Squaw Valley Creek/Aquifer Interaction Study Final Report

Grant Agreement 4600008205

Prepared for:
Squaw Valley Public Service District

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March 2011

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ABBREVIATIONS

bgs .....Below ground surface
cfs.....cubic feet per second
cm .....centimeter
GWMP .....Groundwater Management Plan
NAD83.....North American Datum, 1983
NGVD .....National Geodetic Vertical Datum
PSP.....Project Solicitation Package
SVMWC.....Squaw Valley Mutual Water Company
SVPSD.....Squaw Valley Public Service District

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EXECUTIVE SUMMARY

This final report details the activities undertaken by the Squaw Valley Public Service District (SVPSD) for Phase I of the Squaw Valley Creek/Aquifer Interaction Study. This Phase of the study was funded by the State of California under the Local Groundwater Assistance Grant program, agreement number 4600008205.

The goals of the study, as identified in the Project Solicitation Package (PSP) included:

1. Initiate Element 2, item 2 of the Olympic Valley Groundwater Management Plan (GWMP), which calls for supporting a creek/aquifer interaction study.

2. Identify the impacts of well pumping on shallow groundwater adjacent to Squaw Creek.

3. Develop data that can be used to manage groundwater pumping such that it minimizes impacts on Squaw Creek.

All three goals were fully realized.

The project comprised five tasks:

Task 1: Pre–Construction Activities.
Task 2: Drilling, Well Construction, and Development.
Task 3: Equipping Monitoring Wells.
Task 4: Aquifer Testing.
Task 5: Reporting.

Unusually early winter weather, permitting difficulties, and recent technological advances in estimating stream/aquifer interactions led to a few scope modifications during the course of the project. All modifications were pre-approved and documented in quarterly reports. All tasks have been completed in accordance with the revised project scope.

TASK 1: PRE-CONSTRUCTION ACTIVITIES

This task included developing drilling specifications, securing a drilling contractor, and completing the permitting process. Well permits for the four new monitoring wells were obtained from Placer County Department of Environmental Health Services.

Well specifications were developed for all four monitoring wells. Three monitoring wells were installed using sonic drilling techniques. The deep PlumpJack Squaw Valley Inn was installed using air-rotary drilling techniques.

TASK 2: DRILLING, WELL CONSTRUCTION, AND WELL DEVELOPMENT

This task included installing four new monitoring wells adjacent to Squaw Creek; installing six temporary temperature probes in the base of the trapezoidal channel section of Squaw Creek; installing four temporary piezometers in the base of the trapezoidal channel section of Squaw Creek, and installing two stilling wells in the trapezoidal channel section of Squaw Creek.

The four new monitoring wells were installed between December 10, 2008 and June 3, 2010. Drilling was delayed twice due to weather problems, resulting in the extended drilling schedule. Drilling techniques were used that do not produce drilling mud in order to prevent accidental releases into the adjacent Squaw Creek.

The two Poulsen property monitoring wells and the shallow PlumpJack Squaw Valley Inn well were installed by Water Development Corporation in December, 2008, using an air-rotary drill rig. The deep PlumpJack Squaw Valley Inn well was installed between June 1 and June 3, 2010. The well was drilled using a sonic drill rig by Boart Longyear Inc, which produced a continuous core during drilling. Well depth and well completion information are summarized on Table ES- 1.

Table ES- 1: Monitoring Well Details

	Poulsen Shallow	Poulsen Deep	PlumpJack Shallow	PlumpJack Deep
Method	Air-rotary	Air-rotary	Air-rotary	Sonic
Hole Depth	31 feet	135 feet	39 feet	133 feet
Completed Depth	29 feet bgs	105 feet bgs	34 feet bgs	132 feet
Elevation	6192.31	6191.77	6210.73 feet	6209.60 feet
Borehole Diameter	6 inches	6 inches	6 inches	6 inches
Casing Diameter	2 inches	2 inches	2 inches	2 inches
Casing Material	Schedule 40 PVC	Schedule 40 PVC	Schedule 40 PVC	Schedule 40 PVC
Screened Interval	9 – 29 feet bgs	85 – 105 feet bgs	14 – 34 feet bgs	102 – 132 feet bgs

All wells were installed in accordance with relevant local and state regulations. A County inspector was on site to observe the placement of the annular seal in all four monitoring wells.

Six temperature probes were installed in the trapezoidal channel portion of Squaw Creek on May 27, 2009. Three temperature probes were installed in the creek near well SVPSD #4R and three probes were installed in the creek near wells SVPSD MW-5S and SVPSD MW-5D. Each temperature probe was outfitted with three data loggers; each data logger located at a different depth below the creek bed elevation. Data from the temperature probes facilitate estimating flow of groundwater into and out of Squaw Creek.

Three temporary piezometers were installed in the base of Squaw Creek, and one temporary piezometer was installed on the bank of Squaw Creek on June 3, 2009. The piezometers were located adjacent to the temperature probes to promote coordinated analyses of temperature and water level data. Each piezometer was outfitted with a Micro-Diver transducer with built-in data logger. Two stilling wells were installed at the piezometer sites to record water levels in Squaw Creek. Each stilling well was outfitted with a Micro-Diver transducer.

All reference points for the newly installed monitoring wells, as well as the temporary piezometers and stilling wells were surveyed by Andregg Geomatics

on October 1, 2010. The surveying was performed per GeoTracker guidelines and specifications.

TASK 3: EQUIPPING MONITORING WELLS

New pressure transducers with built-in data loggers were installed in 14 wells on June 3, 2009 and August 27, 2010. The following 14 wells were equipped with new data loggers.

- Poulsen Shallow
- Poulsen Deep
- PlumpJack Shallow
- PlumpJack Deep
- SVPSD MW-5S
- SVPSD MW-5D
- SVPSD #4R
- RSC-312
- RSC-318
- RSC-328
- RSC-324
- RSC-311
- RSC-317
- RSC-327

The transducers are currently recording hourly groundwater elevations.

TASK 4: AQUIFER TESTING

Two constant rate aquifer tests were conducted on well SVPSD #2. Groundwater elevation data were collected during both aquifer tests from eight monitoring and production wells. Groundwater elevation data were additionally collected during both tests from the four temporary piezometers and two stilling wells. Groundwater temperature data were collected from the six temporary temperature probes during each test.

The first aquifer test was conducted on well SVPSD #2 between June 23 and June 25, 2009. Squaw Creek was flowing during the test. The test was run for 52 hours. During the test, well SVPSD #2 was pumped at an average rate of 319 gallons per minute.

The second aquifer test was conducted between September 8 and September 10, 2010. Squaw Creek was dry during the test. The second aquifer test was run for 51 hours. During the test, well SVPSD#2 was pumped at an average rate of 303 gallons per minute.

TASK 5: REPORTING

Reporting consisted of submitting quarterly reports and drafting this final report. Every quarterly report was prepared and submitted on time. This report is the final submittal under Task 5.

COST AND SCHEDULE

The Squaw Valley Creek/Aquifer Interaction Study has been completed within the original budget. Although the total costs remain within the original project budget, some positive and negative cost variances occurred on individual tasks. To keep individual task costs in line with the task budgets, modifications to the individual task budgets were requested by SVPSD in October 2010. No change to the total grant amount was requested. Staff of DWR granted SVPSD's budget modification request.

The schedule was updated every quarter based on progress made, weather delays, and scope changes. A revised schedule was included in every quarterly report.

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SECTION 1
INTRODUCTION AND BACKGROUND

This final report details the activities undertaken by the Squaw Valley Public Service District (SVPSD) for Phase I of the Squaw Valley Creek/Aquifer Interaction Study. This Phase of the study was funded by the State of California under the Local Groundwater Assistance Grant program, agreement number 4600008205.

1.1 SETTING AND BACKGROUND

Squaw Valley is a glacially carved valley in the Sierra Nevada of California. The Valley is situated west of Lake Tahoe, at an elevation of approximately 6,200 feet (Figure 1). Squaw Valley measures approximately 2.5 miles long by 0.4 miles wide, covering an area of approximately 600 acres. Steep mountains bound the Valley on the North, West, and South. A terminal moraine on the Valley's eastern side separates the Valley from the Truckee River. The Valley is drained by Squaw Creek. The north and south forks of Squaw Creek enter along the Valley's western side. Squaw Creek exits the Valley through the terminal moraine on the Valley's eastern side.

