetry system
- ASR No. 4 observation well - transducer
- Sage Place well - transducer
- Davies Road well - manual measurements
- Rubber Reservoir - transducer
- Maverick Street - manual measurements
- ASR No. 3 - manual measurements
- SW 150th Court Seep - transducer
- Dernbach well - transducer
- WASH 9205 - OWRD manual measurements

Please note that water level monitoring in wells located at the Mattel site was discontinued by that firm's consultant in 2003, so no water level data are available. We are uncertain if data will be available in the future from this site. The water level changes at the Mattel wells have not correlated to ASR activities at the Sorrento site since the City's ASR program was started in 1999 (see previous ASR cycle reports). Data presented in previous reports show that the aquifer system at the Sorrento site is isolated hydraulically from the Mattel site.

Table 4 summarizes the response in the network of monitoring wells based on year 2006 data. Figures 2 and 3 present hydrographs of ASR No. 1. Figures 4 and 5 present the specific capacity plots during injection and recovery for ASR No. 1, respectively. The hydrographs for ASR No. 2 is presented in Figure 6 and Figure 7. Figures 8 and 9 present specific capacity plots during injection and recovery for ASR No. 2, respectively. Figure 10 presents a hydrograph for all of the observation wells: ASR No. 4 observation well, Davies, Sage Place, Maverick, Rubber Reservoir, Dernbach, SW 150th Court, and ASR No. 3. And Figure 11 presents a detailed hydrograph of the SW 150th Court piezometer. Figure 12 presents a hydrograph for WASH 9205.

Overall, water level response to ASR activities in all wells was similar to previous ASR events. The maximum drawup in ASR No. 1 and ASR No. 2 was slightly less compared to the previous year, which most likely is related to the fact that less water was injected during the 2006 ASR season because of the large carryover amount from the pervious year. A discussion of the SW 150th Court seep area is presented below and the aquifer response observed at WASH 9205 also is discussed in the following section.

Table 4 –Year 2006 – Network of Observation Wells
Combined Average ASR Injection rate[2]: 1,590 gpm
Combined Average Withdrawal rate[2]: 1029 gpm

Well ID	Distance From Sorrento Site	Maximum Head Rise above SWL Year 2006	Comments
ASR No. 4 Observation Well	350 feet	114 ft	Observation well located next to ASR injection wells – response reflects what is happening in the aquifer near the site
Davies Road Well	1,190 ft	85 ft	Head rise similar to ASR 4 even though it is much farther from the site; response shows a bounded and leaky aquifer system.
Sage Place Well	2,300 ft	77 ft	Head rise less than wells further from the ASR wells, which supports a bounded and leaky aquifer system.
Rubber Reservoir	3,210 ft	79 ft	Head rise response is slightly greater than expected, especially when compared to Maverick. In addition, head response is greater than what should occur because of distance from ASR wells. This supports a highly bounded and leaky aquifer.
Maverick Street	3,750 ft	60 ft	Head rise is relatively high considering distance from injection wells – comment for Rubber Reservoir well.
SW 150th Court	7,000 ft	7 ft	Response most likely influenced by local recharge events, regional response, and ASR activities, but the degree each of these affect the water level in this area is indeterminate.
Dernbach	7,500 ft	10 ft	Appears to be related to ASR activities.
WASH 9205 (monitored by OWRD)	8,700 ft	22 ft	Head rise observed is what would be expected based on the regional response of the aquifer to ASR activities. However, this well shows a direct connection between basin sediments and the basalt aquifer.
ASR No. 3	14,000 ft	3 ft	Appears to be result of ASR activities – note gradual increasing trend in the water level at this site, which could be related to ASR activities – keeping water in the system and only pulling out 95 percent of the stored volume.
Mattel Site Monitoring Wells	8,200 ft	NA	Water level monitoring discontinued by Mattel consultant in 2003.

SWL = pre-injection static water level
[1]Reader is referred to Figure 1 to view relative distance from the injection well to each monitoring well.
[2] As presented in the ASR No. 4 Work Plan dated November 15, 2005, the City requested the Limited License #002 be modified to allow the City to pump its ASR wells up to 3 mgd.

Monitoring Discussion

General

The City of Beaverton has been testing the feasibility of ASR at its Sorrento site since 1999. To date, results have been favorable and ASR has played an important role in helping the City meet peak demand periods during the summer. The City intends to move forward with further ASR testing that will include adding additional ASR wells. Future plans are discussed later in this technical memorandum. Overall, the dynamic response of the aquifer system at the Sorrento site has shown that nearly 450 MG of water can be stored, apparently causing little to no loss of stored water from the aquifer.

The response observed in the ASR wells and the network of monitoring wells, during ASR activities, shows that the aquifer does not have a simple response as what would be predicted by applying the Theis equation to the water level data. Instead, the drawdown and drawup curves are parabolic versus straight lines when plotted in semi-log. Specifically, drawdown/drawup is less than what would be predicted in early-time data and more than what would be predicted in late-time data. Moreover, the response shows that the aquifer has leaky boundaries. For example, the response observed in monitoring wells at different distances from the Sorrento site does not follow a predicted Theis-like trend; wells closer to the injection wells exhibit a similar response to wells that are farther from the injection wells (e.g., ASR No. 4 Observation well and the Maverick Street well). This type of response observed in monitoring wells shows that the system is highly bounded, but that the boundaries are leaky. It is possible that these boundaries are actually decreases in lateral aquifer transmissivity within interflow zones instead of leaky faults.

SW 150th Court

It appears that some degree of groundwater loss may be occurring at the SW 150th Court seepage area as a result of increased head in the aquifer related to ASR recharge. The increase in slope observed in the 2005 and 2006 hydrograph correlates well with the start of ASR injection in December and January. If it is assumed that 15 gpm (conservative estimate) of discharge from the seep is related to ASR activities and the area discharges for 60 days per year (also conservative), the volume of water discharged is approximately 1.3 MG or roughly 0.3 percent of the total volume of aquifer storage (450 MG) at the Sorrento site annually. It should be noted that the overall benefit to the regional aquifer from ASR at the Sorrento site far exceeds the potential loss of 0.3 percent of stored water, especially because a minimum 5 percent of the annual stored volume (which was 22 MG in 2006) is required to be left in the aquifer each year per Condition No. 12 of Limited License #002. Overall the regional aquifer has rebounded due to ASR activities and groundwater levels are near, but not greater than, historical high levels in the 150th Court area.

OWRD Observation Well WASH 9205

OWRD routinely monitors water wells in the Cooper Mountain-Bull Mountain area. Well WASH 9205, which is in OWRD's monitoring program, clearly is showing a response to ASR activities; this well was brought to GSI's attention by OWRD. The well is located approximately 8,700 feet south of the Sorrento site (see Figure 1), and is completed in valley-fill sediments, as described in the water well report. The subsurface log in the water well report indicates a confined or semi-confined aquifer system at this location because 290 feet of clay and silt overlie the primary water-bearing zone, which is described as sands and gravels, most likely of the Troutdale Formation (Schlicker and Deacon, 1967). A hydrograph for this well is presented in Figure 12. The response observed in WASH 9205 shows that the deeper water-bearing sediments are in hydraulic connection with the basalt system that is host to the City's ASR wells. Figure 13 shows a conceptual hydrogeologic cross-section of the area between the Sorrento ASR Facility and the OWRD observation well. The overall increase in the groundwater elevation at this location is approximately 45 feet since ASR activities began. The increase from the start of injection for 2006 was approximately 22 feet, some of which may be related to a natural recharge of the aquifer. It is important to note that the groundwater elevation at this location represents a potentiometric surface, which means unless a preferential pathway exists in this area, (a preferential pathway is not likely because 290 feet of fine-grained sediments overlying the water-bearing zone) surface seeps are unlikely to occur. Regardless, we will continue to review WASH 9205 data collected by OWRD in order to evaluate the response in the aquifer due to ASR activities in the immediate area of the well. Additionally, the City is planning on pumping all stored water and a significant amount of water from their native groundwater right during the summer of 2007. If the water level increase at this location is related to ASR, this significant pumping event should lower water levels in this well.

Sage Place

The regional effect on the aquifer as a result of ASR activities at the Sorrento site was evaluated by assessing water levels at the Sage Place observation well, which have been plotted since the start of ASR activities (see Figure 14). A line was drawn through the plot showing the relative pre-injection static water level of 160 feet msl. A trend line through the cycles also was projected to help evaluate the long-term water level response in the aquifer. Overall, it appears that ASR injection and recovery have not resulted in a regional decline in the static water level. This is in spite of the fact that the cumulative departure from mean rainfall since 2000 is -0.6 inches. ASR operation started in 1999, but only 34 MG were injected that year with the larger injection volumes being injected since 2000. If ASR activities were having an observable adverse impact on the groundwater levels in the aquifer system, then we would expect to see a downward trend in Figure 14. It is also important to note that the City pumped native groundwater under its existing water right after the ASR account was exhausted during Cycles 3, 4, 5, and 6. Pumping of native groundwater also did not appear to have an adverse effect on the groundwater levels in the aquifer. The rebounding of the aquifer system appears to be related to the residual amount of water kept in the aquifer as part of Condition No. 12 of the City's limited license and also because of carryover from year-to-year. It is important to note, that the upward trend also supports the concept that the aquifer is highly bounded because the aquifer does not re-equilibrate to the pre-ASR static water level from year-to-year. Moreover, the upward trend shows that significant quantities of groundwater are not being lost from the system because of ASR activities. If ASR were to be discontinued the static water level most likely would equilibrate to a new and higher static water level, assuming rainfall patterns stay normal, since the basalt aquifer is bounded and because it is closed to further groundwater pumping.

Water Quality Monitoring

Water quality monitoring during year 2006 activities was conducted to demonstrate that the injected and recovered water quality meets potable standards, to assess potential chemical reactions that could result in clogging of the injection wells or impacts to native groundwater quality, and to comply with limited license requirements. The complete list of parameters included in the water quality program is presented in Table 5 along with year 2006 results. Table 6 outlines the year 2007 sampling schedule for ASR No. 1 and Table 7 presents a sampling schedule for ASR No. 2. Please note that because ASR No. 1 and ASR No. 2 are treated as a single ASR system (single wellfield) and to maintain consistency, compliance water quality samples as part of the ASR program are collected only at ASR No. 1. This approach has been used since 2002. ASR No. 4, which has experienced construction-related delays, will be online in 2007 and will be used to collect field parameter information only, much like what is collected at ASR No. 2. This approach was outlined in a work plan addendum for ASR No. 4 that was submitted to the OWRD.

Safe Drinking Water Act Compliance

Analytical results showed that the water quality remained excellent during all stages of last year's ASR program. Regulated parameters for source water and recovered water were below all state and federal limits for water quality criteria, and all aesthetic parameters (e.g., odor, color) remained good. Volatile organic compounds (with the exception of disinfection byproducts), synthetic organic compounds, and semivolatile organic compounds were not detected. Metals and radionuclides were detected at concentrations below their respective regulatory screening criteria. Total coliform bacteria were not detected in source or recovered water. Quality assurance/quality control (QA/QC) was performed on all analyzed data in general compliance with the U.S. Environmental Protection Agency's (EPA) National Functional Guidelines.

Groundwater and Source Water Chemistry

Several parameters were monitored throughout last year's ASR pilot testing to track any potential reactions during ASR operation; geochemical parameters also have been monitored since the start of ASR activities at the Sorrento site.

Water Chemistry Tends

In general, the water chemistry data collected during 2006 ASR testing indicates a mixing trend from ASR injection through ASR recovery. Figure 17 is a piper trilinear diagram and Figure 18 is a stiff diagram. Figures 19 through 21 present select time-series plots for specific geochemical constituents.

As the piper (Figure 17) and stiff (Figure 18) diagrams indicate, major cation and anion concentrations in source water are considerably lower than the native groundwater sample. Source water cation/anion concentrations generally increase throughout injection portion of the ASR cycle. During recovery, cation/anion concentrations change over time and approach native groundwater concentrations. However, by the end of recovery, cation/anion concentrations do not match native groundwater concentration, likely because of approximately 160 MG of stored water were carried over into 2007. As noted in previous annual ASR reports, water chemistry data indicate a general mixing trend.

Time-series plots (Figures 19 through 21) are presented to determine if reactions were occurring because of mixing source water with native groundwater. The plots support a mixing trend and dispersion effects rather than a change in chemistry during recovery. Specifically, the concentrations of chloride, calcium, and bicarbonate during recovery are initially similar to source water and increase with time, approaching native groundwater concentrations. This trend is very similar to trends noted in previous ASR cycles. Overall, it appears that concentrations of these constituents, as well as most major cations and anions, have generally decreased in recovered water over the last several years. The later is likely a result of significant volumes of residual source water, which generally has lower concentrations of all major ions, remaining in the aquifer.

Radon

Radon has been detected historically during ASR operation in baseline groundwater and in recovered water and was detected during the 2006 ASR cycle testing at concentrations between 430 and 630 pCi/L. This concentration is typical of the radon concentration detected in water sampled from the wells at the Sorrento site. Based on work by Richard Glanzman of CH2M HILL, the marine sediments underlying the basalts are the likely source of the radon because basalts typically contain low amounts of radon.

There has been no change to or implementation of EPA public health standards for radon in drinking water. Under EPA's proposed standards, two options are provided to states and community water systems for reducing radon health risks in both drinking water and indoor air quality. Under the first option, states can choose to develop enhanced programs addressing radon in indoor air in conjunction with individual water systems meeting a drinking water standard of 4,000 pCi/L. Under the second option, individual water systems in a state would either reduce radon in their system's drinking water to 300 pCi/L or develop a multimedia mitigation program for radon and reduce radon levels in drinking water to 4,000 pCi/L.

Corrosivity

Corrosivity (Langelier Saturation Index [LSI]) ranged from -0.7 to -1 during Cycle 9. The LSI is a measure of the degree of saturation with respect to calcium carbonate. A negative LSI indicates that the water will tend to dissolve calcium carbonate. A positive LSI indicates the water has a tendency to precipitate calcium carbonate. The LSI is used as a general rule-of-thumb indicator of the corrosivity of water. For example, water that tends to dissolve calcium carbonate (versus precipitate it) is more likely to be corrosive to steel. While a positive LSI is favorable with respect to a low potential for casing corrosion, it also may be deleterious because of the potential for clogging of the aquifer near the borehole resulting from the tendency of the water to precipitate calcium carbonate. The values for corrosivity indicate that source water and recovered water are only mildly corrosive and should not be of concern; this parameter will continue to be tracked during ASR activities.

Year 2006/2007 Monitoring and Operation

During the year 2006/2007 ASR season, approximately 290 MG of treated water will be injected and stored at the Sorrento site using ASR No. 1 and ASR No. 2. Normally, the City injects approximately 450 MG in a recharge season, but because approximately 160 MG of residual storage has been carried over from last year, only 290 MG are needed to meet its storage goal.

