Attachment 5: Work Plan

The work plan must be consistent with and support the budget and schedule. The level of detail must be sufficient for the work plan to function as the scope of work for the agreement and to allow reviewers to understand the level of effort of the work being performed as to further substantiate the cost estimates in the budget. If the applicant does not have an existing GWMP, then it should use this section to detail the process by which one will be created. The work plan should include, at a minimum, the following items:

 Scope of the proposed project including (as appropriate) maps of agency area and area of proposed tasks;

 Specific purpose, goals, and objectives of the proposed project related to improving groundwater management and implementing the GWMP and/or where applicable the IRWM Plan;

 Work items to be performed under each task of the proposed tasks (consistent with the budget and schedule);

 Present a sound strategy for evaluating progress and performance at each step of the proposed project.

 Project deliverables for assessing progress and accomplishments, which include quarterly progress and final reports.

 If access to private property is needed, provide assurance that access can be granted. For example, if wells will be constructed or sampled on private land, submit a letter or agreement that demonstrates that access for well construction and monitoring on the property has been obtained.

 Explain the plan for environmental compliance and permitting, including a discussion of the following items: a description of the plan, proposed efforts, and approach to environmental compliance, including addressing any CEQA obligations in connection with the proposal; a listing environmental related permits or entitlements that are needed for the project; and any other applicable permits that will be required. Briefly describe the process and schedule for securing each permit/approval. Discuss necessary local drilling permits and the submittal of Well Completion Reports to DWR. Describe the proposed process for securing each environmental permit and any other regulatory agency approval.

Project Purpose, Goals, and Objectives

The primary purpose of this project is to evaluate data already collected in the Olympic Valley Creek/Aquifer Interaction Project Phase I, and to use those data in a groundwater flow model that will be used as a tool to improve basin management with respect to reducing impacts on Squaw Creek and increasing basin storage.

The project's goals are:

1. Improve and quantify our understanding of creek/aquifer interaction;
2. Diminish groundwater pumping impacts on Squaw Creek and the associated Truckee River; and
3. Increase groundwater storage in Olympic Valley.

Specific objectives of the project include:

1. Quantify the impact of pumping wells on Squaw Creek;
2. Quantify the amount of groundwater being drained by the trapezoidal channel in Squaw Creek;
3. Quantify climate change impacts on Squaw Creek;
4. Improve the existing groundwater model to more confidently evaluate groundwater and stream impacts from pumping;
5. Provide a management tool that can be used for Squaw Creek restoration being undertaken by Friends of Squaw Creek and Truckee River Watershed Counsel; and
6. Develop data that can be shared with other Stakeholders.

Apart from supporting the goals and objectives of the GWMP, as discussed in Attachment 4, the project meets numerous objectives that are listed in the adopted IRWM. This project addresses the objectives by implementing a number of management strategies that are outlined in the IRWM. Specific IRWM objectives and management strategies include:

IRWM Objective	IRWM Management Strategy
Water Quality Objective WQ5: Restore degraded streams and wetlands to re-establish natural water filtering processes.	– Ecosystem restoration – Environmental and habitat protection and improvement – Groundwater management
Water Supply Objective WS1: Provide adequate water supply for a 20-year management window.	– Water supply reliability – Groundwater management
Groundwater Management Objective GWM1: Create reliable groundwater supply. Groundwater Management Objective GWM3: Manage groundwater for multiple uses.	– Water supply reliability – Groundwater management

IRWM Objective	IRWM Management Strategy
Ecosystem Restoration Objective ER1: Enhance and restore degraded stream environment zones (SEZs) to support healthy and viable native fish populations. Ecosystem Restoration Objective ER5: Minimize disturbance caused by urban development.	– Ecosystem restoration – Environmental and habitat protection and improvement – Groundwater management
Integrated Watershed Management Objective IWM1: Ensure sound planning that is based on watershed science.	– Ecosystem restoration – Environmental and habitat protection and improvement – Water supply reliability – Groundwater management – Water quality protection and improvement

Description of Work

The proposed scope of work is divided into five tasks:

1. Assessment and Evaluation of Phase I Data;
2. Integrate the Creek/Aquifer Interaction Results into the Olympic Valley Groundwater Flow Model;
3. Develop Groundwater Pumping Guidelines for Olympic Valley;
4. Reporting, and
5. Administration

A map showing the project location is provided at the end of this attachment (Figure Att5-1). A detailed description of the work items to be performed for each task is presented below:

Task 1: Assessment and Evaluation of Phase I Data

Task 1.1: Quantify Creek/Aquifer Interaction using Depth Specific Temperature Data

As a first step towards reducing pumping impacts on Squaw Creek, we will quantify seasonal and long-term creek/aquifer interactions using heat (temperature) as a tracer to track the movement of water between Squaw Creek and the underlying groundwater system. The method is based on quantifying changes in phase and amplitude of temperature variations between pairs of subsurface sensors set below the streambed. The figure below illustrates the temperature sensors at different depths and the resultant temperature data plotted from data stored on the loggers.