All water used in Squaw Valley is derived from groundwater pumping. Water for municipal and commercial uses is served by two water companies. The SVPSD is a County Water District formed under Division 12 of the California Water Code; the Squaw Valley Mutual Water Company (SVMWC) is a non-profit, member owned corporation. In addition to the two water companies, groundwater is pumped for domestic and irrigation uses by the Resort at Squaw Creek, the PlumpJack Squaw Valley Inn, and the Squaw Valley Ski Corporation.

Squaw Creek and its tributaries are the only significant surface water bodies in Squaw Valley. Two forks of Squaw Creek, the South Fork and Shirley Canyon, enter Squaw Valley along the western margin (Figure 2). Shirley Canyon is the larger of the two forks of Squaw Creek, with flows of up to 138 cubic feet per second (cfs) recorded during Water Years 2003 and 2004. Over the same time period, the highest flow recorded in the South Fork was 103 cfs.

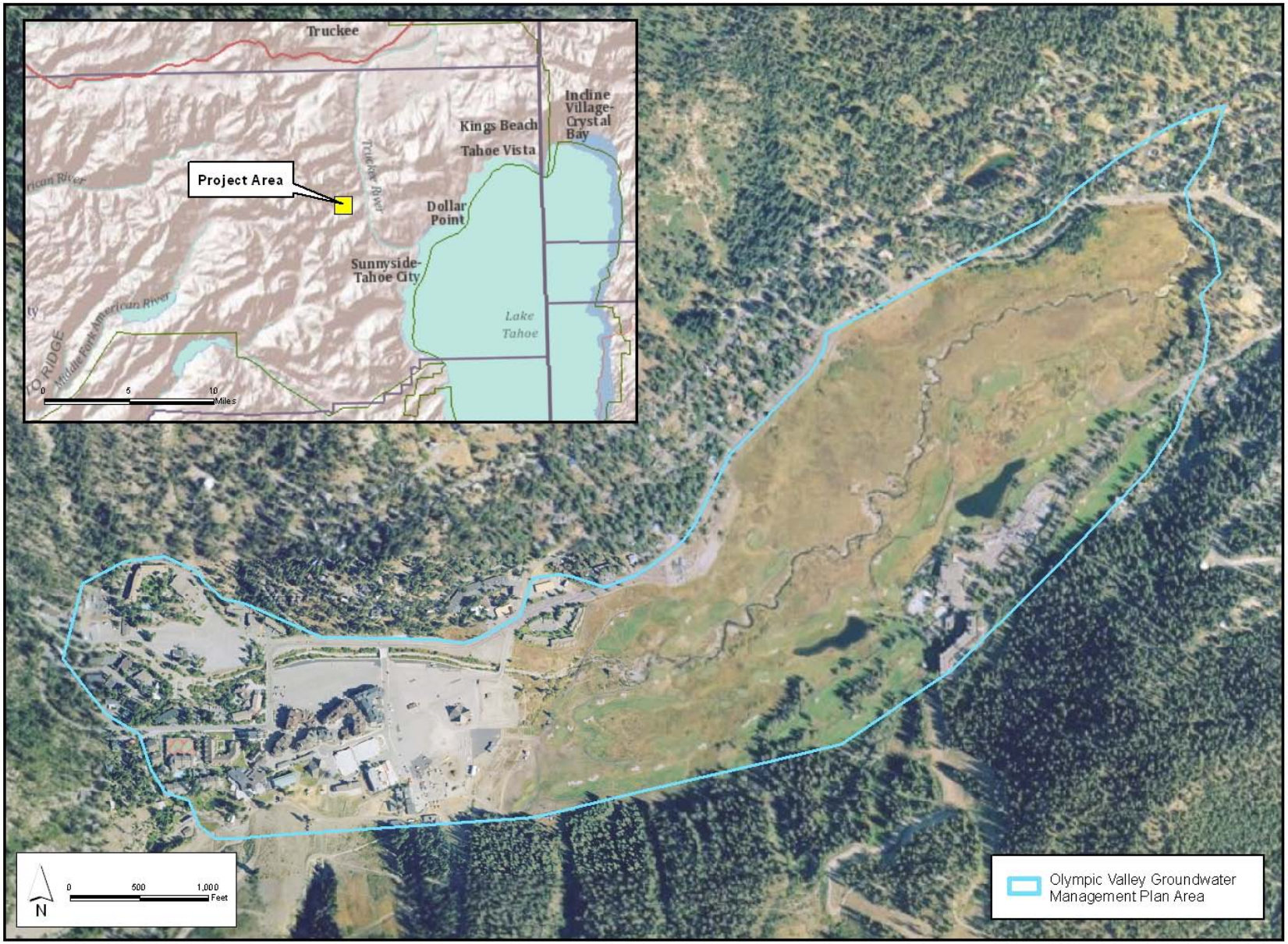

Figure 1: Squaw Valley Location and Management Area Boundary

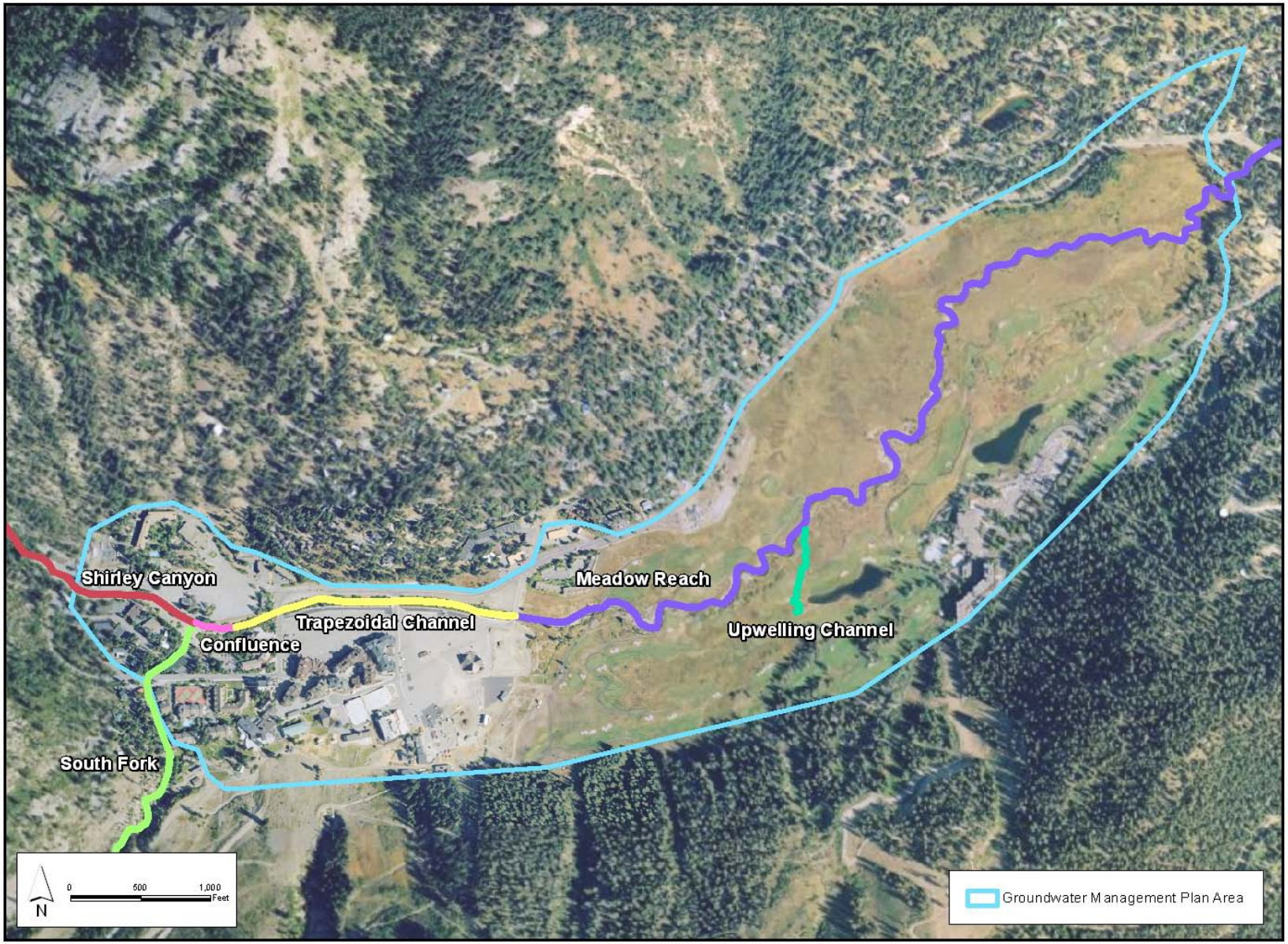

Figure 2: Squaw Creek Location and Reaches

The two main forks converge in an area locally known as the confluence. The confluence is a wide gravel filled portion of Squaw Creek that has generally maintained its natural configuration. Water flows from the confluence into a manmade trapezoidal channel. This channel is not lined, and runs generally parallel to Squaw Valley Road to the bridge on the eastern end of the Squaw Valley parking lot.