The City's ASR limited license does not have a volume limit prescribed to individual wells; however, the overall storage limit of ASR Limited License #002 is 1.2 billion gallons and because the limited license is a joint permit between the Tualatin Valley Water District and for the City of Beaverton, we have assumed the City's storage volume limit is 600 MG. The limited license does limit the amount of withdrawal per well to 1.5 million gallons per day (mgd). In the ASR No. 4 work plan addendum submitted to OWRD in November 2005, a request was made to change the limited license to allow the City to pump its ASR wells at a rate up to 3 mgd. The proposed increase in withdrawal rate of stored water will provide the City with greater operational flexibility in using its ASR wells at the Sorrento site and it will ensure that the City realizes its investment in designing and constructing ASR No. 4 as a 3-mgd water supply well. Moreover, it has been shown that the water level in the regional aquifer has increased due to ASR activities, and that pumping at higher rates, as outlined in the November 2005 addendum to OWRD, is anticipated to **not** negatively impact the basalt aquifer. Because no other native groundwater wells are located near the Sorrento site, that, too, is a non-issue related to pumping at higher rates. With that said and because water levels in the regional basalt aquifer have increased as a result of ASR, the option of allowing the City to pump more native groundwater under the ASR license or under a separate native groundwater limited license is something the City will be pursuing in the coming months with the OWRD.

During 2006/2007, the City intends to maintain the same monitoring network that was used last year (see Figure 1). After ASR No. 4 is online, it too will be monitored through the City's telemetry system with a dedicated transducer. The wells that will be monitored include the following:

- Hanson Road Well (ASR No. 1) - Transducer
- ASR No. 2 - Transducer
- Sorrento Observation well - Transducer
- Sage Place well - Transducer
- Davies Road well - Manual measurements
- Rubber Reservoir well - Transducer
- Maverick Street well - Manual measurements
- ASR No. 3 - Manual measurements
- SW 150th Court - Transducer
- Dernbach well - Transducer
- WASH 9205 - OWRD

This network of wells will continue to assist in evaluating the dynamic response of the regional aquifer to ASR activities and it will help the City in directing future ASR expansion. Currently, the City is evaluating two additional ASR sites: Dernbach and another site near

Previous Reports

CH2M Hill, June 1997. *Aquifer Storage and Recovery Hydrogeologic Feasibility Study of the Cooper Mountain Basalt Aquifer*, for Tualatin Valley Water District.

CH2M Hill, June 1997, *Aquifer Storage and Recovery Pilot Test Work Plan and Wellhead Facility Design*, for Tualatin Valley Water District.

CH2M Hill, March 1999, *Aquifer Storage and Recovery Pilot Test Work Plan Addendum*, for City of Beaverton.

CH2M Hill, July 1997. *Hanson Road Well Aquifer Storage and Recovery – Cycle 1 Pilot Test Results*, for City of Beaverton

CH2M Hill, January 2000, *Hanson Road Well – Cycle 2 ASR Pilot Test Results*, for City of Beaverton.

CH2M Hill, February 2001, *City of Beaverton Hanson Road Well – Cycle 3 ASR Pilot Test Results*, for City of Beaverton.

CH2M Hill and Groundwater Solutions, March 2002, *City of Beaverton – Cycle 4 ASR Pilot Test Results*, for City of Beaverton.

CH2M Hill, September 2001, *Wellhead Protection Study, Hanson Road Faculty (Hanson Road Well and ASR No. 2)*, for City of Beaverton

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Tables

Table 5

Cycle 9 ASR Water Quality Data

City of Beaverton ASR Program - Sorrento Water Works Facility

Category	Analyte	Regulatory Standard	Regulatory Criteria	Units Standards	Baseline Groundwater	Source Water			Recovered Water	
					HNSN-C9GW 11/10/2005	HNSN-C9SW-1 12/29/2005 0% Injected	HNSN-C9SW-2 3/9/2006 50% Injected	HNSN-C9SW-3 5/11/2006 96% Injected	HNSN-C9R-1B 6/13/2006 9% Recovered	HNSN-C9R-2 11/29/2006 90% Recovered
Bacteriological	Total Coliform	<1 per 100 mL	MML	CFU/100 ml		1.1 U				
Disinfection by-Products	Bromodichloromethane	None	None	mg/L	0.0044	0.0033			0.0055	0.004
	Bromoform (Tribromomethane)	0.08	MCL	mg/L	0.0005 U	0.0005 U			0.0005 U	0.0005 U
	Chlorodibromomethane	0.08	MCL	mg/L	0.0006	0.0005 U			0.0007	0.0006
	Chloroform (Trichloromethane)	0.08	None	mg/L	0.026	0.025			0.031	0.025
	Total Trihalomethanes	0.08	MCL	mg/L	0.031	0.028			0.037	0.03
	Dibromoacetic Acid	None	None	mg/L	0.001 U	0.001 U			0.001 U	0.001 U
	Dichloroacetic Acid	0.06	MCL	mg/L	0.001	0.018			0.001 U	0.001 U
	Monobromoacetic Acid	None	None	mg/L	0.001 U	0.001 U			0.001 U	0.001 U
	Monochloroacetic Acid	0.06	MCL	mg/L	0.002 U	0.002 U			0.002 U	0.002 U
	Trichloroacetic Acid	0.06	MCL	mg/L	0.0014	0.021			0.001 U	0.0054
	Total Haloacetic Acids	0.06	MCL	mg/L	0.0024	0.039			0.001 U	0.0054
Field Parameters	Dissolved Oxygen	None	None	mg/L	8.7		9.39	8.5	8.42	9.51
	ORP	None	None	mV			663	651	189	625
	pH	6.5 - 8.5 standard units	SMCL	pH	6.85		7.81	7.94	7.4	7.28
	Specific Conductance	None	None	mS/cm	0.191		0.122	0.123	0.132	0.16
	Temperature	None	None	degC	11		7.88	12.06	11.52	10.45
	Turbidity	1 NTU	MCL, MML	NTU		0.35		0.11	0.3	0.4
Geochemical	Bicarbonate	None	None	mg/L	78	24		36.5	45	64
	Calcium	None	None	mg/L	18	7.2		9.5	10	16
	Carbonate	None	None	mg/L	2 U	2 U		2 U	2 U	2 U
	Chloride	250	SMCL, MML	mg/L	24	4.9		5.2	5.7	12
	Hardness (as CaCO3)	250	SMCL	mg/L	68.8	27		35.7	38	61
	Magnesium	None	None	mg/L	5.8	2.1		2.9	3.1	5
	Nitrate as N	10	MCL, MML	mg/L	1	1		0.29	0.44	0.51
	Nitrate+Nitrite	10	MCL	mg/L	1	1		0.29	0.44	0.51
	Nitrite as N	1	MCL	mg/L	0.2 U	0.1 U		0.1 U	0.1 U	0.1 U
	Potassium	None	None	mg/L	1.2	1 U		1 U	1 U	1.2
	Silica	None	None	mg/L	39	16		18	30	34
	Sodium	20	MCLG	mg/L	12	11		10	10	13
	Sulfate	250	SMCL, MML	mg/L	23	14		16	11	10
	Total Alkalinity	None	None	mg/L	64	24		30	40	53
	Total Dissolved Solids	500	SMCL, MML	mg/L	160	70		80	78	106
	Total Organic Carbon	None	None	mg/L	0.6	0.97		0.83	0.49	0.59
	Total Suspended Solids	None	None	mg/L	10 U	10 U		10 U	10 U	10 U
Metals	Aluminum	0.05 - .2	SMCL	mg/L	0.025 U	0.025 U		0.025 U	0.025 U	0.02 U
	Antimony	0.006	MCL	mg/L	0.001 U	0.001 U		0.001 U	0.001 U	0.001 U
	Arsenic	0.01	MCL	mg/L	0.001 U	0.001 U		0.001 U	0.001 U	0.001 U
	Barium	2	MML	mg/L	0.0042	0.0062		0.0053	0.0045	0.0045
	Beryllium	0.004	MCL	mg/L	0.001 U	0.001 U		0.001 U	0.001 U	0.001 U
	Cadmium	0.005	MCL	mg/L	0.0005 U	0.0005 U		0.0005 U	0.0005 U	0.0005 U
	Chromium	0.05	MML	mg/L	0.001 U	0.001 U		0.001 U	0.001 U	0.0012
	Copper	1	MCL	mg/L	0.0025	0.01		0.002 U	0.002	0.0025
	Iron, Dissolved	0.3	SMCL, MML	mg/L	0.02 U	0.02 U		0.02 U	0.02 U	0.02 U
	Iron, Total	0.3	SMCL	mg/L	0.02 U	0.02 U		0.02 U	0.02 U	0.026
	Lead	0.015	Action Level	mg/L	0.0005 U	0.0005 U		0.0005 U	0.0005 U	0.0005 U
	Manganese, Dissolved	0.05	SMCL, MML	mg/L	0.0031			0.002 U	0.002 U	0.002 U
	Manganese, Total	0.05	SMCL	mg/L	0.002 U	0.002 U		0.002 U	0.002 U	0.002 U
	Mercury	0.002	MCL, MML	mg/L	0.0002 U	0.0002 U		0.0002 U	0.0002 U	0.0002 U
	Nickel	None	None	mg/L	0.005 U	0.005 U		0.005 U	0.005 U	0.005 U
	Selenium	0.05	MML	mg/L	0.005 U	0.005 U		0.005 U	0.005 U	0.005 U
	Silver	0.05	MML	mg/L	0.0005 U	0.0005 U		0.0005 U	0.0005 U	0.0005 U
	Thallium	0.002	MCL	mg/L	0.001 U	0.001 U		0.001 U	0.001 U	0.001 U
	Zinc	5	SMCL, MML	mg/L	0.005 U	0.005 U		0.005 U	0.005 U	0.005 U
Miscellaneous	Color	15 standard units	SMCL, MML	ACU		3			3 U	3
	Corrosivity (Langelier Saturation Index)	Non-Corrosive	SMCL	mg/L	-0.7	-0.2		-1	-0.9	-0.5
	Cyanide	0.2	MCL, MML	mg/L		0.025 U		0.025 U	0.025 U	0.005 U
	Fluoride	2	MML, SMCL	mg/L				0.75	0.66	0.54
	Methylene Blue Active Substance	0.5	SMCL, MML	mg/L		0.05 U		0.05 U	0.05 U	0.05 U
	Odor	3 threshold #s	SMCL, MML	TON		2		4	1	1
Radionuclides	Gross Alpha	15	MCL, MML	pCi/L		3 U			3	
	Gross Beta	50 pCi/L	MML			3 U			3	
	Radon 222, Two Sigma Error			pCi/L	16	2.3			21	23
	Radon-222			pCi/L	436	50 U			562	630
	Uranium	0.03		mg/L		0.001 U				

Table 5
Cycle 9 ASR Water Quality Data
City of Beaverton ASR Program - Sorrento Water Works Facility

					Baseline Groundwater	Source Water			Recovered Water	
Category	Analyte	Regulatory Standard	Regulatory Criteria	Units Standards	HNSN-C9GW 11/10/2005	HNSN-C9SW-1 12/29/2005 0% Injected	HNSN-C9SW-2 3/9/2006 50% Injected	HNSN-C9SW-3 5/11/2006 96% Injected	HNSN-C9R-1B 6/13/2006 9% Recovered	HNSN-C9R-2 11/29/2006 90% Recovered
Synthetic Organic Compounds	2,4,5-TP	0.01	MML	mg/L		0.0002 U			0.0002 U	
	2,4-D	0.07	MCL	mg/L		0.0001 U			0.0001 U	
	3-Hydroxycarbofuran	None	None	mg/L		0.0005 U			0.0005 U	
	Alachlor (Lasso)	0.002	MCL	mg/L		0.0001 U			0.0001 U	
	Aldicarb	None	None	mg/L		0.0005 U			0.0005 U	
	Aldicarb Sulfone	None	None	mg/L		0.0005 U			0.0005 U	
	Aldicarb Sulfoxide	None	None	mg/L		0.0005 U			0.0005 U	
	Aldrin	None	None	mg/L		0.00001 U			0.00001 U	
	Aroclor-1016	None	None	mg/L		0.00007 U			0.00007 U	
	Aroclor-1221	None	None	mg/L		0.0001 U			0.0001 U	
	Aroclor-1232	None	None	mg/L		0.0001 U			0.0001 U	
	Aroclor-1242	None	None	mg/L		0.0001 U			0.0001 U	
	Aroclor-1248	None	None	mg/L		0.0001 U			0.0001 U	
	Aroclor-1254	None	None	mg/L		0.0001 U			0.0001 U	
	Aroclor-1260	None	None	mg/L		0.0001 U			0.0001 U	
	Atrazine	0.003	MCL	mg/L		0.00005 U			0.00005 U	
	Benzo (a) pyrene	0.0002	MCL	mg/L		0.00002 U			0.00002 U	
	BHC-gamma (Lindane)	0.0002	MCL, MML	mg/L		0.00001 U			0.00001 U	
	Butachlor	None	None	mg/L					0.00005 U	
	Carbaryl	None	None	mg/L		0.0005 U			0.0005 U	
	Carbofuran	0.04	None	mg/L		0.0005 U			0.0005 U	
	Chlordane	0.002	MCL	mg/L		0.0001 U			0.0001 U	
	Dalapon	0.2	MCL	mg/L		0.001 U			0.001 U	
	Di-(2-Ethylhexyl)adipate	0.4	MCL	mg/L		0.0006 U			0.0006 U	
	Di-(2-Ethylhexyl)phthalate	0.006	MCL	mg/L		0.0006 U			0.0006 U	
	Dibromochloropropane (DBCP)	0.0002	MCL	mg/L		0.00001 U			0.00001 U	
	Dicamba	None	None	mg/L		0.00008 U			0.00008 U	
	Dieldrin	None	None	mg/L		0.00001 U			0.00001 U	
	Diethyl Phthalate	None	None	mg/L					0.0005 U	
	Dimethyl Phthalate	None	None	mg/L					0.0005 U	
	di-n-Butylphthalate	None	None	mg/L					0.001 U	
	Dinoseb	0.007	MCL	mg/L		0.0002 U			0.0002 U	
	Diquat	0.02	MCL	mg/L		0.0004 U			0.0004 U	
	Endothall	0.1	MCL	mg/L		0.005 U			0.005 U	
	Endrin	0.0002	MML	mg/L		0.00001 U			0.00001 U	
	Ethylene Dibromide (EDB)	0.00005	MCL	mg/L		0.00001 U			0.00001 U	
	Glyphosate	0.7	MCL	mg/L		0.006 U			0.006 U	
	Heptachlor	0.0004	MCL	mg/L		0.00001 U			0.00001 U	
	Heptachlor Epoxide	0.0002	MCL	mg/L		0.00001 U			0.00001 U	
	Hexachlorobenzene	0.001	MCL	mg/L		0.00005 U			0.00005 U	
	Hexachlorocyclopentadiene	0.05	MCL	mg/L		0.00005 U			0.00005 U	
	Methomyl	None	None	mg/L		0.0005 U			0.0005 U	
	Methoxychlor	0.04	MCL	mg/L		0.00005 U			0.00005 U	
	Metolachlor	None	None	mg/L					0.00005 U	
	Metribuzin	None	None	mg/L					0.00005 U	
	Pentachlorophenol	0.001	MCL	mg/L		0.00004 U			0.00004 U	
	Picloram	0.5	MCL	mg/L		0.0001 U			0.0001 U	
	Polychlorinated Biphenyls (PCBs)	0.0005	MCL	mg/L					0.00007 U	
	Propachlor	None	None	mg/L					0.00005 U	
	Simazine	0.004	MCL	mg/L		0.00005 U			0.00005 U	
	Toxaphene	0.003	MCL	mg/L		0.0005 U			0.0005 U	
	Vydate	0.2	MCL	mg/L		0.0005 U			0.0005 U	

Table 5
Cycle 9 ASR Water Quality Data
City of Beaverton ASR Program - Sorrento Water Works Facility