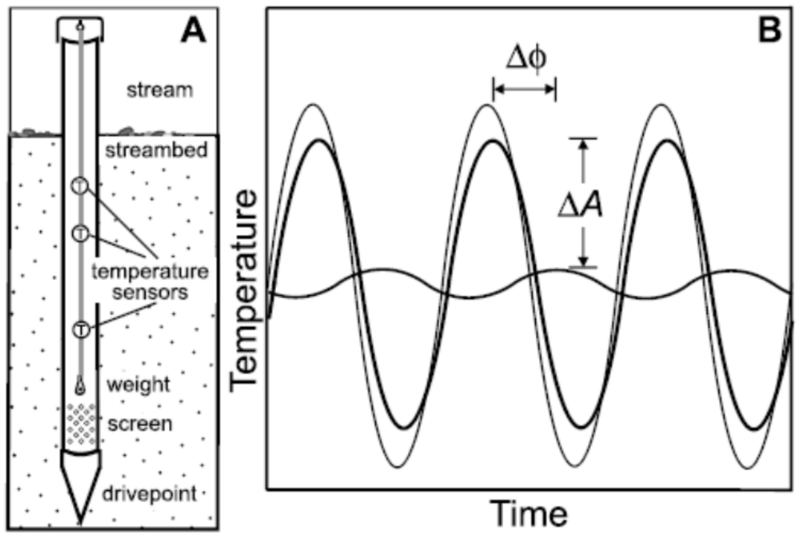

Figure 1. Diagrams illustrating acquisition of streambed temperature records and basis for new analytical method. (a) Streambed piezometer with temperature sensors at various depths. (b) Temperature versus time records showing reduction in amplitude (ΔA) and shift in phase ($\Delta\phi$) with greater depth.

Source: Hatch, *et al.* (2006)

Our approach to analyzing the temperature data is based on well documented methods developed by the U.S. Geological Survey and researchers at U.C. Santa Cruz. The following published scientific papers document the development and application of our methodology:

Constantz, J., Su, G.W., and Hatch, C., 2006, Heat as a ground water tracer at the Russian River RBF facility, Sonoma County, California, in Hubbs, S.A., ed., Riverbank Filtration Hydrology: Dordrecht, Springer, p. 243-259.

Hatch, C.E., Fisher, A.T., Revenaugh, J. S., Constantz, J., and Ruehl, C, 2006, Quantifying surface water - groundwater interactions using time series analysis of streambed thermal records: Methods development : Water Resources Research, v. 42, W10410, doi: 10.1029/2005WR004787.

Sun, M., and Fisher, A., 1992, WSTP/Origin, Graphical Software for Windows-based processing of temperature data from the Water-sampling Temperature Probe.

USGS Fact Sheet 2004-3010, February 2004. Using temperature to study stream-ground water exchanges.

Andy Fisher at UC Santa Cruz, is one of the developers of this technique, and has successfully applied it in a number of studies. We will draw on his expertise to assist us with analyzing the depth-specific temperature data collected in Squaw Creek.

The available data for this subtask are eight months of 15-minute interval temperature measurements from six probes that were installed in Squaw Creek. In addition to the depth-specific temperature loggers, stilling wells and groundwater piezometers were installed next to the temperature probes. These were equipped with pressure transducers that recorded water levels. From these data, it is possible to identify accurately when the creek was flowing and what the vertical hydraulic gradients were at any point in time. These data will be used in conjunction with the temperature data, and other nearby well groundwater level, to develop a conceptual understanding of when the monitored reach of Squaw Creek is gaining water from the aquifer and when it is losing water to the aquifer.

It is envisioned that the order of work for this task will be as follows:

1. Initial meeting with Dr. Andy Fisher to establish working protocol.
2. Manually filter already compiled temperature data according to defined protocols and water level data.
3. Apply frequency bandpass filter to extract daily temperature signal, and resample.
4. Run data through creek/aquifer interaction software developed by Dr. Fisher and other to calculate time series of amplitude ratio and phase shift.
5. Iterate for seepage rates from amplitude ratio and phase shift.
6. Determine final daily seepage rates between Squaw Creek and the underlying aquifers.

Results from this task will quantify the long-term interaction between Squaw Creek and the adjoining aquifer. These results will show when the stream is gaining water from the aquifer, and when it is losing water to the aquifer. These results will inform future groundwater management decisions, as well as provide important input to the groundwater model.

Task 1.2: Establish Pumping Impacts on Squaw Creek by Analyzing Aquifer Test Data

Pumping impacts on Squaw Creek can be directly measured by analyzing results from two similar aquifer tests. Two controlled aquifer tests were conducted on Squaw Valley Public Service District Well 2 in 2009 and 2010. The first test in June 2009 was designed to collect data while Squaw Creek was flowing. A second, similar test took place in September 2010 after Squaw Creek had dried up and before winter rain started. Data collected during the tests include SCADA groundwater level and pumping data from the pumping well; groundwater level data for one nearby municipal well, five nearby monitoring wells and four streambed piezometers.