Below the bridge on the eastern end of the Squaw Valley ski resort parking lot, Squaw Creek meanders through a meadow in a relatively natural channel. Squaw Creek exits the Valley beneath Squaw Valley Road Bridge on the eastern end of the meadow, and flows through an incised channel cut into the terminal moraine to the Truckee River.

1.2 PROJECT GOALS AND OUTCOMES

The Project Solicitation Package (PSP) identified three goals. Each goal and the associated outcomes are listed below.

1. Initiate Element 2, item 2 of the Olympic Valley GWMP, which calls for supporting a creek/aquifer interaction study.

   This goal was fully realized. Supporting a creek/aquifer interaction study was an important element of the Olympic Valley GWMP, assuring that the plan is collaborative and addresses all stakeholder concerns. The creek/aquifer interaction study was not only supported, it was designed and initiated under this agreement.

2. Identify the impacts of well pumping on shallow groundwater adjacent to Squaw Creek.

   All data necessary to support this goal have been collected. The data will be analyzed, and the pumping impacts identified, under Phase II of this study.

3. Develop data that can be used to manage groundwater pumping such that it minimizes impacts on Squaw Creek.

   This goal was fully realized. All data necessary to mange groundwater pumping such that it minimizes impacts on Squaw Creek have been collected. The Actions

needed to minimize the pumping impacts will be developed in Phase II of this study.

1.3 SUMMARY OF COMPLETED WORK

1.3.1 PROJECT SOLICITATION PACKAGE SCOPE

The original scope of work proposed in the PSP consisted of five tasks. Each of the original tasks is described briefly below:

Task 1: Pre–Construction Activities. This task included developing drilling specifications, securing a drilling contractor, and completing the permitting process.

Task 2: Drilling, Well Construction, and Development. This task included installing six new monitoring wells adjacent to Squaw Creek: three shallow wells and three deep wells. The monitoring wells will provide groundwater level data from the aquifer tests as well as long-term monitoring data.

Task 3: Equipping Monitoring Wells. This task consisted of installing permanent pressure transducers in each of the six new monitoring wells, along with eight existing monitoring wells adjacent to Squaw Creek. The data loggers provide groundwater level data during the aquifer tests, as well as long-term groundwater level data that show both daily and seasonal fluctuations.

Task 4: Aquifer Testing. Three 24-hour aquifer tests were proposed at three different wells. These were intended to estimate the impact of pumping on streamflows from three different locations within the Valley.

Task 5: Reporting. This task covered quarterly reporting, meetings, and final reporting.

1.3.2 SCOPE MODIFICATIONS

Unusually early winter weather, permitting difficulties, and recent advances in technologies for estimating stream/aquifer interactions led to a few scope modifications during the course of the project. All modifications were pre-

approved and documented in quarterly reports. These scope modifications are detailed below.

Task 1: Pre–Construction Activities. No scope modifications were necessary, however this task proved more difficult than anticipated due to scope modifications in Task 2. Difficulties included additional site access requirements for the added temporary piezometers and temperature probes; and unanticipated extended permitting issues resulting from weather-caused delays. All of these difficulties were successfully addressed during the project. The added time and expense needed to negotiate access agreements for the temporary piezometers and temperature probes was offset by the cost savings of replacing two monitoring wells with the temporary piezometers and temperature probes. The added time and expense needed to address the extended permitting issues was absorbed by the project sponsor.

Task 2: Drilling, Well Construction, and Development. Permitting difficulties along with recent technological advances in estimating stream/aquifer interactions led to scope modifications in Task 2. These included:

- Installing four temporary piezometers in the trapezoidal channel section of Squaw Creek. These temporary piezometers measure groundwater elevations directly beneath Squaw Creek, allowing calculation of shallow vertical gradients that drive groundwater into and out of Squaw Creek.
- Installing six temporary temperature probes in the trapezoidal channel section of Squaw Creek. Temperature has become the tracer of choice by the U.S. Geological Survey and others for measuring stream/aquifer interactions.
- Removing two of the planned monitoring wells from the drilling plan.

Task 3: Equipping Monitoring Wells. The four new temporary piezometers and six new temporary temperature probes installed in trapezoidal channel in Task 2 required additional monitoring well equipment. The additional equipment and effort included:

- Equipping each of the four temporary piezometers with transducers that collect shallow groundwater elevations every 15 minutes.
- Equipping each of the six temporary temperature probes with three temperature data loggers; for a total of 18 temperature data loggers.

The temperature data loggers are installed at various depths to identify vertical temperature gradients.

- Removing the temporary equipment during the winter to avoid losing the equipment in floods, and re-installing the equipment after the threat of floods has passed.

The added time and expense needed to equip the temporary piezometers and temporary temperature probes with data loggers was offset by the cost savings realized from deleting two of the monitoring wells

Task 4: Aquifer Testing. The aquifer testing program was modified to take advantage of the temporary monitoring equipment installed in Task 2. The three 24-hour tests were replaced with two 50-hour tests at the same well. Extra pumping time was added to each test to ensure that the cone of depression was observable in the temporary piezometers beneath Squaw Creek.

Task 5: Reporting. No scope modifications were necessary; however the weather delays resulted in considerably more quarterly reports than originally scoped.

1.3.3 WORK COMPLETED

All work described under the modified scope is complete. This report is the final submittal for this project. All data have been collected as planned. The extent of data collected are expanded on in Section 2.

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SECTION 2
DESCRIPTION OF WORK PERFORMED

This section provides detailed descriptions of the work performed. Supporting information, including raw data and photographs, are provided in Appendices A through G as well as the enclosed CD.

2.1 TASK 1: PRE–CONSTRUCTION ACTIVITIES

Pre-construction activities included obtaining access to drilling sites, obtaining required well permits, developing well specifications, and contracting drillers. As discussed in Section 1.3.2, three locations required access: the PlumpJack Squaw Valley Inn; the Poulsen property at the west end of the meadow; and the trapezoidal channel.

Well permits for the four permanent wells were obtained from the Placer County Department of Environmental Health Services. Unusually early snowfall in 2008 prevented all four wells from being installed at the same time. The fourth well, which was the deep PlumpJack Squaw Valley Inn well, had to be installed at a later date. It therefore required a separate well permit. Both the original well permit for all four monitoring wells and the supplemental well permit for installing the deep PlumpJack Squaw Valley Inn well are included in Appendix A.

Well specifications were developed for all four monitoring wells. Three monitoring wells were installed using sonic drilling techniques. The deep PlumpJack Squaw Valley Inn was installed using air-rotary drilling techniques. The specifications for the well installations are included in Appendix B.

Two separate drillers were contracted for the two well installation events. The two wells on the Poulsen property and the shallow well at the PlumpJack Squaw Valley Inn were installed by Water Development Corporation, using air-rotary drilling techniques. The deep well at the PlumpJack Squaw Valley Inn was installed by Boart Longyear using a sonic drilling technique.

2.2 TASK 2: DRILLING, WELL CONSTRUCTION, AND DEVELOPMENT

2.2.1 MONITORING WELLS

Four new monitoring wells were installed between December 10, 2008 and June 3, 2010. Drilling was delayed twice due to weather problems, resulting in the extended drilling schedule. Details of the four monitoring wells are summarized in Table 1. Locations of the four monitoring wells are shown on Figure 3.

The monitoring wells are located in areas that are covered with snow in the winter, and used for recreation in the summer. To accommodate these factors, the window for drilling and installing the wells was limited to a couple weeks every year in the spring and fall. Drill rig availability therefore became an important factor in selecting a drilling technique. In addition to drill rig availability, mudless drilling techniques were used in order to prevent accidental releases into the adjacent Squaw Creek.