Category	Analyte	Regulatory Standard	Regulatory Criteria	Units Standards	Baseline Groundwater: HNSN-C9GW 11/10/2005	Source Water: HNSN-C9SW-1 12/29/2005 0% Injected	Source Water: HNSN-C9SW-2 3/9/2006 50% Injected	Source Water: HNSN-C9SW-3 5/11/2006 96% Injected	Recovered Water: HNSN-C9R-1B 6/13/2006 9% Recovered	Recovered Water: HNSN-C9R-2 11/29/2006 90% Recovered
Volatile Organic Compounds	1,1,1,2-Tetrachloroethane	None	None	mg/L		0.0005 U			0.0005 U	
	1,1,1-Trichloroethane	0.2	MCL, MML	mg/L		0.0005 U			0.0005 U	
	1,1,2,2-Tetrachloroethane	None	None	mg/L		0.0005 U			0.0005 U	
	1,1,2-Trichloroethane	0.005	MCL	mg/L		0.0005 U			0.0005 U	
	1,1-Dichloroethane	None	None	mg/L		0.0005 U			0.0005 U	
	1,1-Dichloroethene	0.007	MCL, MML	mg/L		0.0005 U			0.0005 U	
	1,1-Dichloropropene	None	None	mg/L		0.0005 U			0.0005 U	
	1,2,3-Trichloropropane	None	None	mg/L		0.0005 U			0.0005 U	
	1,2,4-Trichlorobenzene	0.07	MCL	mg/L		0.0005 U			0.0005 U	
	1,2,4-Trimethylbenzene	None	None	mg/L		0.0005 U			0.0005 U	
	1,2-Dichloroethane	0.005	MCL, MML	mg/L		0.0005 U			0.0005 U	
	1,2-Dichloroethene (Cis)	0.07	MCL	mg/L		0.0005 U			0.0005 U	
	1,2-Dichloropropane	0.005	MCL, MML	mg/L		0.0005 U			0.0005 U	
	1,3-Dichloropropane	None	None	mg/L		0.0005 U			0.0005 U	
	1,3-Dichloropropene	None	None	mg/L					0.0005 U	
	2,2-Dichloropropane	None	None	mg/L		0.0005 U			0.0005 U	
	Benzene	0.005	MCL	mg/L		0.0005 U			0.0005 U	
	Bromobenzene	None	None	mg/L		0.0005 U			0.0005 U	
	Bromodichloromethane*	0.08	MCL	mg/L		0.003			0.0052	
	Bromoform (Tribromomethane)*	0.08	MCL	mg/L		0.0005 U			0.0005 U	
	Bromomethane	None	None	mg/L		0.0005 U			0.0005 U	
	Carbon Tetrachloride	0.005	MCL, MML	mg/L		0.0006 U			0.0005 U	
	Chlorodibromomethane*	0.08	MCL	mg/L		0.0005 U			0.0005	
	Chloroethane	None	None	mg/L		0.0005 U			0.0005 U	
	Chloroform (Trichloromethane)*	0.08	None	mg/L		0.026			0.033	
	Chloromethane	None	None	mg/L		0.0005 U			0.0005 U	
	Cis-1,3-Dichloropropene	None	None	mg/L		0.0005 U			0.0005 U	
	Dibromomethane	None	None	mg/L		0.0005 U			0.0005 U	
	Dichloromethane	0.005	MCL	mg/L		0.0005 U			0.0005 U	
	Ethylbenzene	0.7	MCL	mg/L		0.0005 U			0.0005 U	
	M-dichlorobenzene	None	None	mg/L		0.0005 U			0.0005 U	
	Monochlorobenzene	0.1	MCL	mg/L		0.0005 U			0.0005 U	
	O-Chlorotoluene	None	None	mg/L		0.0005 U			0.0005 U	
	O-Dichlorobenzene	0.6	MCL	mg/L		0.0005 U			0.0005 U	
	P-Chlorotoluene	None	None	mg/L		0.0005 U			0.0005 U	
	P-Dichlorobenzene	0.075	MCL, MML	mg/L		0.0005 U			0.0005 U	
	Styrene	0.1	MCL	mg/L		0.0005 U			0.0005 U	
	Tetrachloroethylene	0.005	MCL, MML	mg/L		0.0005 U			0.0005 U	
	Toluene	1	MCL	mg/L		0.0005 U			0.0005 U	
	Total Trihalomethanes*	0.08	MCL	mg/L		0.029			0.039	
	Trans-1,2-Dichloroethene	0.1	MCL	mg/L		0.0005 U			0.0005 U	
	Trichloroethene	0.005	MCL	mg/L		0.0005 U			0.0005 U	
	Vinyl Chloride	0.002	MCL, MML	mg/L		0.0003 U			0.0003 U	
	Xylenes, Total	10	MCL	mg/L		0.0005 U			0.0005 U	

Notes:
Blank cell indicates analyate not tested.
U = Analyte not detected at indicated detection limit.
* = These VOCs are part of the trihalomethane family of disinfection by-products.

Table 6

YEAR 2007 -- COB ASR No. 1(Hanson Road Well): Cycle 10 (Year 10)

Input Values in Yellow Cells

Estimated -- QA needed

AVERAGE Injection Rate:	800	(gpm)				Previous Year Carrryover
AVERAGE Recovery Rate:	800	(gpm)			gallons	80,400,000
Injection Start Date	Thursday 2/1/2007 11:45 AM					
Injection End Date	Sunday 4/15/07 12:00 AM					
Elapsed Injection Days		72.5	days			
Elapsed Injection Hours		1740	hours			
	Target	83,532,000	gallons injected at injection rate			
Total Planned Injection Volume (MG)*		163.9	MG Total with Carryover			
Storage Start Date	Sunday 4/15/07 12:00 AM					
Storage End Date	Friday 6/15/07 12:00 AM					
Elapsed Storage Days		61.0				
Elapsed Storage Hours		1464				
Total Planned Recovery Volume		155.74	Assume	95%	Recovered	
Recovery Start Date	Friday 6/15/07 12:00 AM					
Days Required to Recover 100% of Injection Volume	Sunday 11/4/07 7:15 AM	142.3				
Days Required to Recover Planned Volume	Sunday 10/28/07 4:29 AM	135.2	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 11/29/06 12:00 PM	-	FP, DBP, GC, & **Radon**	HNSN-C10GW			
Injection Period								
Source	0%	Thursday 2/1/07 12:00 PM	0	FP, GC, DBP, & SDWA,	HNSN-C10SW-1			
Source	50%	Friday 3/9/07 6:07 PM	36	FP only	HNSN-C10SW-2			
Source	100%	Sunday 4/15/07 12:15 AM	73	FP, & GC	HNSN-C10SW-3			
Storage Period								
Stored	50%	Tuesday 5/15/07 12:00 PM	31	FP, GC, DBP **& Radon**	HNSN-C10T-1			
Stored	100%	Friday 6/15/07 12:00 AM	61	Bac-T -- City	HNSN-C10T-2			
Recovery Period								
Recovered	0%	Friday 6/15/07 12:00 AM	0	FP, GC, DBP, SDWA, & **, Radon**	HNSN-C10R-1			
Recovered	50%	Saturday 8/25/07 3:37 AM	71	FP, GC & DBP	HNSN-C10R-3			
Recovered	75%	Saturday 9/29/07 5:26 PM	107	FP & GC	HNSN-C10R-4			
Recovered	95%	Sunday 10/28/07 4:29 AM	135	FP, GC, DBP & **Radon**	HNSN-C10R-5			

Notes:

FP = Field Parameters

GC = Geochemical Parameters

DBP = Disinfection By-Products

SDWA = Safe Drinking Water Act Parameters (Oregon Dept of Health, EPA and DEQ recent water quality parameter list)

Radon = Radon in drinking water analysis, SM 7500 or EPA 913.0

* Includes carryover from previous year

Table 7

YEAR 2007 -- COB ASR No. 2: Cycle 7 (Year 10 in the Program)

Modified 2/12/2007

Input Values in Yellow Cells

AVERAGE Injection Rate:	1100	(gpm)				Previous Year Carrryover
AVERAGE Recovery Rate:	1400	(gpm)		gallons		80,400,000
Injection Start Date	Tuesday 12/19/2006 11:45 AM					
Injection End Date	Sunday 4/15/07 12:00 AM					
Elapsed Injection Days		116.5	days			
Elapsed Injection Hours		2796	hours			
	Target	184,552,500	gallons injected at injection rate			
Total Planned Injection Volume (MG)*		265.0	MG Total with Carryover			
Storage Start Date	Sunday 4/15/07 12:00 AM					
Storage End Date	Tuesday 6/19/07 12:00 AM					
Elapsed Storage Days		65.0				
Elapsed Storage Hours		1560				
Total Planned Recovery Volume		251.70	Assume	95%	Recovered	
Recovery Start Date	Tuesday 6/19/07 12:00 AM					
Days Required to Recover 100% of Injection Volume	Sunday 10/28/07 10:11 AM	131.4				
Days Required to Recover Planned Volume	Sunday 10/21/07 8:29 PM	124.9	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	-	Sunday 12/3/06 11:45 AM	-	FP	ASR2-C7GW	N/A		
Injection Period								
Source	0%	Sunday 12/3/06 11:45 AM	0	FP	ASR2-C7SW-1	N/A		
Source	50%	Tuesday 1/30/07 5:52 PM	58	FP	ASR2-C7SW-2	N/A		
Source	100%	Friday 3/30/07 12:00 AM	117	FP	ASR2-C7SW-3	N/A		
Storage Period								
Stored	50%	Thursday 5/17/07 12:00 PM	33	FP	ASR2-C7T-1	N/A		
Stored	75%	Saturday 6/2/07 6:00 PM	49	FP	ASR2-C7T-2	N/A		
Recovery Period								
Recovered	0%	Tuesday 6/19/07 4:43 AM	0	Bac-T (City)	ASR2-C7R-1	N/A		
Recovered	25%	Saturday 7/21/07 8:32 PM	33	FP	ASR2-C7R-2	N/A		
Recovered	50%	Thursday 8/23/07 5:05 PM	66	FP	ASR2-C7R-3	N/A		
Recovered	75%	Tuesday 9/25/07 1:38 PM	99	FP	ASR2-C7R-4	N/A		
Recovered	100%	Sunday 10/28/07 10:11 AM	131	FP & GC	ASR2-C7R-5	N/A		

Notes:

FP = Field Parameters

GC = Geochemical Parameters

DBP = Disinfection By-Products

SDWA = Safe Drinking Water Act Parameters (Oregon Dept of Health, EPA and DEQ recent water quality parameter list)

Radon = Radon in drinking water analysis, SM 7500 or EPA 913.0

* Includes Carrryover from previous year

Figures

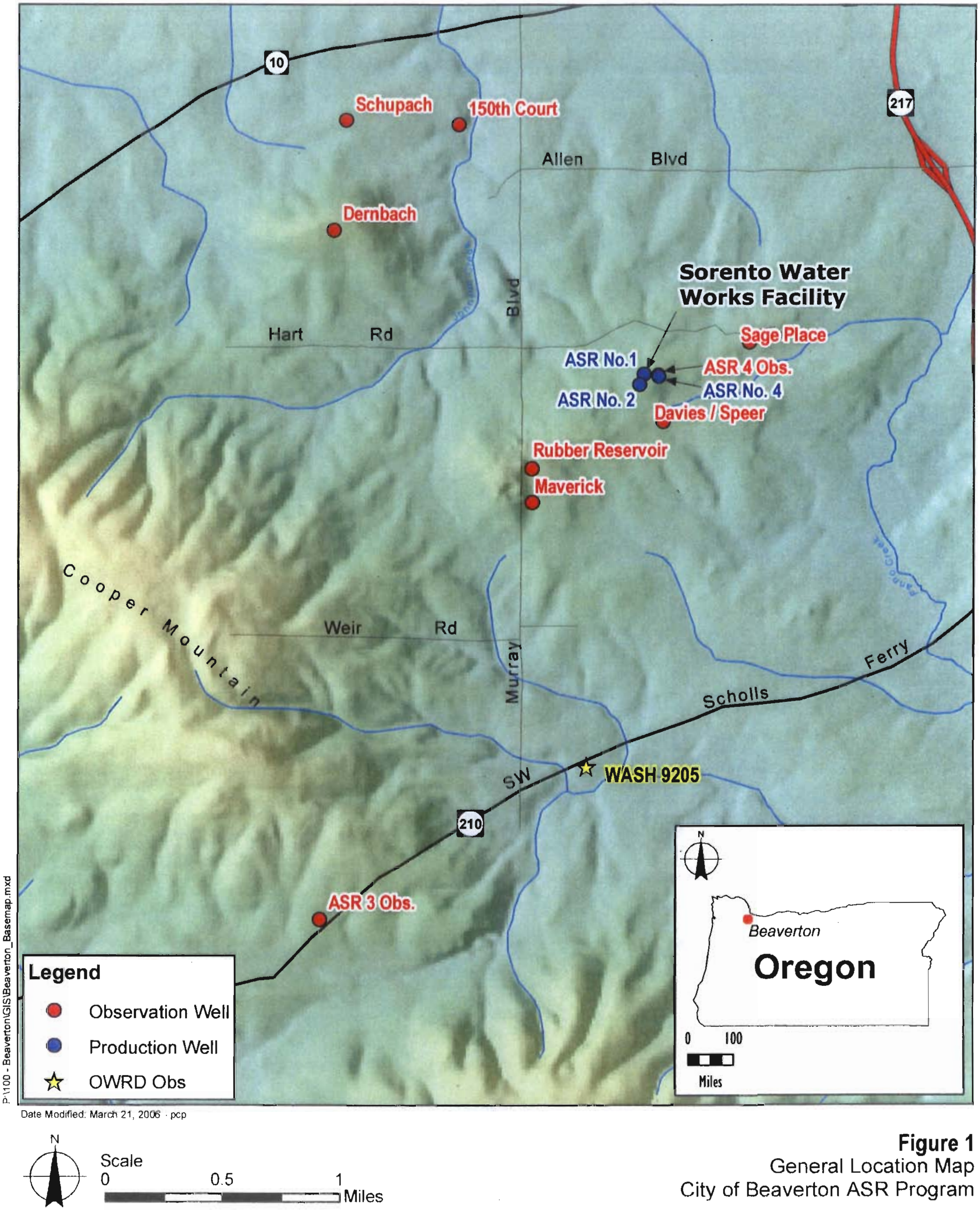
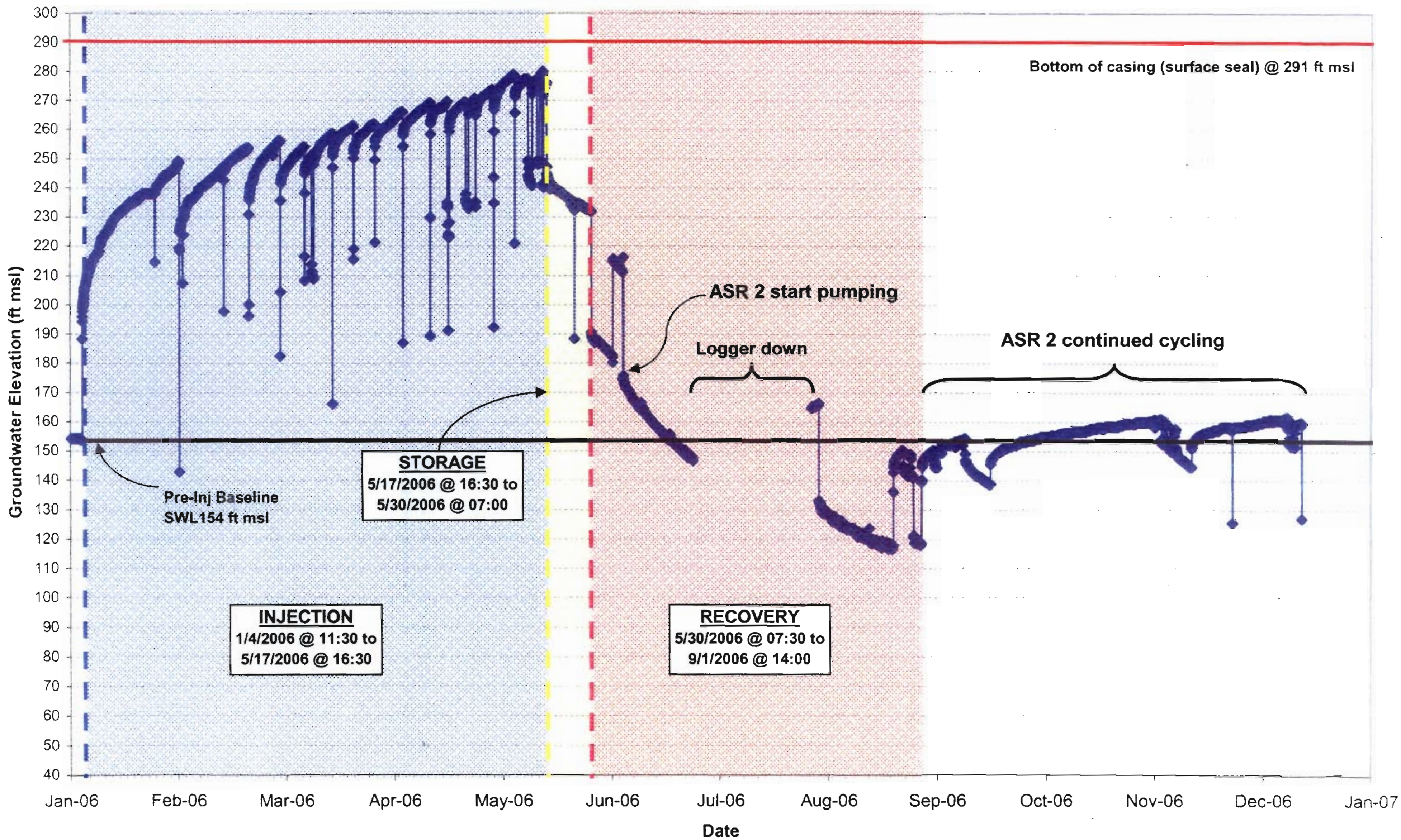


Figure 1
General Location Map
City of Beaverton ASR Program

Figure 2
ASR No. 1 Groundwater Elevation
City of Beaverton ASR Program



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Last modified 4/30/2007 by pcpalmer

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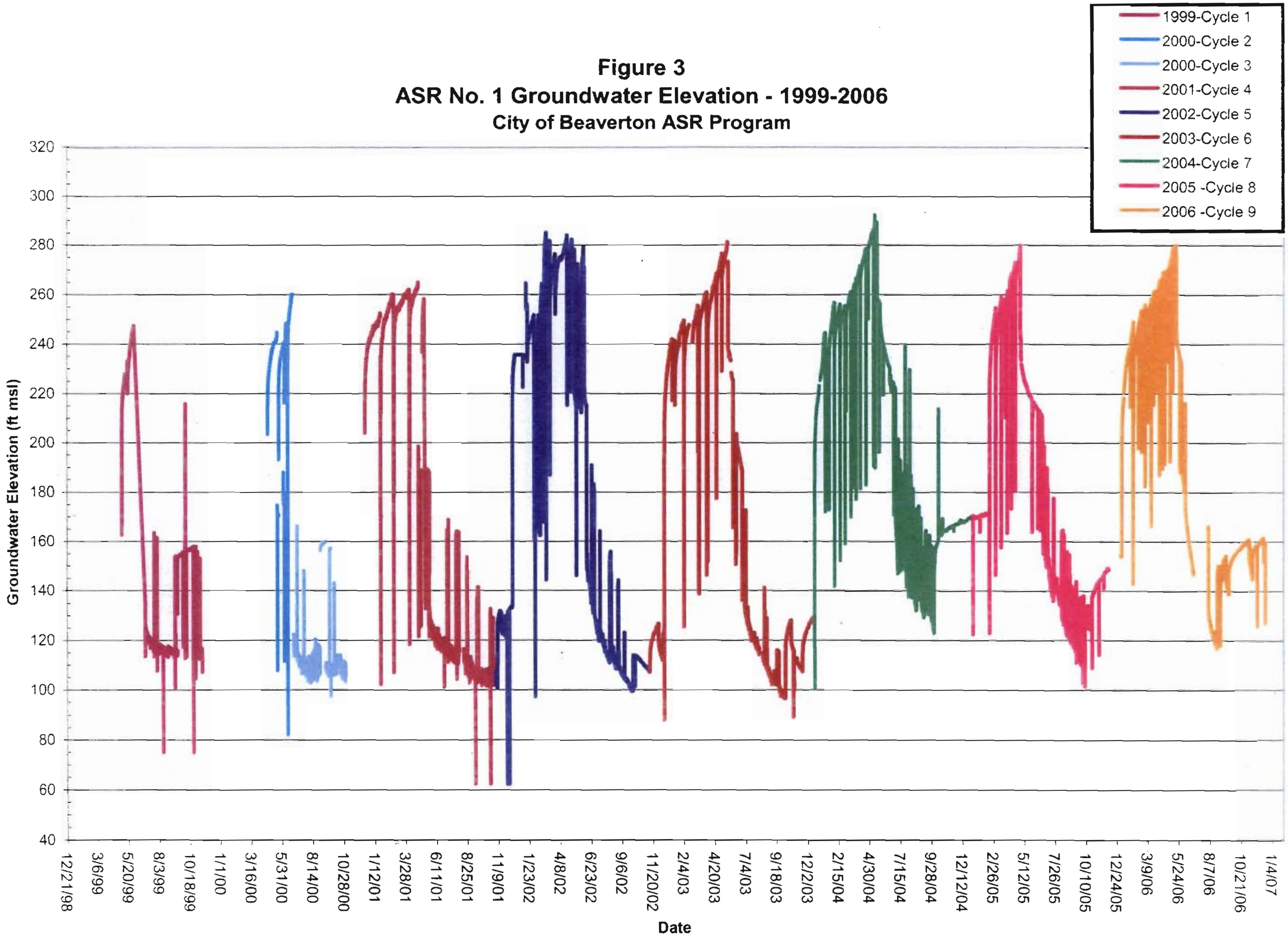

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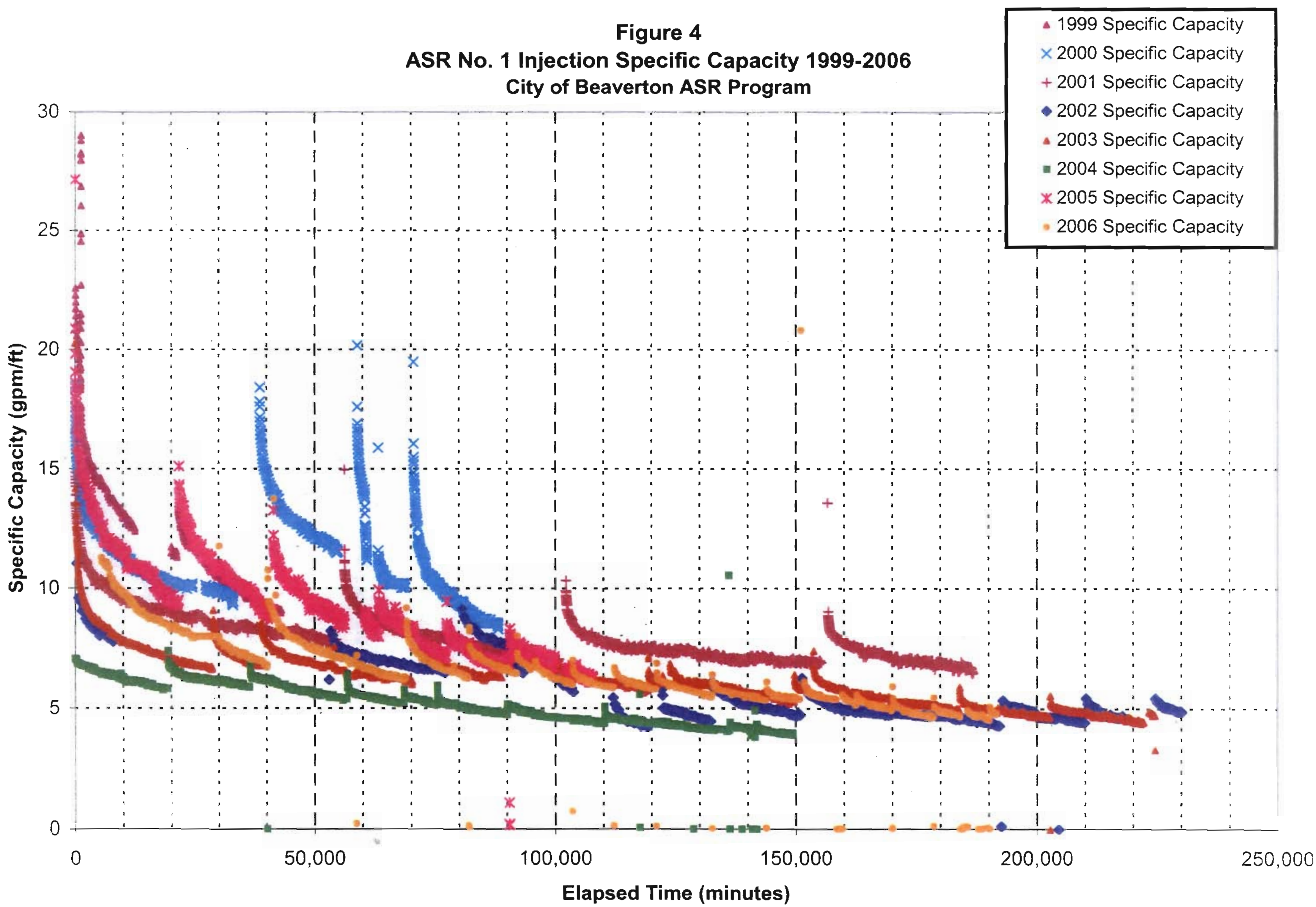

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Figure 5
ASR No. 1 - Recovery Specific Capacity 1999-2006
City of Beaverton ASR Program

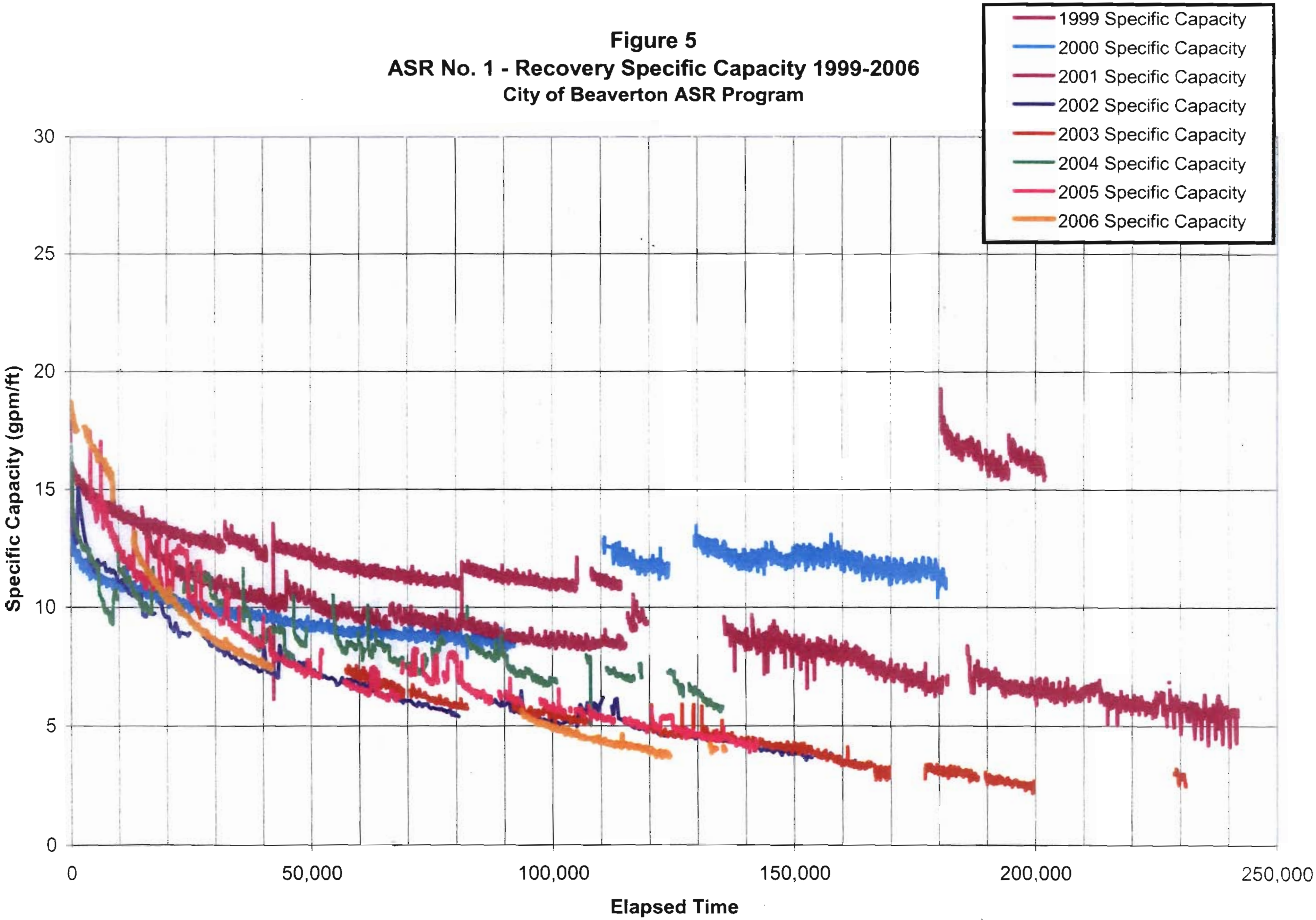

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Figure 6
ASR No. 2 Groundwater Elevation
City of Beaverton ASR Program