The two Poulsen property monitoring wells and the shallow PlumpJack Squaw Valley Inn well were installed by Water Development Corporation in December, 2008, using an air-rotary drill rig. Drill cuttings were obtained at every five foot interval. A State of California professional geologist from HydroMetrics WRI was onsite throughout the well drilling, installation, and development. Snow storms prevented Water Development Corporation from installing the deep PlumpJack monitoring well.

The deep PlumpJack Squaw Valley Inn well was installed between June 1 and June 3, 2010. The well was drilled using a sonic drill rig by Boart Longyear Inc. Continuous cores were obtained during the drilling. A State of California professional geologist from HydroMetrics WRI was onsite throughout the well drilling, installation, and development. Additional details on the well installations at each site are included below.

Figure 3: Location of New Monitoring Wells

Table 1: Summary of Monitoring Well Details

	Poulsen Shallow	Poulsen Deep	PlumpJack Shallow	PlumpJack Deep
Dates installed	12/10/08 – 12/12/08	12/10/08 – 12/12/08	12/17/08 – 12/19/08	6/01/10 – 6/03/10
Driller	Water Development Corp.	Water Development Corp.	Water Development Corp.	Boart Longyear
Method	Air-rotary	Air-rotary	Air-rotary	Sonic
Hole Depth	31 feet	135 feet	39 feet	133 feet
Completed Depth	29 feet bgs	105 feet bgs	34 feet bgs	132 feet
Top of Casing Elevation	6192.31	6191.77	6210.73 feet	6209.60 feet
Borehole Diameter	6 inches	6 inches	6 inches	6 inches
Casing Diameter	2 inches	2 inches	2 inches	2 inches
Casing Material	Schedule 40 PVC	Schedule 40 PVC	Schedule 40 PVC	Schedule 40 PVC
Screened Interval	9 – 29 feet bgs	85 – 105 feet bgs	14 – 34 feet	102 – 132 feet bgs

POULSEN PROPERTY WELLS

The two Poulsen property wells were installed between December 10 and December 12, 2008. The borehole for the deep Poulsen property well was drilled to 135 feet below ground surface. Gray silt was encountered between 105 and 135 feet below ground surface. The deep well was screened above the silt, from 85 to 105 feet below ground surface. The well screen consisted of 2-inch schedule 40 PVC with 0.02-inch factory cut slots.

The borehole for the shallow Poulsen property well was drilled to 31 feet below ground surface. The shallow well was screened between 9 and 29 feet below ground surface. This well screen was placed high in the borehole so that it would cross the shallow water table that is connected to nearby Squaw Creek. The well screen consisted of 2-inch schedule 40 PVC with 0.02-inch factory cut slots.

The gravel pack for both Poulsen property wells consisted of Cemex #3 sand. Gravel pack in the deep well was placed from the bottom of the borehole to 79 feet below ground surface: six feet above the top of the screen. Gravel pack in the shallow well was placed from the bottom of the borehole to 6.7 feet below ground surface: 2.3 feet above the top of the screen. The gravel packing was monitored and documented, and the final depth to the top of the gravel pack was measured and recorded by the on-site geologist.

Bentonite chip transition seals were placed in the annulus on top of the gravel pack. Approximately 5 feet of bentonite chips were placed in each of the well's annuluses. The placement of the bentonite chips was monitored and documented; and the final depth to the top of the bentonite chips was measured and recorded by the on-site geologist.

Neat cement annular seals were placed in the well annuluses through tremmie pipes. The cement for the deep well included 5% bentonite to slow the curing process and protect the integrity of the well casing. The cement for the shallow well contained no bentonite. A County inspector was on site to observe the sealing of both wells. Both wells were completed with steel pipes that stick up approximately 4 feet above ground surface. The steel pipes were outfitted with locking covers.

Well logs for the Poulsen property wells are all included in Appendix C. Photos of the drilling operation are included in Appendix D.

PLUMPJACK SQUAW VALLEY INN WELLS

The shallow PlumpJack Squaw Valley Inn well was installed between December 17 and December 19, 2008. The borehole for the shallow PlumpJack Squaw Valley Inn well was drilled to 39 feet below ground surface. Heaving sand prevented the well from being completed to 39 feet bgs. The well was screened between 14 and 34 feet below ground surface. The well screen consisted of 2-inch schedule 40 PVC with 0.02-inch factory cut slots.

The gravel pack for the shallow PlumpJack Squaw Valley Inn well consisted of Cemex #3 sand. Gravel pack was placed from the bottom of the borehole to 11 feet below ground surface: three feet above the top of the screen. The gravel packing was monitored and documented; and the final depth to the top of the gravel pack was measured and recorded by the on-site geologist.

A two foot bentonite chip transition seal was placed in the well annulus above the gravel pack. The placement of the bentonite chips was monitored and documented; and the final depth to the top of the bentonite chips was measured and recorded by the on-site geologist.

A neat cement annular seal was placed in the well annulus through a tremmie pipe. The cement contained no bentonite. A county inspector was on site to observe the sealing of the shallow well. The well was completed with a traffic-bearing at-grade completion.

The deep PlumpJack Squaw Valley Inn well was installed between June 1 and June 3, 2010. The borehole for the deep PlumpJack Squaw Valley Inn well was drilled to 133.5 feet below ground surface. The bottom of the borehole encountered granitic bedrock. The well was screened between 102 and 132 feet below ground surface. The well screen consisted of 2-inch schedule 40 PVC with 0.02-inch factory cut slots.

The gravel pack for the deep PlumpJack Squaw Valley Inn well consisted of Lonestar #3 sand. Gravel pack was placed from the bottom of the borehole to 97 feet below ground surface: five feet above the top of the screen. The gravel packing was monitored and documented; and the final depth to the top of the gravel pack was measured and recorded by the on-site geologist.

A five foot bentonite chip transition seal was placed in the well annulus above the gravel pack. The placement of the bentonite chips was monitored and

documented; and the final depth to the top of the bentonite chips was measured and recorded by the on-site geologist.

A neat cement annular seal was placed in the well annulus through a tremmie pipe. The cement contained 5% bentonite to slow the curing process and protect the integrity of the well casing. A county inspector was on site to observe the sealing of the deep well. The well was completed with a traffic-bearing at-grade completion.

Well logs for the PlumpJack Squaw Valley Inn wells are included in Appendix C. Photos of the drilling operation are included in Appendix D.

2.2.2 TEMPERATURE PROBES

Six temperature probes were installed in the trapezoidal channel portion of Squaw Creek on May 27, 2009. Three temperature probes were installed in the creek near well SVPSD #4R and three probes were installed in the creek near wells SVPSD MW-5S and SVPSD MW-5D. The locations of the six temperature probes are shown in Figure 4. Data from the temperature probes help estimate the flow of groundwater into and out of Squaw Creek.

The temperature probes were based on a design provided by Dr. Andrew Fisher from the University of California, Santa Cruz (personal communication). The probes are designed to measure ambient groundwater temperature at three depths below the streambed. This design has been developed to gather data that can be analyzed using the techniques outlined in Hatch et al. (2006). Details on the depth of the data loggers in each temperature probe are shown on Table 2. The temperature data loggers were set to record temperature every 15 minutes. A schematic showing the probe design is shown in Figure 5.

The data loggers were removed from the probes on November 4, 2009 to prevent them from being lost in winter floods. The data loggers were re-installed in the probes on August 27, 2010, prior to the second aquifer test. The data loggers and probes were completely removed from the trapezoidal channel on October 18, 2010. Photos of the probes, probe installation, and probe removal are included in Appendix E.

Figure 4: Temperature Probe and Stream Piezometer Locations

Table 2: Temperature Probe Construction Details

Temperature Probe	Depth to First Data Logger (cm bgs)	Depth to Second Data Logger (cm bgs)	Depth to Third Data Logger (cm bgs)
Near SVPSD #4R - South	9.8	24.8	46.9
Near SVPSD #4R – Mid	9.3	24.3	46.5
Near SVPSD #4R – North	9.0	24.8	48.5
Near SVPSD 5S/5D – South	10.0	25.4	47.1
Near SVPSD 5S/5D – Mid	10.2	25.9	46.8
Near SVPSD 5S/5D – North	11.0	25.8	47.3

2.2.3 In-Stream Piezometers

Three temporary piezometers were installed in the base of Squaw Creek, and one temporary piezometer was installed on the bank of Squaw Creek on June 3, 2009. The piezometers were located adjacent to the temperature probes to promote coordinated analyses of temperature and water level data. Groundwater level data from the temporary piezometers assist with estimating the creek/aquifer interactions.