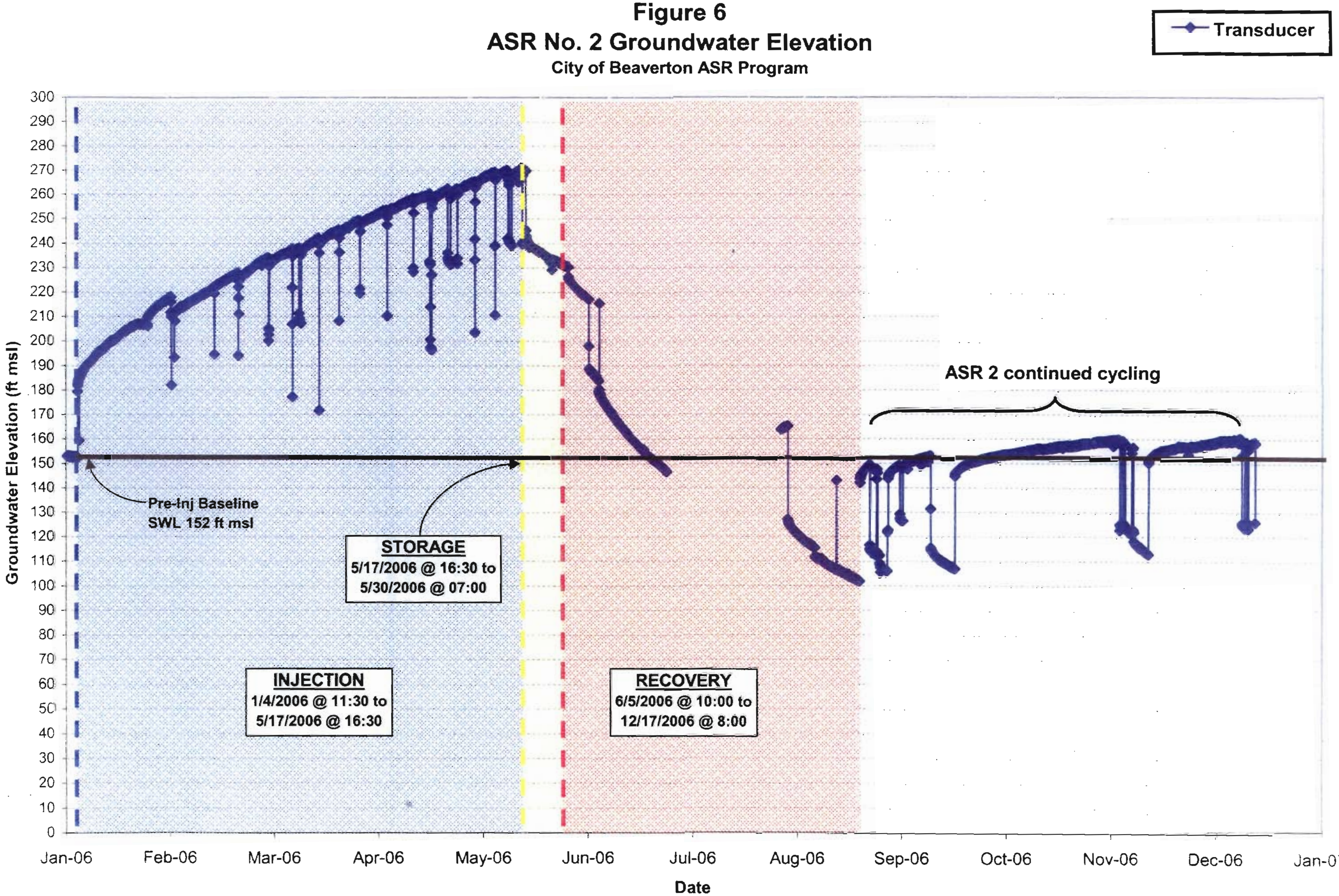

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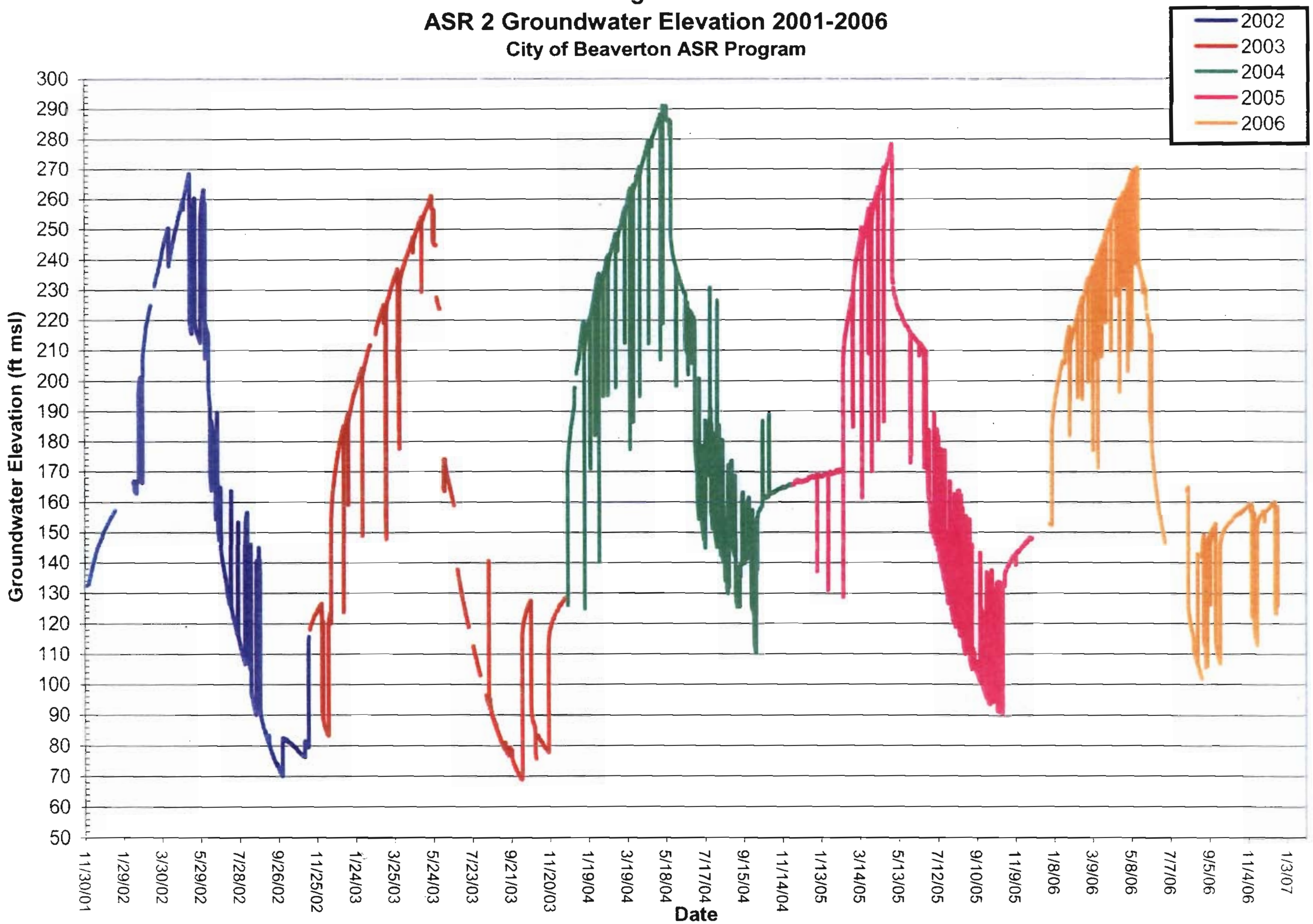
Figure 7
ASR 2 Groundwater Elevation 2001-2006
City of Beaverton ASR Program



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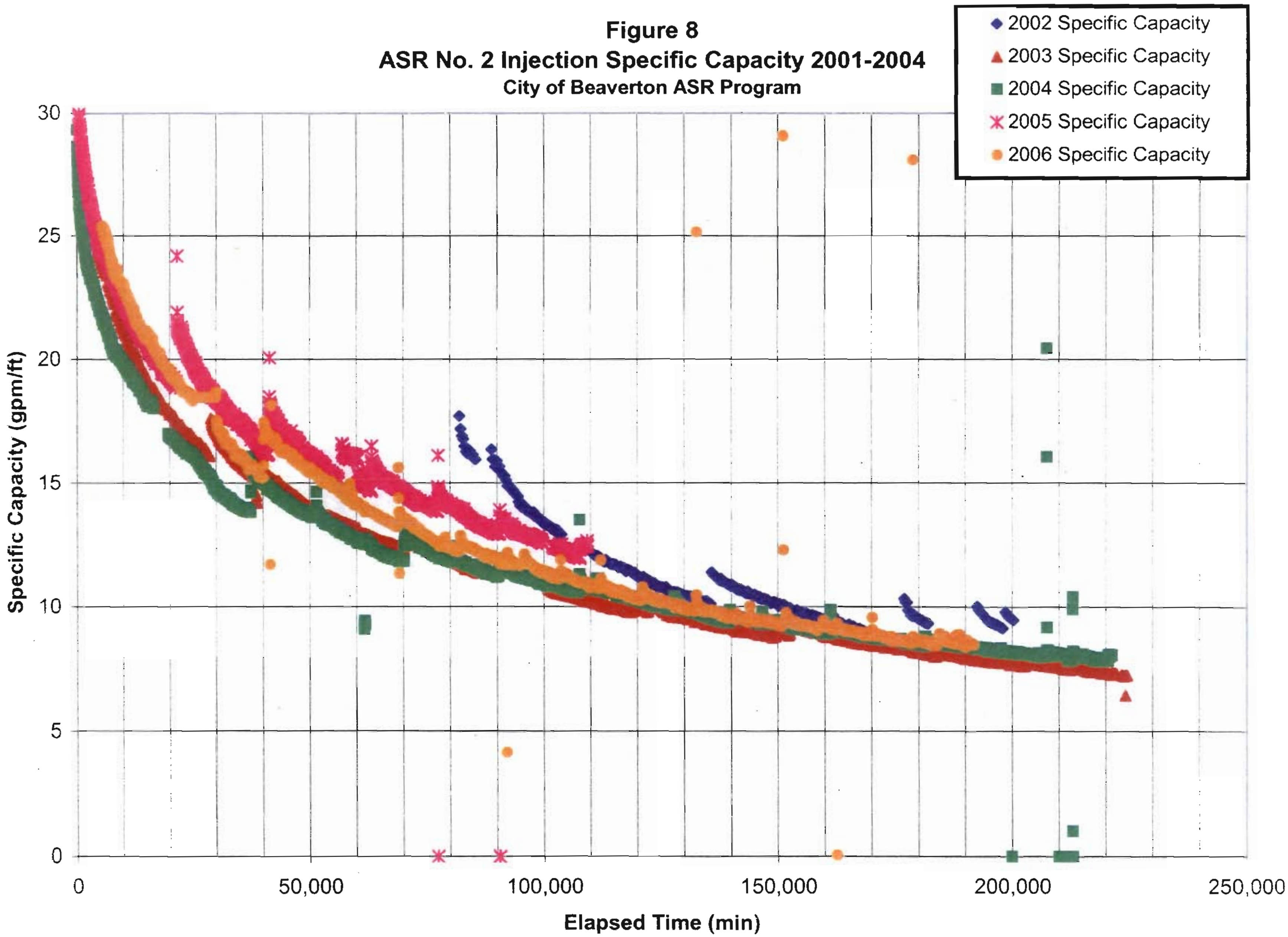

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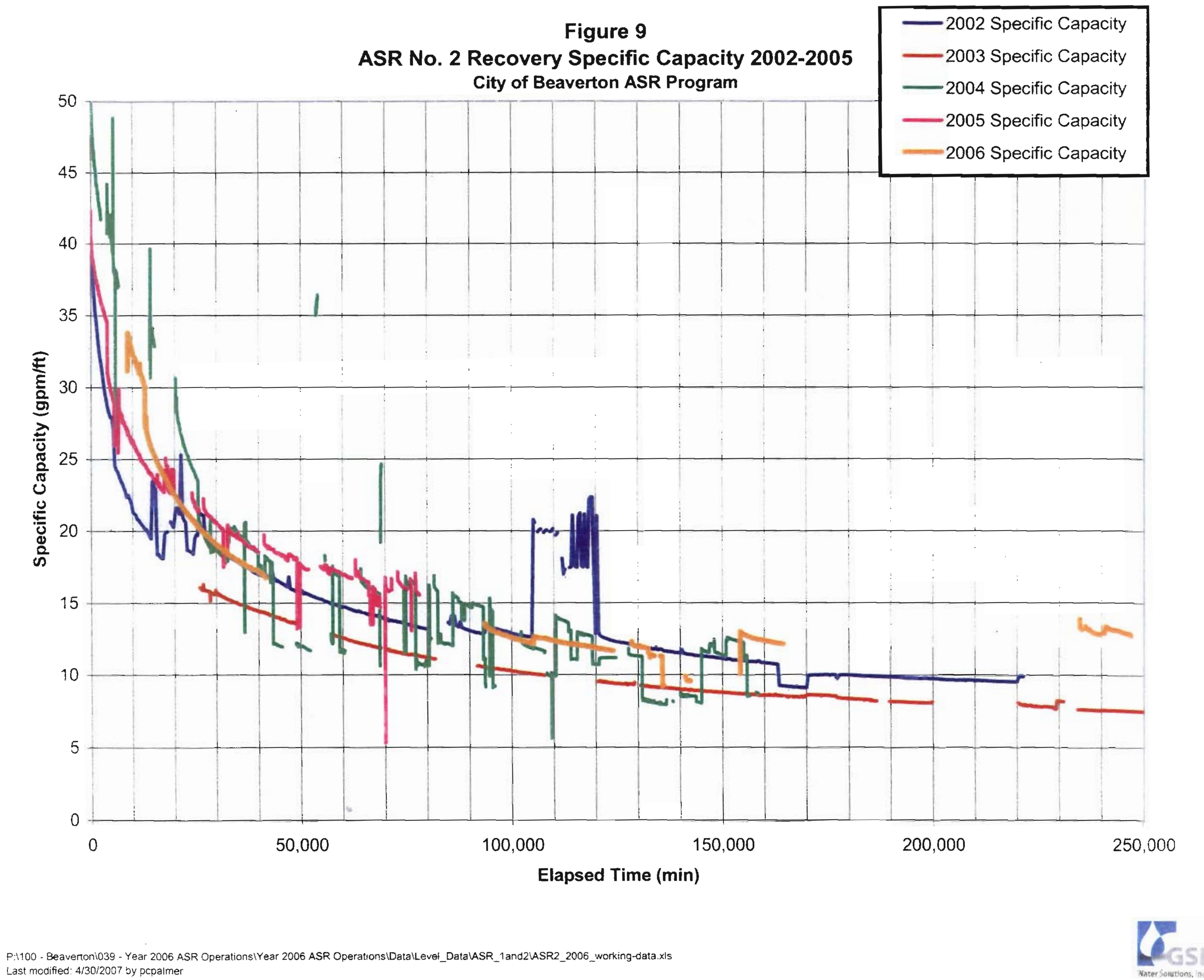
Figure 9
ASR No. 2 Recovery Specific Capacity 2002-2005
City of Beaverton ASR Program
2002 Specific Capacity
2003 Specific Capacity
2004 Specific Capacity
2005 Specific Capacity
2006 Specific Capacity
Specific Capacity (gpm/ft)
50
45
40
35
30
25
20
15
10
5
0
0
50,000
100,000
150,000
200,000
250,000
Elapsed Time (min)
P:\100 - Beaverton\039 - Year 2006 ASR Operations\Year 2006 ASR Operations\Data\Level_Data\ASR_1and2\ASR2_2006_working-data.xls
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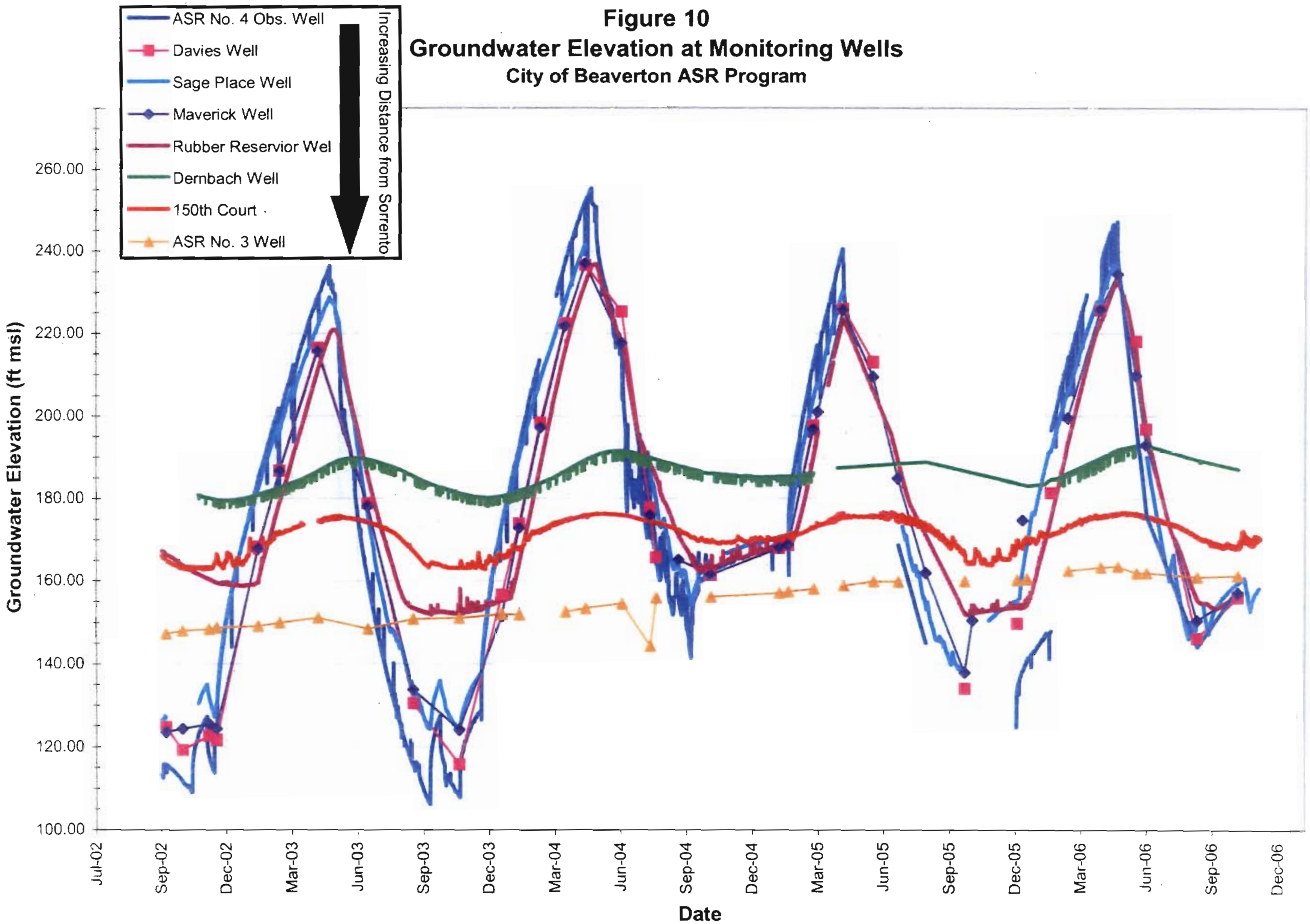
Figure 10
Groundwater Elevation at Monitoring Wells
City of Beaverton ASR Program



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Last modified: 4/30/2007 by pcpalmer

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Figure 11
Groundwater Elevation and Precipitation at 150th Court Seep
City of Beaverton ASR Program

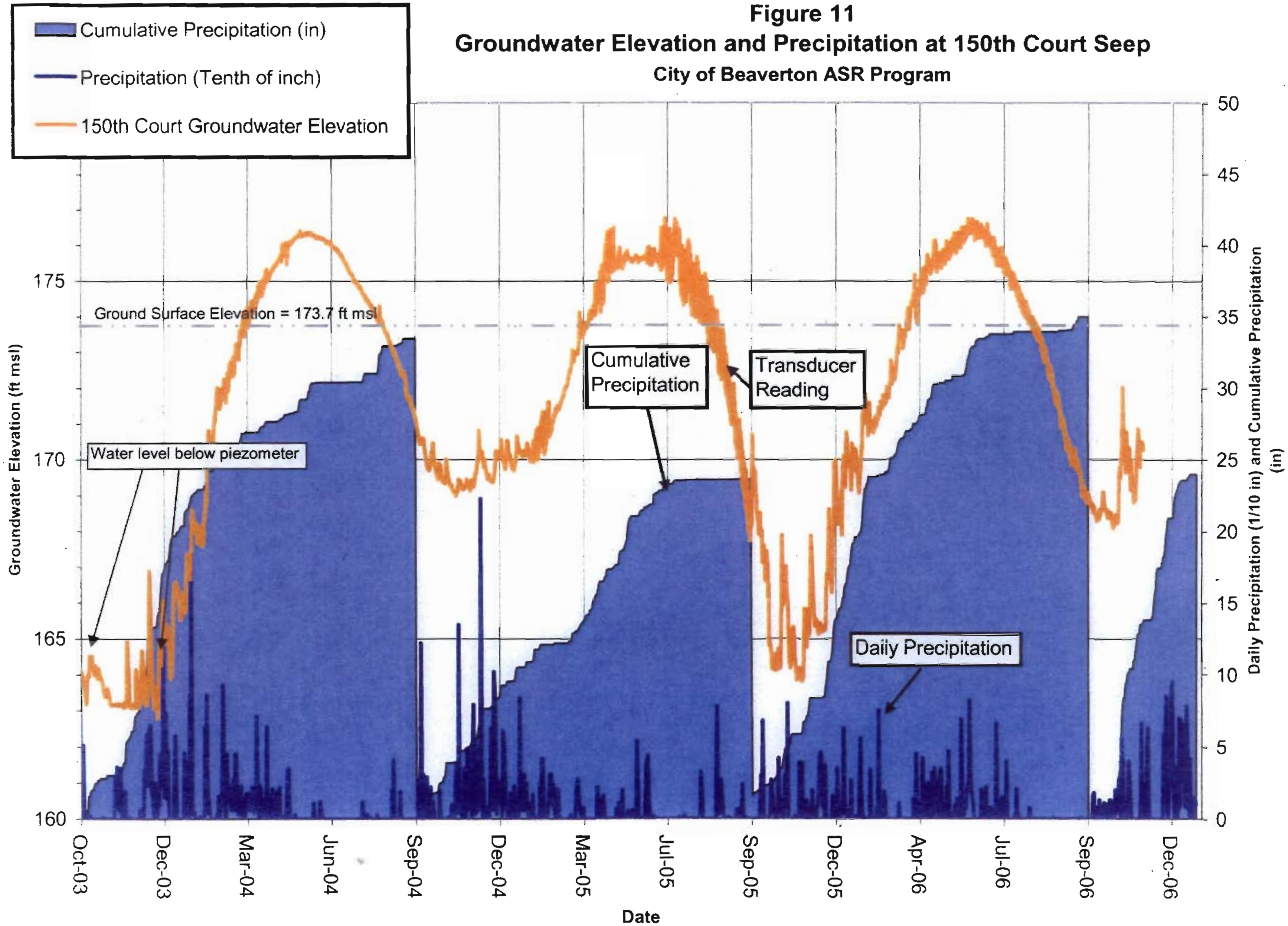
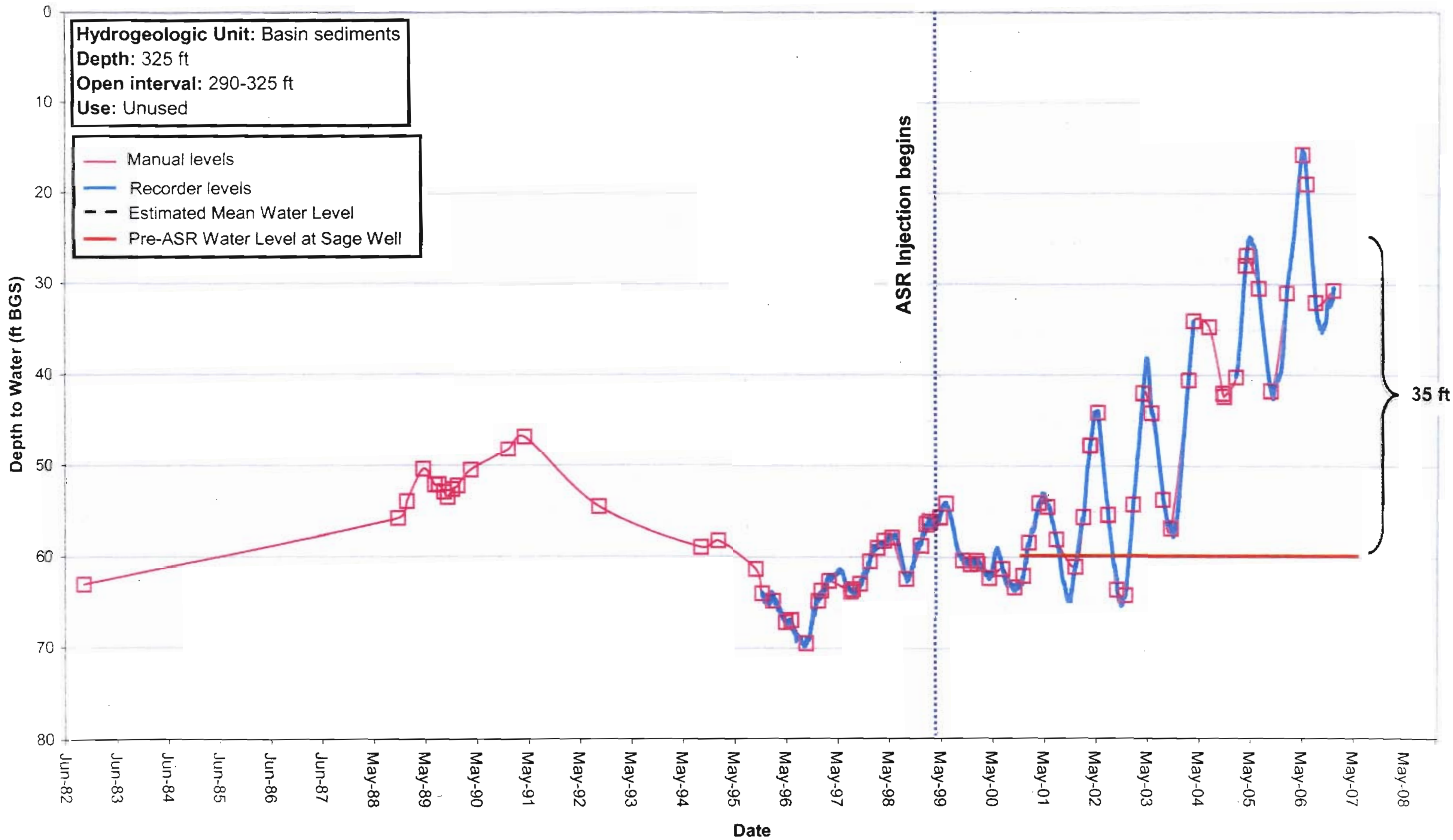


Figure 12
City of Beaverton ASR Program
OWRD Observation Well (WASH 9205)



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Last Modified: 4/30/2007 - pcp

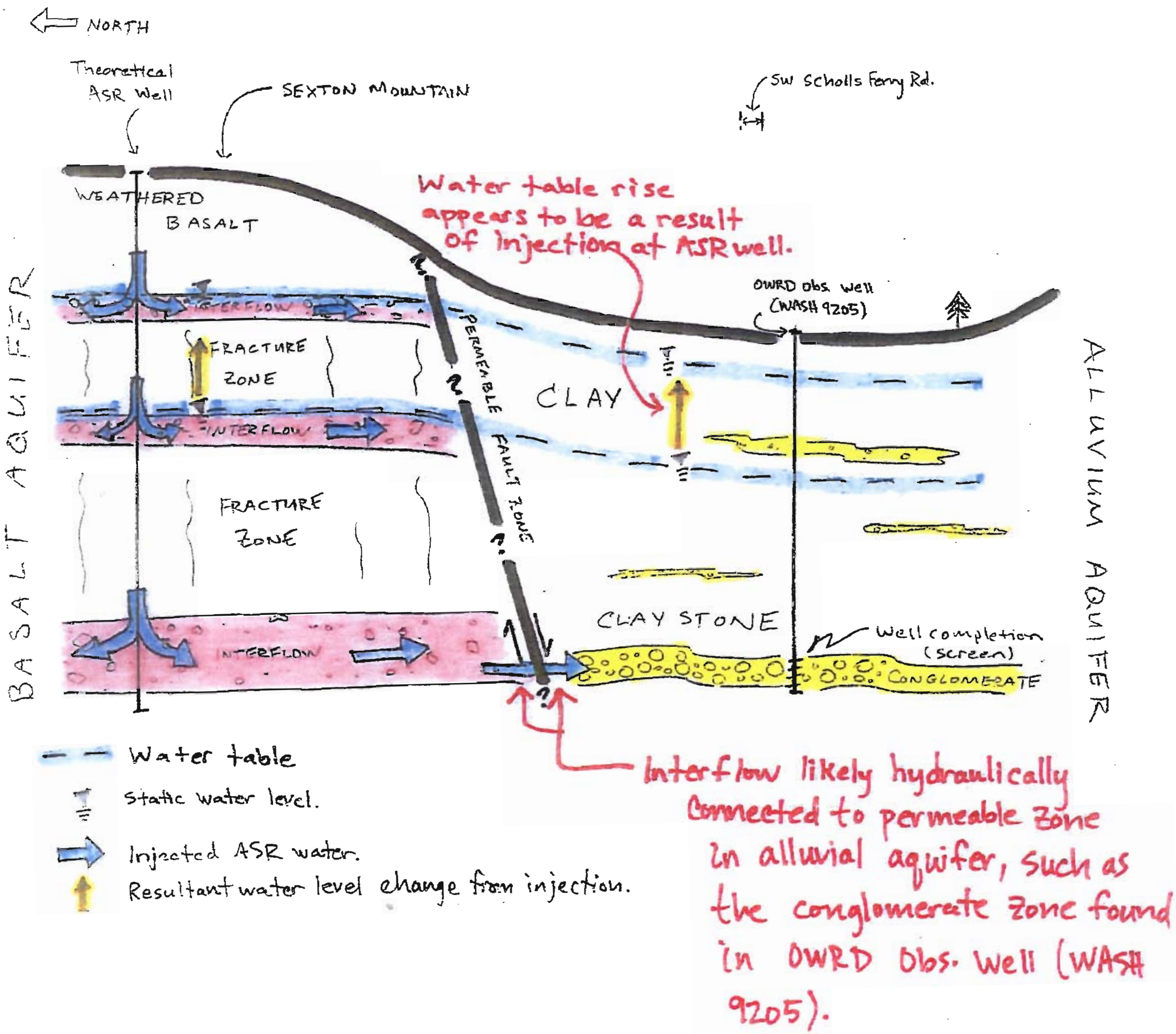
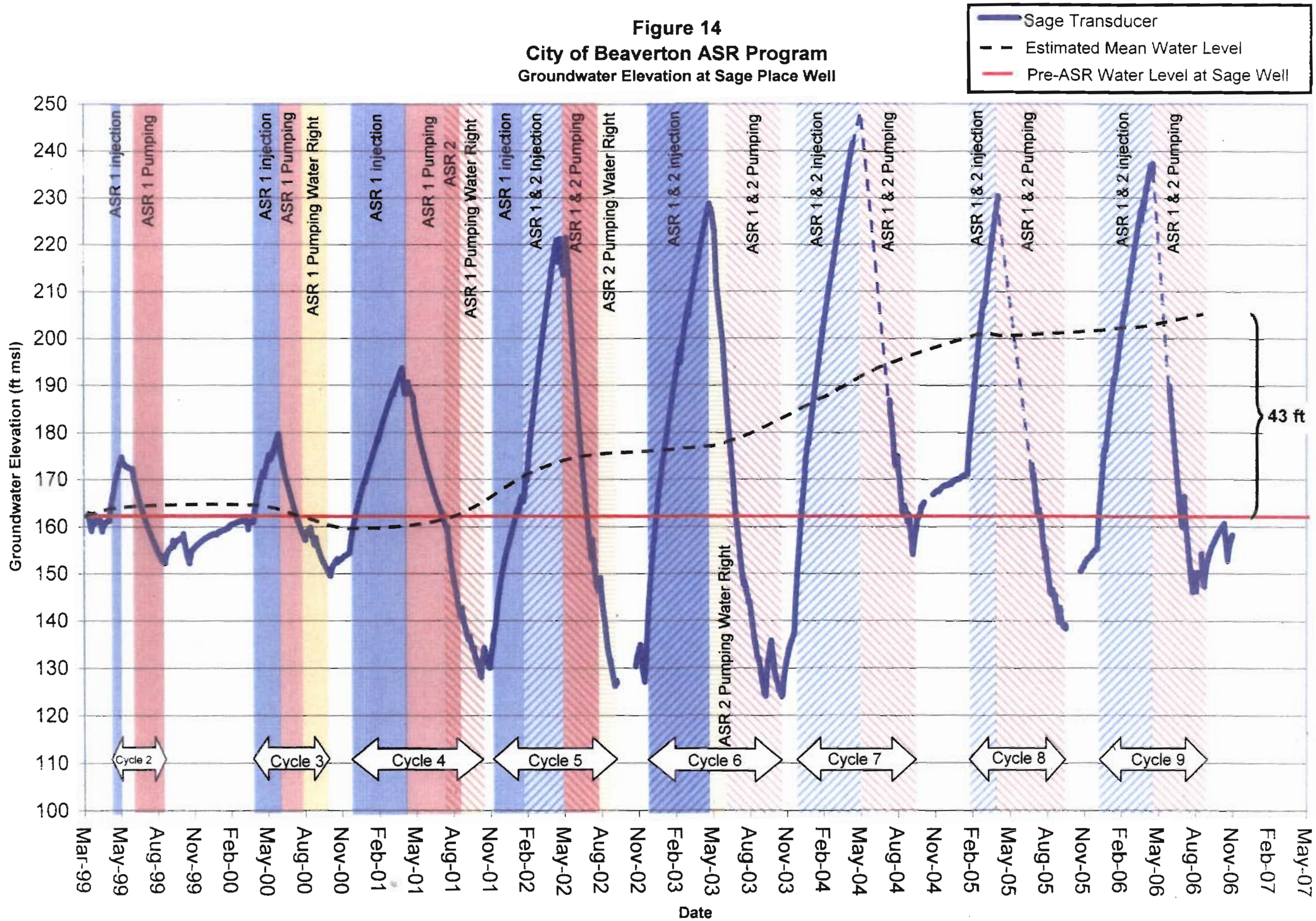