The piezometers were constructed of ¾-inch threaded steel tubes. A screened drive point was threaded onto the end of each tube, and the piezometers were driven into the stream bottom with a slide hammer. Each piezometer was outfitted with a Micro-Diver transducer with built-in data logger. The transducers had 10 meter ranges and 0.2 centimeter (cm) resolutions. A photo of the transducers is included in Appendix E.

Two stilling wells were installed at the piezometer sites to record water levels in Squaw Creek. Each stilling well was outfitted with a Micro-Diver transducer with built-in data logger. The combination of water levels in the piezometers and water levels measured in the stilling wells allows us to calculate vertical groundwater gradients in the shallow sediments directly beneath Squaw Creek.

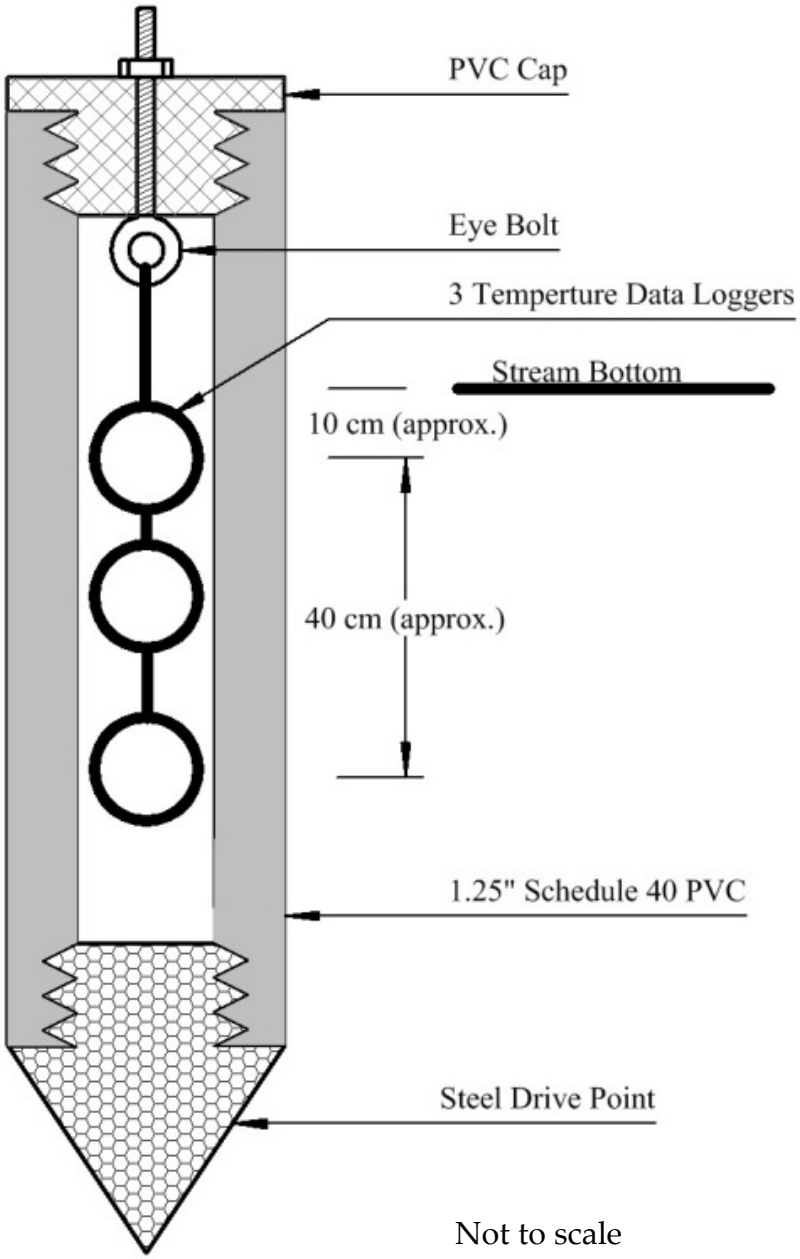

Figure 5: Temperature Probe Schematic

The Micro-Diver transducers were removed from the piezometers and stilling wells on November 4, 2009 to prevent them from being lost in winter floods. The transducers were re-installed in the piezometers on August 27, 2010, prior to the second aquifer test. The transducers and piezometers were completely removed from the trapezoidal channel on October 18, 2010. Piezometer locations are shown in Figure 4.

2.2.4 SURVEYING

All reference points for the newly installed monitoring wells, as well as the temporary piezometers and stilling wells were surveyed by Andregg Geomatics on October 1, 2010. The surveying was performed per GeoTracker guidelines and specifications. The horizontal location of the reference points were surveyed to the North American Datum of 1983, California State Plane Coordinate System, Zone 2. The vertical elevation of the reference points were surveyed to within 0.01 foot precision, referenced to NGVD29.

The temperature probes were not surveyed, because all data analyses are referenced to distance below ground surface. The distance below ground surface of each temperature data logger is shown in Table 2.

Survey data are summarized in Table 3. Complete survey data are included in Appendix F.

Table 3: Summary of Survey Data

NAD83 - California State Plane Coordinates Zone 2 - US Survey Feet
NGVD29 - Based on BM H-172 (PID KS0274) EL: 6177.99

FIELD_PT_NAME	XY_SURVEY_DATE	LATITUDE	LONGTITUDE	NORTHING	EASTING	ELEVATION
MW 5 Deep; PVC Pipe	10/1/2010	39.1979586	-120.2300327	2202983.734	7063225.154	6197.74
MW 5 Shallow; PVC Pipe	10/1/2010	39.1979623	-120.2300576	2202985.038	7063218.054	6197.63
Stilling Well near 5D/5S; PVC Pipe	10/1/2010	39.1980844	-120.2300289	2203029.557	7063225.318	6187.75
Deep Piezometer near 5D/5S; Steel Pipe	10/1/2010	39.1980844	-120.2300294	2203029.545	7063225.202	6187.72
Poulsen Deep; PVC Pipe	10/1/2010	39.1977463	-120.2286313	2202914.142	7063623.726	6191.77
Poulsen Deep; Steel Casing	10/1/2010	39.1977468	-120.2286313	2202914.327	7063623.730	6192.04
Poulsen Shallow; PVC Pipe	10/1/2010	39.1977616	-120.2286477	2202919.646	7063618.962	6192.31
Poulsen Shallow; Steel Casing	10/1/2010	39.1977622	-120.2286476	2202919.834	7063618.986	6192.50
SCPSD Well 4R; Sounding Tube	10/1/2010	39.1978166	-120.2319902	2202921.204	7062671.521	6204.90
Stilling Well east of Bridge; PVC Pipe	10/1/2010	39.1984107	-120.2320092	2203137.427	7062661.918	6188.46
Shallow Piezometer east of Bridge; Steel Pipe	10/1/2010	39.1984107	-120.2320095	2203137.436	7062661.833	6188.53
Deep Piezometer east of Bridge; Steel Pipe	10/1/2010	39.1984103	-120.2319939	2203137.364	7062666.277	6188.59
Bank Piezometer east of Bridge; Steel Pipe	10/1/2010	39.1983864	-120.2320039	2203128.635	7062663.611	6188.55
PlumpJack Shallow; PVC Pipe	10/1/2010	39.1974515	-120.2374377	2202758.283	7061130.612	6210.73
PlumpJack Shallow; Steel Grate	10/1/2010	39.1974519	-120.2374382	2202758.431	7061130.471	6211.05
PlumpJack Deep; Steel Grate	10/1/2010	39.1974262	-120.2372503	2202750.109	7061183.898	6209.60
PlumpJack Deep; PVC Pipe	10/1/2010	39.1974255	-120.2372507	2202749.821	7061183.780	6209.36
MW 5 Deep; Steel Grate	10/1/2010	39.1979593	-120.2300325	2202983.987	7063225.197	6198.25
MW 5 Shallow; Steel Grate	10/1/2010	39.1979633	-120.2300574	2202985.296	7063218.128	6198.30

2.3 TASK 3: EQUIPPING MONITORING WELLS

In accordance with the modified scope of work, new pressure transducers were installed in 14 wells. Competitive bids for the transducers were received from three companies:

Quotes were obtained by SVPSD from the following vendors:

Rockware
2221 East Street, Suite 101
Golden, CO. 80401
Tel: (303) 278-3534

Pine Environmental Services, Inc.
92 North Main Street, Building 20
Windsor, NJ 08561
Tel: (800) 3019663

Schlumberger Water Services
6590 South McCarran Boulevard
Suite A, Reno, Nevada 89509
Tel: (519) 746-1798

The monitoring equipment was installed in monitoring wells on June 3, 2009 and August 27, 2010. Figure 6 shows the locations of all 14 data loggers installed as part of this project.