Figure 13
Conceptual Hydrogeologic Cross-Section
OWRD Observation Well
WASH 9205



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Last modified: 6/5/2007 by pcp

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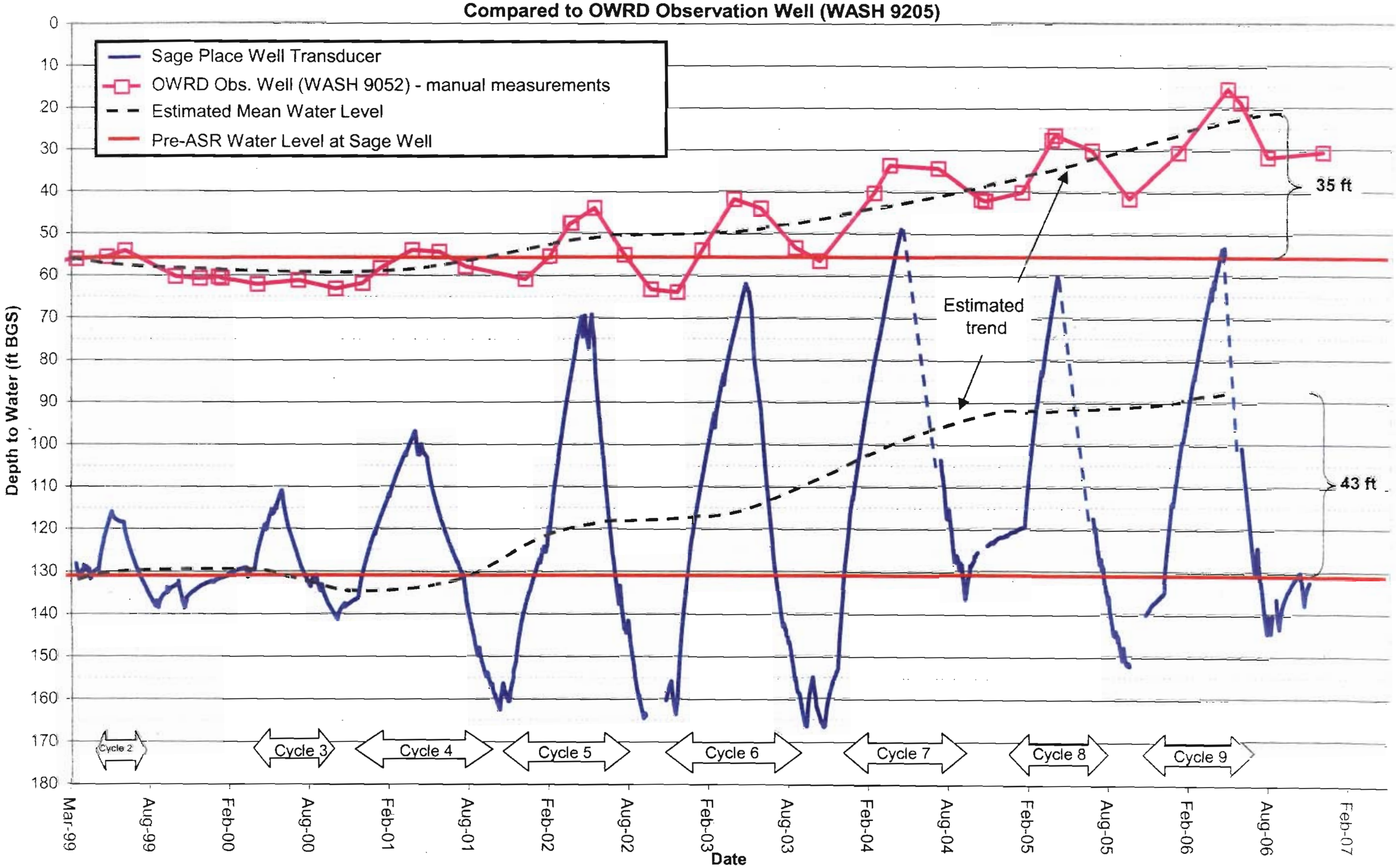
Figure 15
City of Beaverton ASR Program
Depth to Water at Sage Place Observation Well
Compared to OWRD Observation Well (WASH 9205)



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Last Modified: 6/5/2007 - pcp

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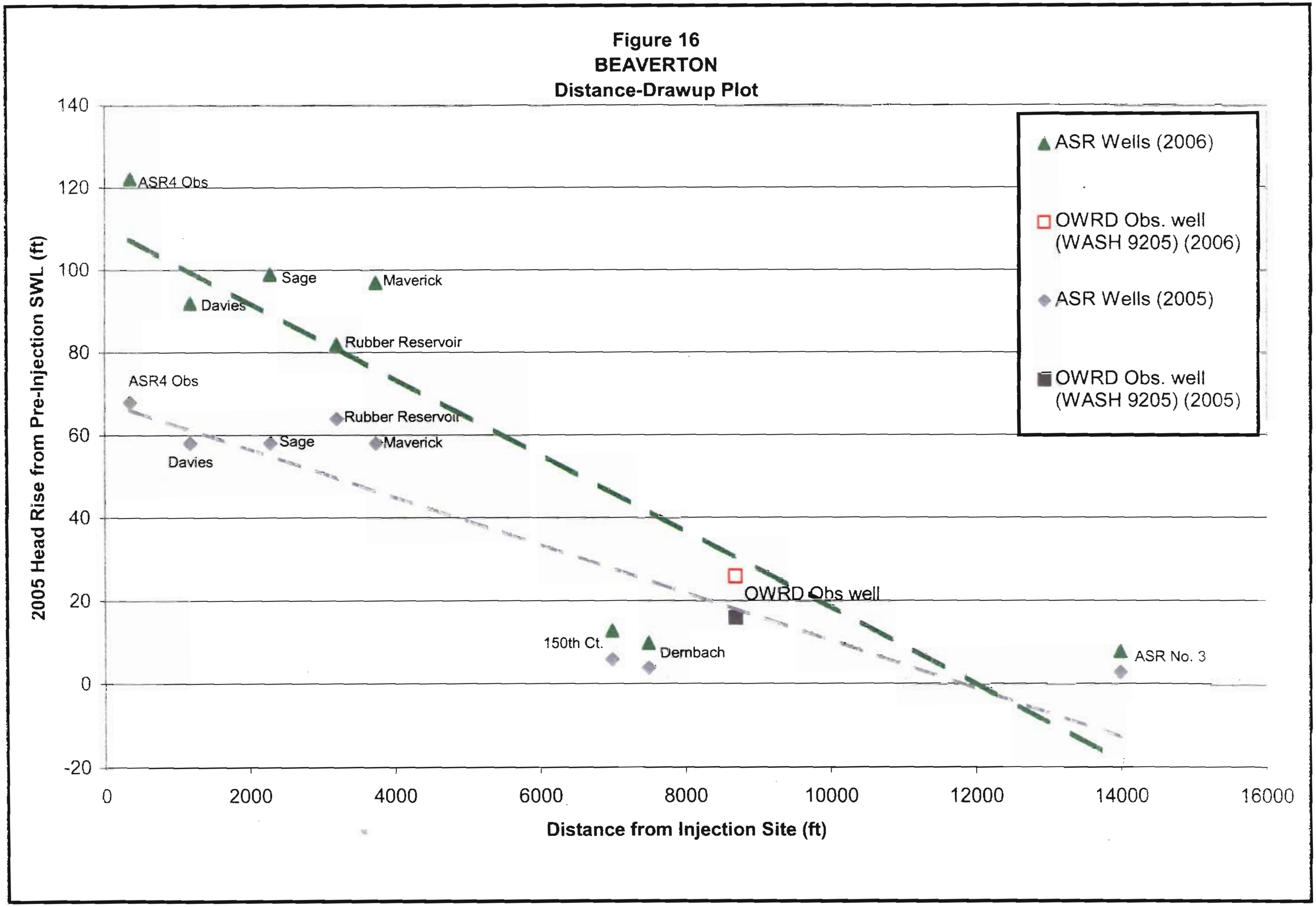

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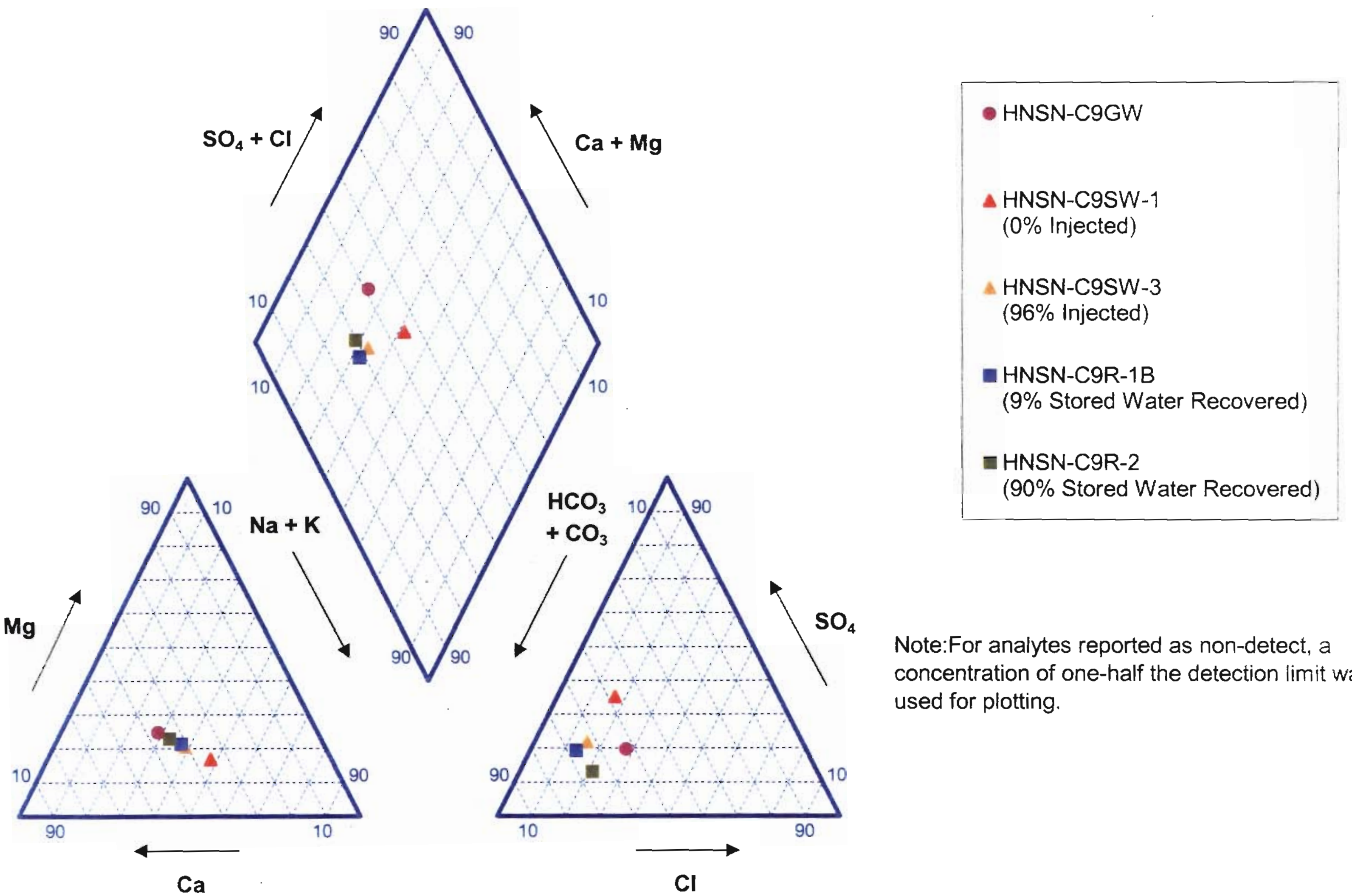
Last modified: 6/5/2007 by pcp



Note: For analytes reported as non-detect, a concentration of one-half the detection limit was used for plotting.