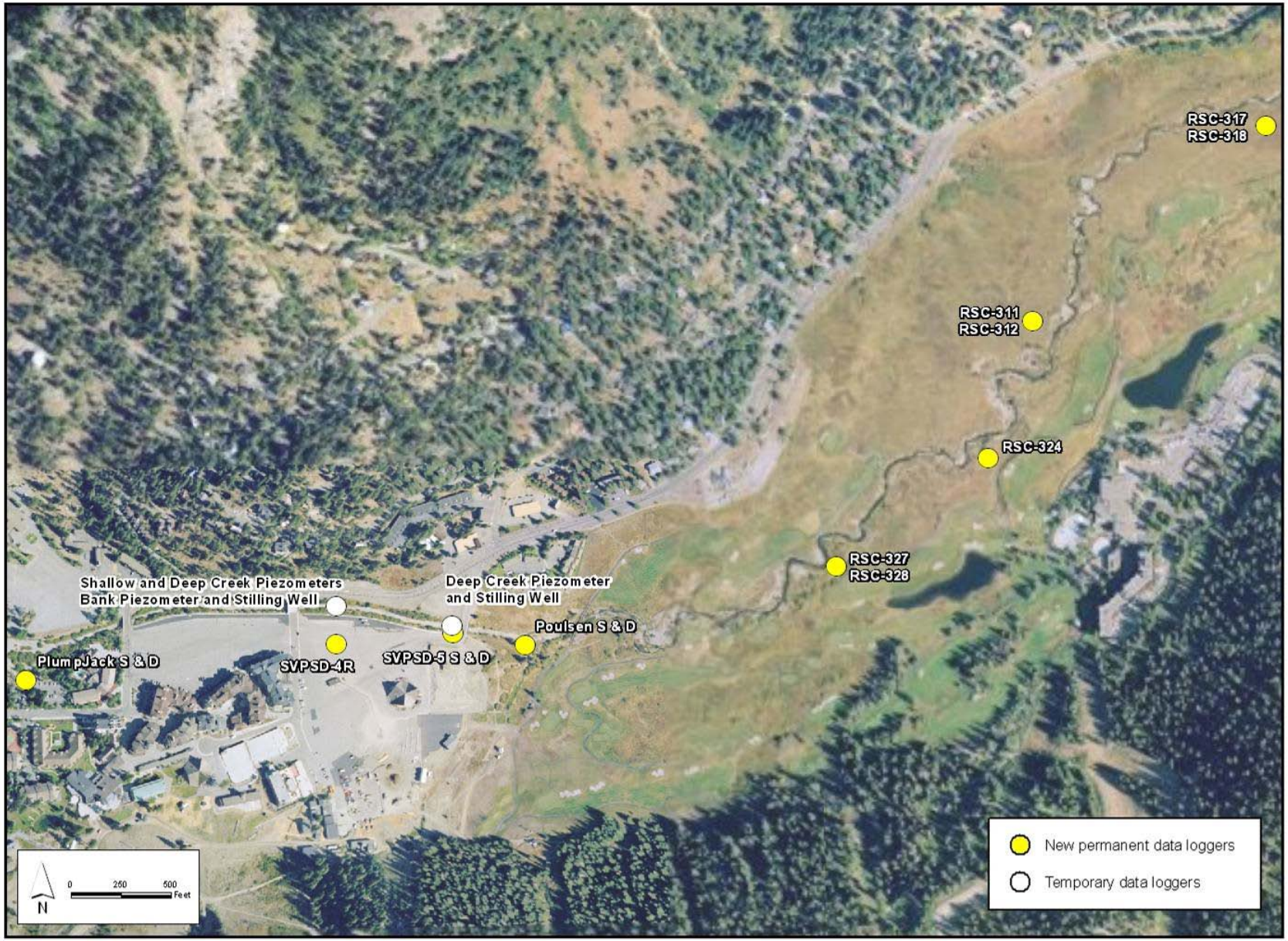

Figure 6: Locations of New Data Loggers

The equipment installed in each well is shown in Table 4.

Table 4: Summary of Monitoring Equipment Installed in Wells

Well	Monitoring Equipment
RSC-312	10m Mini-Diver and DDC
RSC-318	10m Mini-Diver and DDC
RSC-328	10m Mini-Diver and DDC
RSC-324	10m Mini-Diver and DDC
RSC-311	10m Mini-Diver and DDC
RSC-317	10m Mini-Diver and DDC
RSC-327	10m Mini-Diver and DDC
Poulsen Shallow	10m Mini-Diver and DDC
Poulsen Deep	20m Mini-Diver and DDC
PlumpJack Shallow	20m Mini-Diver and DDC
PlumpJack Deep	20m Mini-Diver and DDC
SVPSD MW-5S	20m Mini-Diver and DDC
SVPSD MW-5D	20m Mini-Diver and DDC
SVPSD #4R	20m Mini-Diver and DDC

DDC = Diver Data Cable
10m = 10 meter range
20m = 20 meter range

2.4 TASK 4: AQUIFER TESTING

Two constant rate aquifer tests were conducted in accordance with the modified scope of work. Both tests were conducted on well SVPSD #2, which is SVPSD's lead pumping well.

The first aquifer test was conducted on well SVPSD #2 between June 23 and June 25, 2009. Squaw Creek was flowing during the test. A photo shoing the condition of Squaw Creek during the first test is shown in Figure 7.

The first test was run for 52 hours. During the test, well SVPSD 2 was pumped at an average rate of 319 gallons per minute. All other SVPSD wells were idle during the test. Water level data were collected at the following wells throughout the test:

- SVPSD #2
- SVPSD #4R
- SVPSD #1

- SVPSD MW-5S
- SVPSD MW-5D
- SVMWC #1
- Poulsen Well, Shallow
- Poulsen Well, Deep
- The four piezometers in Squaw Creek and the two stilling wells that measure surface water levels in Squaw Creek

The eighteen temperature data loggers discussed above were also monitored during the test.

Groundwater drawdown data were collected during the 52-hour test. Groundwater recovery data were collected for approximately three and a half hours after the end of the test. Recovery measurements were stopped when SVPSD needed to restart its wells to meet demand.

Graphs of the measured groundwater elevation data and pumping rate data collected during the first aquifer test are provided in Appendix G. The raw data collected during the test is included on the enclosed CD.

The second aquifer test was conducted between September 8 and September 10, 2010. Squaw Creek was dry during the test. There were scattered showers on September 8, but not enough to develop any standing water in Squaw Creek. A photo showing the condition of Squaw Creek during the test is shown on Figure 8.

The second aquifer test was run for 51 hours. During the test, well SVPSD#2 was pumped at an average rate of 303 gallons per minute. All other SVPSD wells were idle during the test. Wells that were monitored during the test included:

- Well SVPSD #2
- Well SVPSD #4R
- Well SVPSD #1
- Well SVPSD MW-5S
- Well SVPSD WM-5D
- Well SVMWC #1
- Poulsen Well, Shallow
- Poulsen Well, Deep
- Four well points that measure shallow groundwater levels beneath Squaw Creek.

The eighteen temperature data loggers discussed above were also monitored during the second aquifer test.

Groundwater drawdown data were collected during the 51-hour test. Groundwater recover data were collected for approximately four hours after the end of the test. Recovery measurements were stopped when SVPSD needed to restart its wells to meet demand.

Graphs of the measured groundwater elevation data and pumping rate data collected during the second aquifer test are provided in Appendix G. The raw data collected during the test is included on the enclosed CD.

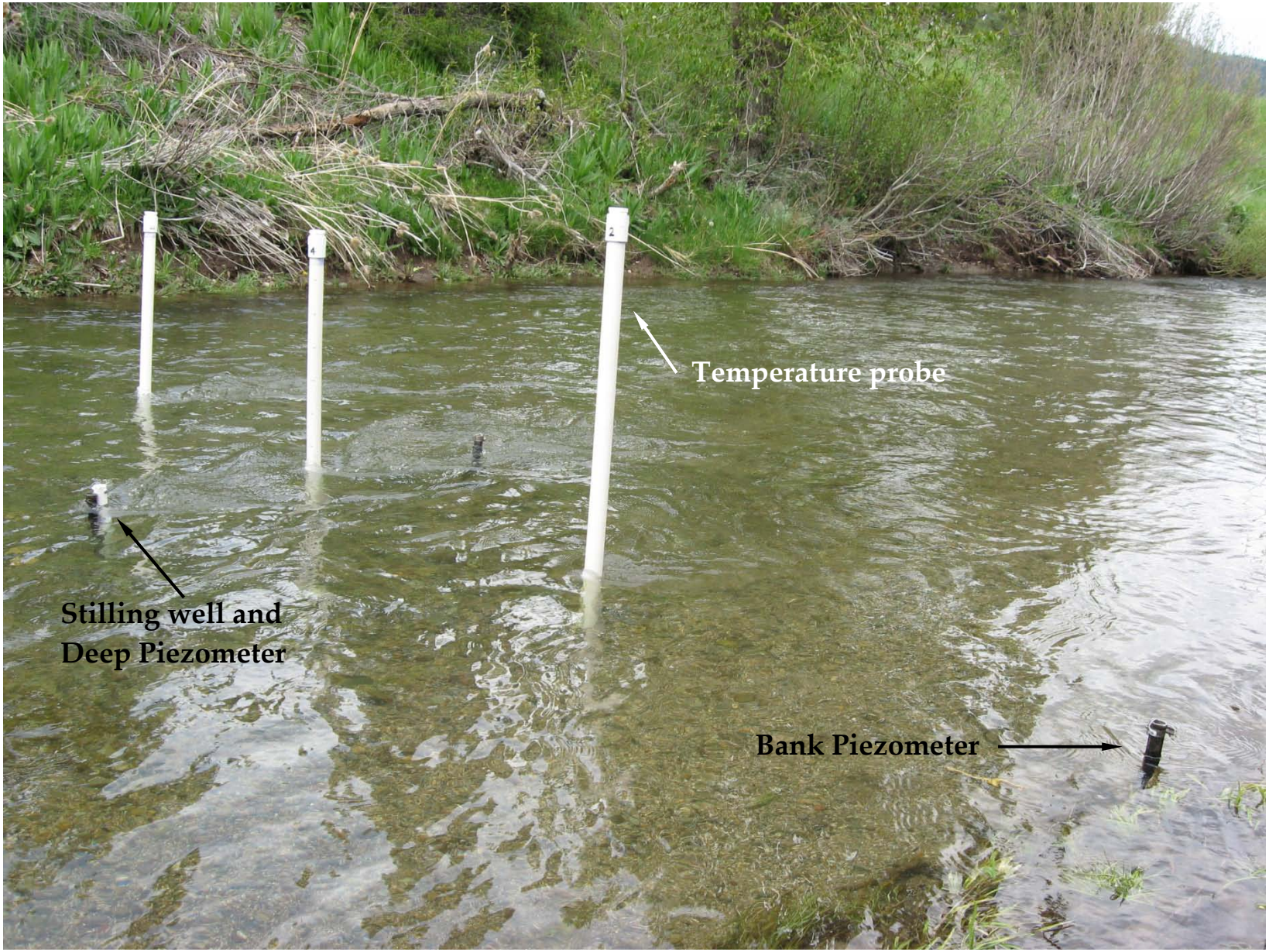

Figure 7: Monitoring Equipment in Flowing Squaw Creek during First Aquifer Test

Figure 8: Monitoring Equipment in Dry Squaw Creek during Second Aquifer Test

2.5 TASK 5: REPORTING

Reporting consisted of submitting quarterly reports and drafting this final report. Every quarterly report was prepared and submitted on time. The following quarterly reports were submitted:

- Fourth Quarter 2008; submitted in January 2009
- First Quarter 2009; submitted in April 2009
- Second Quarter 2009; submitted in July 2009
- Third Quarter 2009; submitted in October 2009
- Fourth Quarter 2009; submitted in January 2010
- First Quarter 2010; submitted in April 2010
- Second Quarter 2010; submitted in July 2010
- Third Quarter 2010; submitted in October 2010
- Fourth Quarter 2010; submitted in January 2011

Weather delays resulted in a longer project schedule than initially planned, and therefore more quarterly reports were produced than originally planned. The additional cost was minor because there was little to report during winter quarters, and therefore the quarterly reports were more brief than anticipated.

SECTION 3
COST INFORMATION

The Squaw Valley Creek/Aquifer Interaction Study has been completed within the original budget. Table 5 provides a breakdown of the original budget included in LGA Agreement 4600008205.

Table 5: Squaw Valley Creek/Aquifer Study Original Budget

Task	Description	Grant Amount
1	Pre-Construction Activities	$17,419
2	Drilling, Well Construction, and Development	$102,997
3	Equipping Monitoring Wells	$40,766
4	Aquifer Tests	$28,448
5	Reporting	$31,000
	Total	**$220,630**

Although the costs remain within the original project budget, some positive and negative cost variances occurred on individual tasks. Reasons for the variances between budgeted amounts and incurred costs for various tasks are detailed below.

TASK 1: PRE-CONSTRUCTION ACTIVITIES

Task 1 costs exceeded the budget largely due to efforts to incorporate recent technological advances in estimating stream/aquifer interactions. The project initially called for three monitoring well sites along the edge of Squaw Creek. Monitoring well locations at the Poulsen and PlumpJack Squaw Valley Inn sites remained as in the original plan. The monitoring well pair originally planned for the Squaw Valley Ski Corporation parking lot was replaced with the four temporary piezometers and six temperature probes in Squaw Creek. The extra costs incurred in Task 1 related to reconfiguring the monitoring plan and obtaining the necessary permissions and permits.

Additional costs were incurred in Task 1 to cover the second round of well permitting necessitated by the weather-caused delays. These additional permitting costs have been absorbed by SVPSD, and are not reflected in the modified budget.

TASK 2: DRILLING, WELL CONSTRUCTION, AND WELL DEVELOPMENT

Task 2 costs were slightly less than originally budgeted because we were able to combine field work on Tasks 2 and 3 into single field days. This allowed us to reduce the total time spent in the field, and bring in Task 2 under budget.

TASK 3: EQUIPPING MONITORING WELLS

Task 3 costs were less than originally budgeted because of savings on the cost of transducers and temperature data loggers. The cost of the 14 pressure transducers and associated data readers bought for the project was less than the cost originally estimated, when the project was being budgeted.

TASK 4: AQUIFER TESTS

Task 4 costs exceeded the original budget because the second aquifer test was delayed due to weather conditions in 2009. Money had been expended preparing for the second aquifer test in 2009 before it was delayed. This 2009 expenditure for the aborted aquifer test put this task over budget. The second aquifer test was run in 2010.

TASK 5: REPORTING

Task 5 costs were slightly less than originally budgeted because weather delays resulted in many quarters when there was little to report, and therefore the quarterly reports were more brief than anticipated.

Based on the above justifications, SVPSD requested that the individual task budgets be modified. The modification was requested as part of the third quarter 2010 quarterly report, submitted in October 2010. No change to the total grant amount was requested. DWR staff granted SVPSD's budget modification request. Table 6 provides a breakdown of the final budget for LGA Agreement 4600008205.

Table 6: Squaw Valley Creek/Aquifer Study Final Budget

Task	Description	Grant Amount
1	Pre-Construction Activities	$25,465.97
2	Drilling, Well Construction, and Development	$101,636.05
3	Equipping Monitoring Wells	$37,395.91
4	Aquifer Tests	$32,184.58
5	Reporting	$23,947.49
	Total	**$220,630.00**

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SECTION 4
SCHEDULE INFORMATION

Figure 9 shows the proposed schedule from the grant application. The schedule was updated every quarter based on progress made, weather delays, and scope changes. A revised schedule was included in every quarterly report. The final project schedule is shown in Figure 10.