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Figure 17
Piper Diagram for ASR 1 Well
Beaverton ASR Program

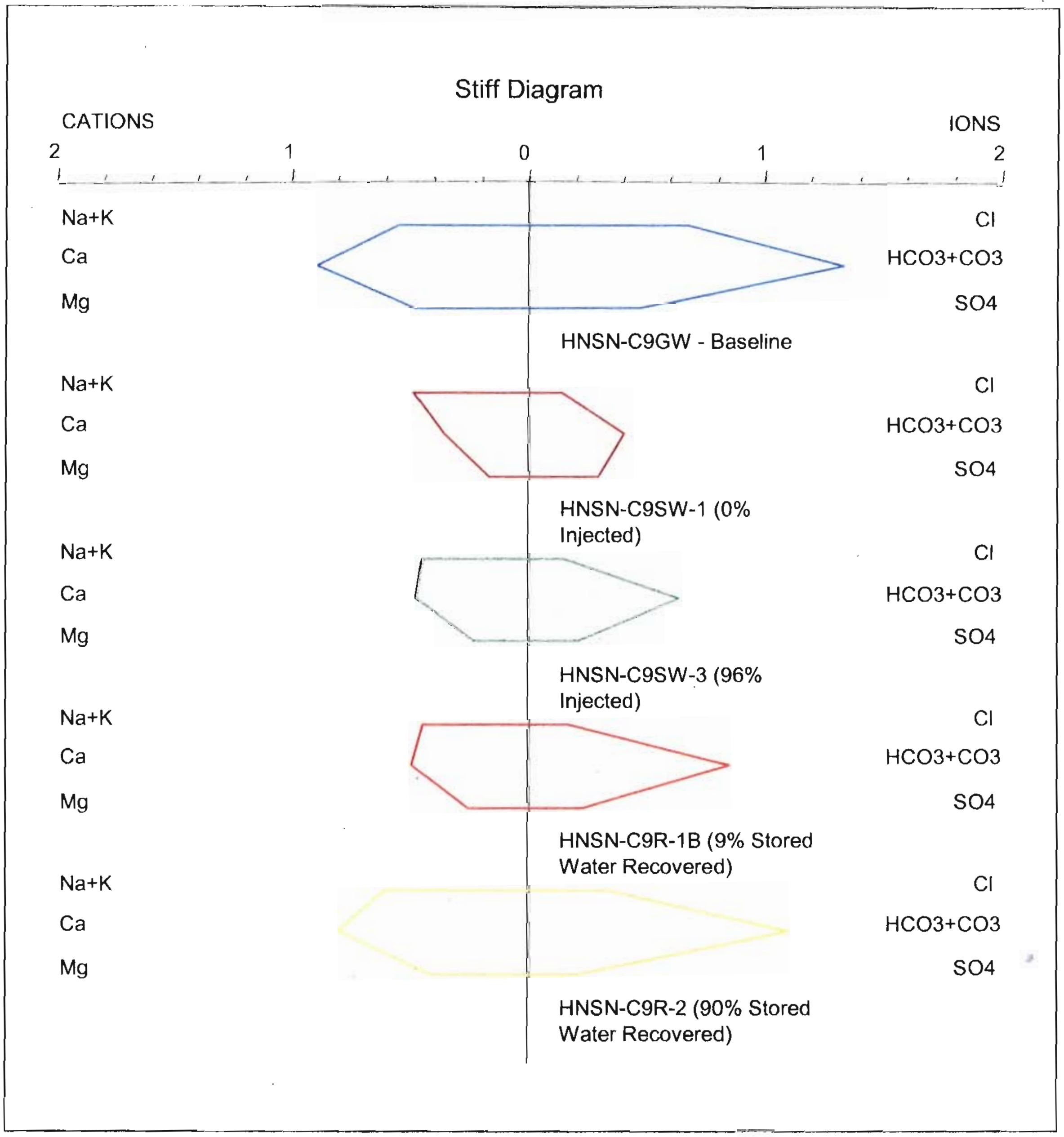

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Figure 18
Stiff Diagram for ASR 1 Well
Beaverton ASR Program

Figure 19
Chloride Concentration
ASR No. 1

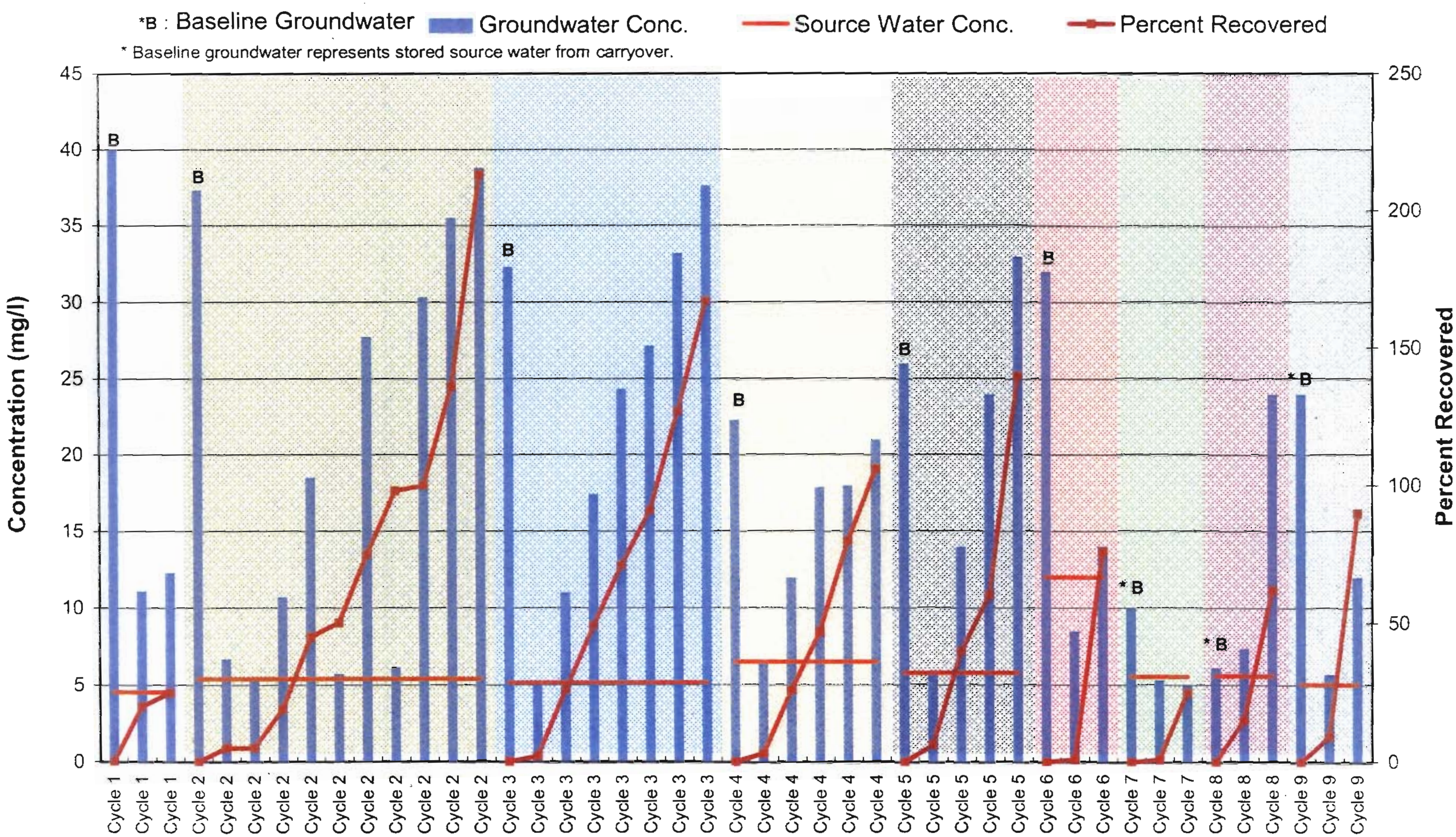

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Figure 20
Calcium Concentration
ASR No. 1

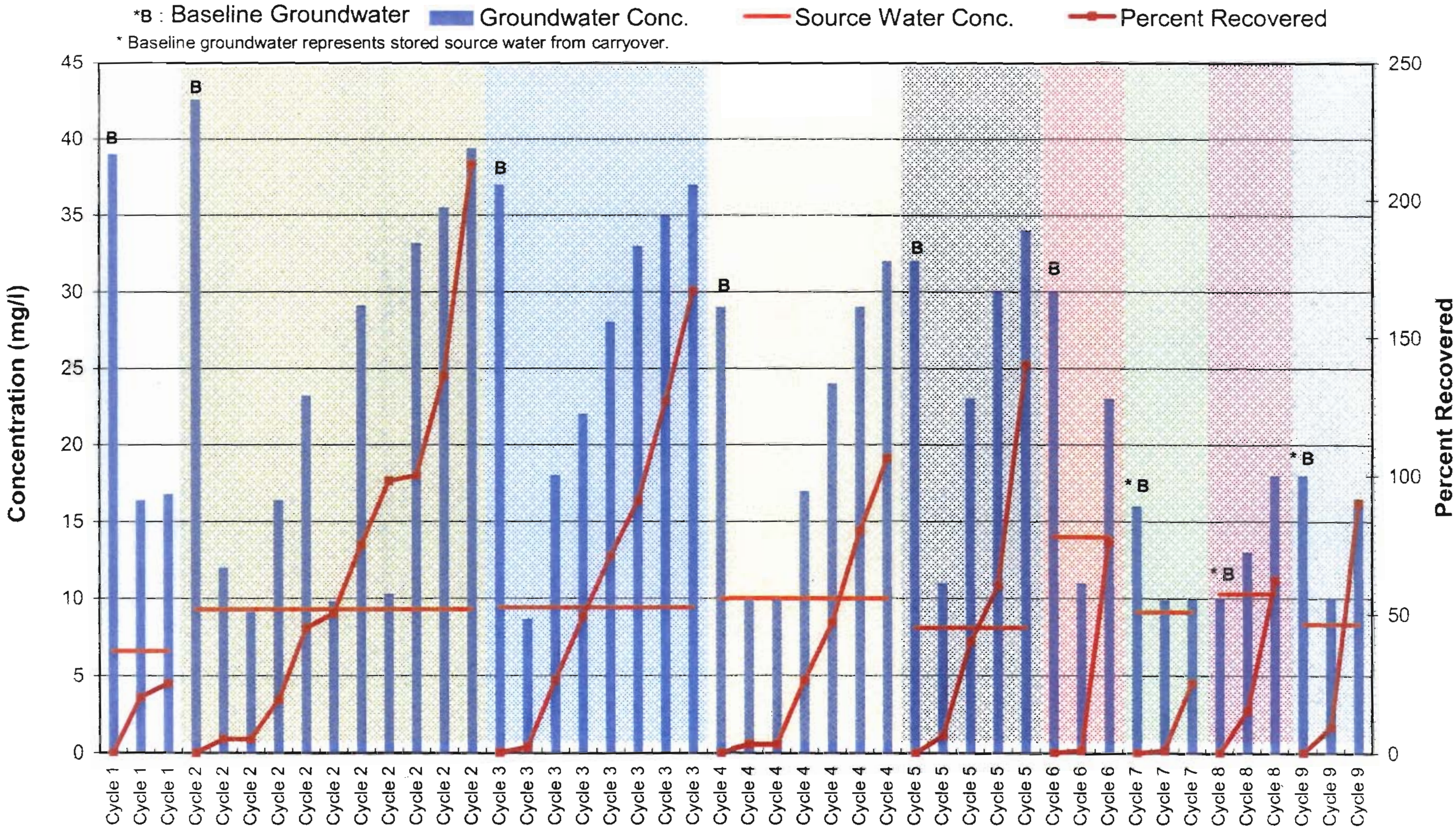

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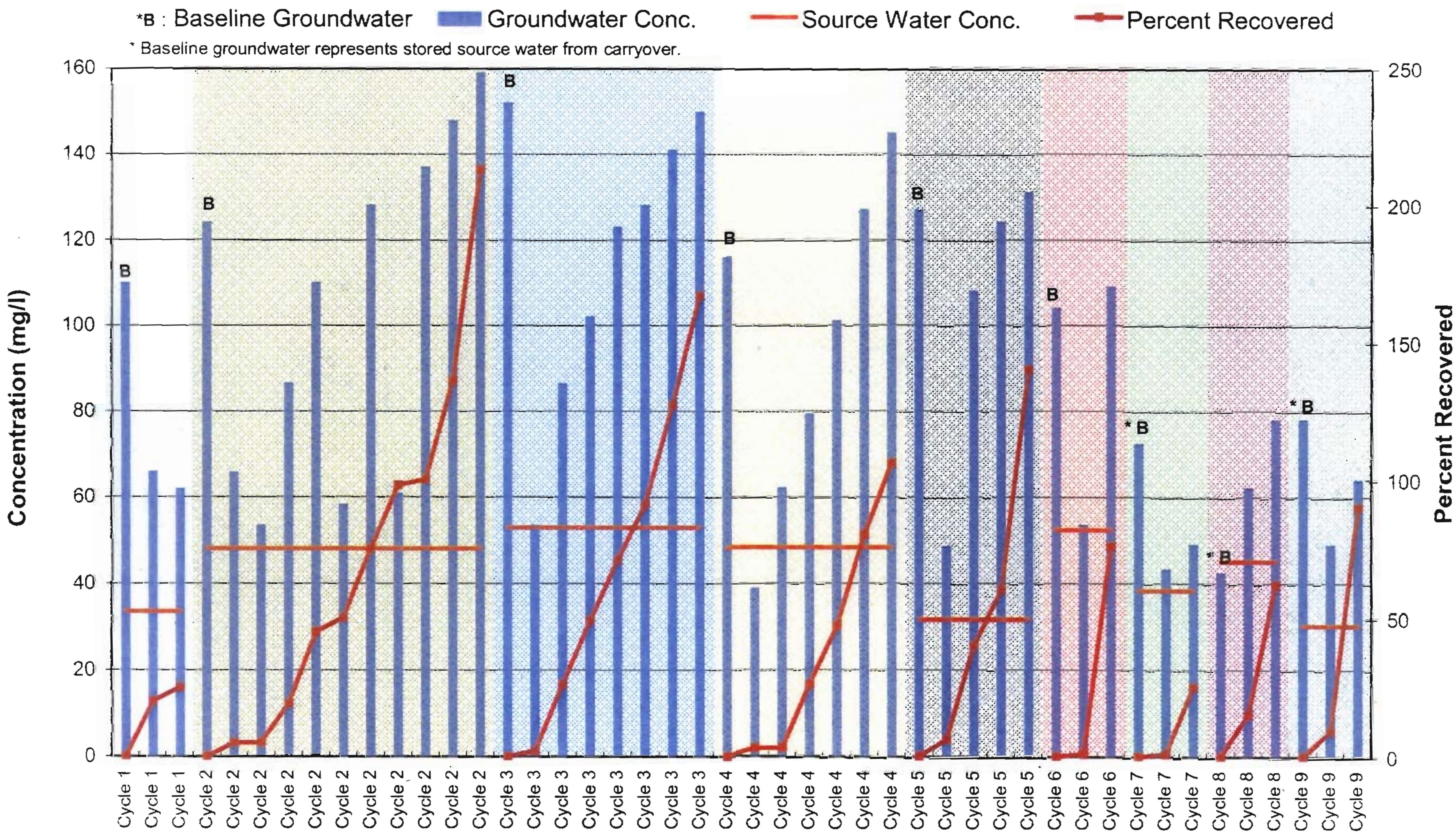
Figure 21
Bicarbonate Concentration
ASR No. 1



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