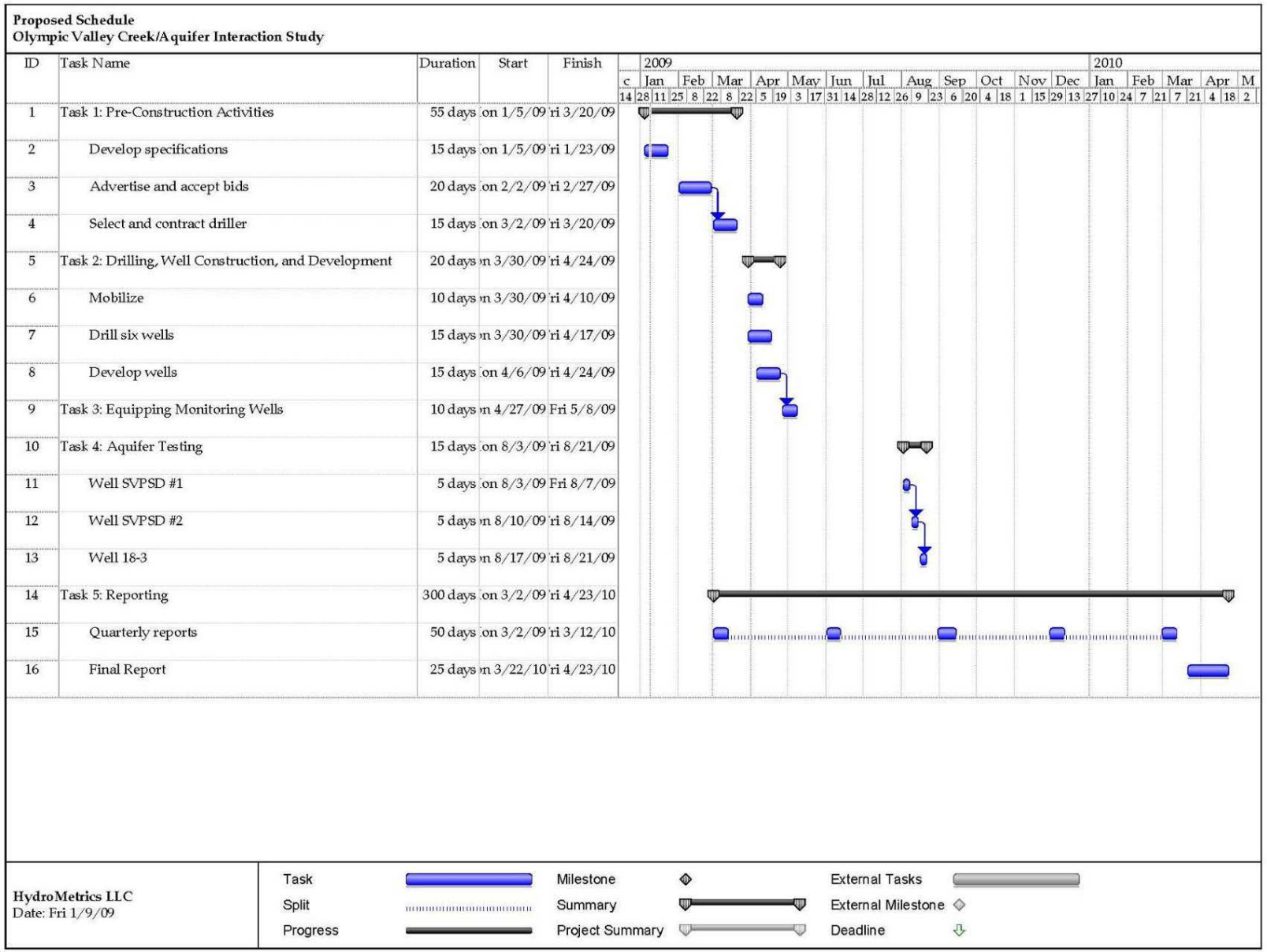

Figure 9: Original Schedule

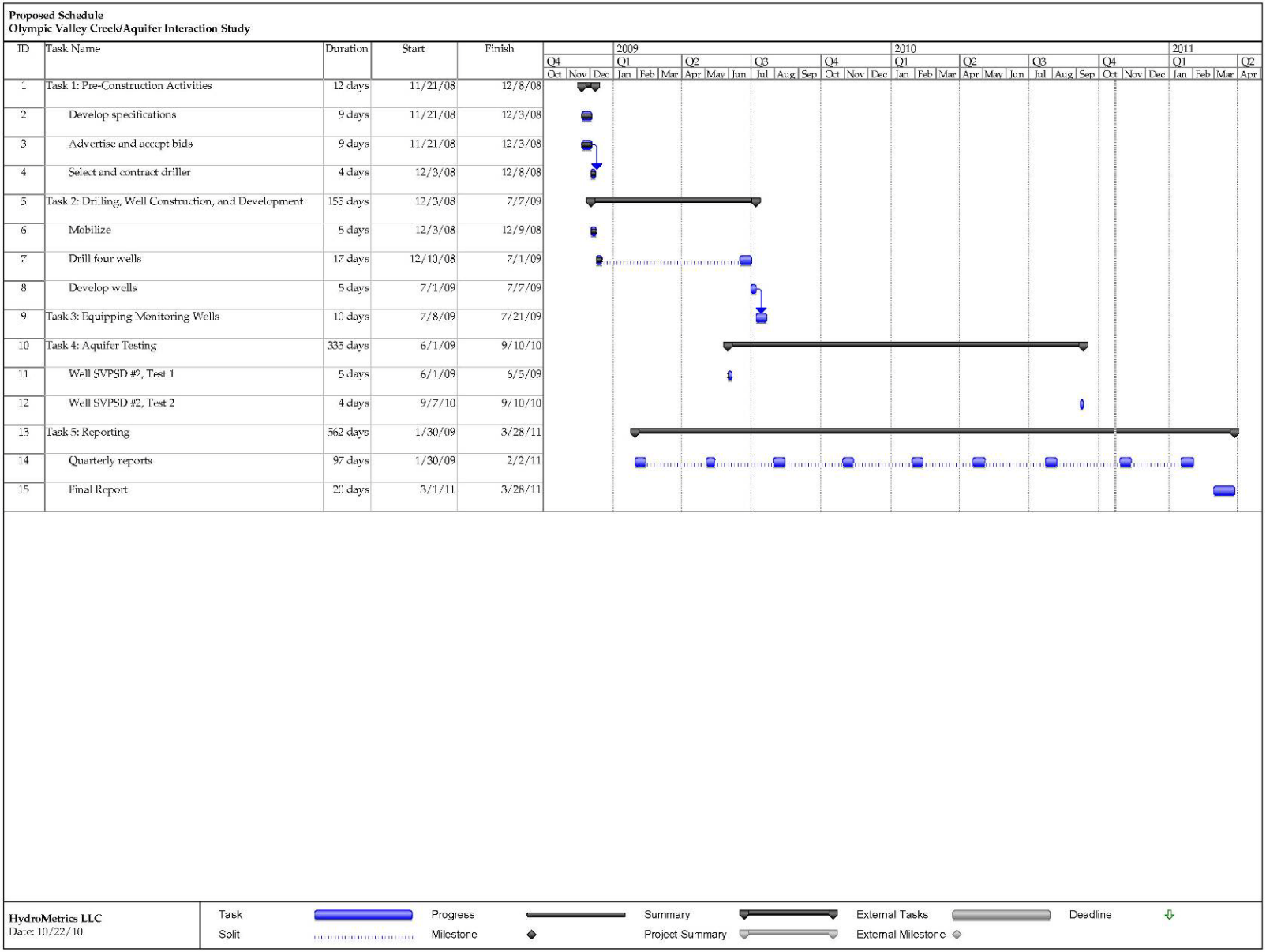

Figure 10: Final Revised Schedule

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SECTION 5
REFERENCES

Hatch, C.E., A.T. Fisher, J.S. Revenaugh, J. Constantz, and C. Ruehl, C., Quantifying surface water – ground water interactions using time series analysis of streambed thermal records: method development, *Water. Resour. Res.,* 42(10): 10.1029/2005WR004787.

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