By conducting two similar aquifer tests under different hydrologic conditions, it is possible to compare the drawdown characteristics of the two tests to determine whether there are differences in the response curve. It is expected this comparative analysis will indicate whether and when Squaw Creek is a source of water to the well when it pumps. We will first analyze the two aquifer tests using standard hydrogeologic techniques such as Theis analyses, Cooper-Jacob analyses, and Hantush leaky-aquifer analyses. These analyses will be used to estimate the aquifer's hydraulic properties such as transmissivity, storage, and leakance from the aquifer tests. The transmissivity and storage properties estimated from the test when Squaw Creek is not flowing constrain the hydraulic properties of the test when Squaw Creek is flowing. This allows us to compare the two tests and establish exactly how much of the pumping was directly extracted from Squaw Creek.

Results from this task will quantify the direct relationship between pumping an individual well and flows in Squaw Creek. These results will inform future groundwater management decisions, as well as provide important input to the groundwater model.

Task 1.3: Integrate Results from Tasks 1.1 and 1.2 with LLNL Climate Change and Tracer Study

Jean Moran was a principal investigator during the Olympic Valley groundwater study carried out and funded by Lawrence Livermore National Laboratory (LLNL) in 2008 and 2009. Dr. Moran will be brought in as a collaborator in the proposed project to integrate and interpret data generated in 2008 and 2009 by LLNL during experiments designed to delineate groundwater inflow to Squaw Creek. These data were not included in the LLNL Water Resources Research publication which focused on groundwater residence time and recharge area determination in Squaw Valley (Singleton and Moran, 2010).

For this project, Dr. Moran will compile and evaluate temperature data collected during the Distributed Temperature Sensor experiment in the middle reach of Squaw Creek, which took place in July 2009, along with geochemical data such as dissolved Radon, major ions, and carbon isotopes collected during Squaw Creek sampling in June and July of 2009 (approximately 100 sample results). These tracers can be interpreted to identify locations of groundwater inflow and potentially to quantify groundwater inflow to Squaw Creek during the time period over which the sampling took place. Dr. Moran will supervise a graduate student who will be engaged in an effort to model Radon gas loss at the stream water-air interface during transport downstream from groundwater input locations.

In addition, Dr. Moran will work with staff from our consultant, HydroMetrics Water Resources Inc., to integrate all data generated during the surface water and groundwater LLNL studies with data collected by Hydrometrics and SVPSD. Interpretation of results will center on seasonal creek/aquifer interaction, groundwater recharge, and the effects of climate change (higher snowline, more precipitation as rain) on runoff, groundwater recharge, and the water budget for the basin.

Task 2: Integrate the Creek/Aquifer Interaction Results into the Olympic Valley Groundwater Flow Model

Integrating the results of the seasonal temperature data, aquifer test data, and LLNL study data into the Olympic Valley groundwater flow model will allow the model to accurately predict seasonal interactions between shallow aquifers and Squaw Creek, as well as the impact of pumping on Squaw Creek flows. This will then allow us to use the model to establish groundwater management guidelines that minimize pumping impacts on Squaw Creek and maximize groundwater storage.

The Olympic Valley groundwater flow model was developed 13 years ago, using the USGS's MODFLOW code. This model will be updated to the end of 2011 using data already stored in the Olympic Valley groundwater database. The conceptual understanding of the basin will be updated based on the results of the temperature data, results of the aquifer test analysis, and findings of the LLNL climate change study discussed in Task 1.3. This will require that some of the input terms, such as boundary conditions, horizontal flow barriers, and spatial distribution of recharge be changed. Aquifer parameters may also be revised based on properties estimated from the aquifer tests (Task 1.2).

The model will be re-calibrated according to industry standard methods, such as those discussed in Applied Groundwater Modeling (Anderson and Woessner, 1992), Groundwater Flow Modeling Guideline (Murray Darling Basin Commission, 2000), and Effective Groundwater Model Calibration (Hill and Tiedeman, 2007). Hydrographs showing both modeled and measured groundwater levels for key wells will be used to demonstrate the effectiveness of the model for simulating historical conditions in the Olympic Valley.

Up to 5 model scenarios will be run with the updated groundwater model to answer a combination of the following questions:

1. During times when the creek flows, how much water is drawn from the creek into the aquifer when all municipal wells are pumping?
2. How much water is flowing from the aquifer into the creek and what impact does that have on groundwater storage?
3. What are the recommended pumping scenarios to reduce pumping impacts on the stream and to maximize the use of aquifer storage?
4. What climatic conditions will result in critical conditions when flow in Squaw Creek is minimal but still sustains biota?
5. What is the maximum sustainable groundwater yield, without significantly impacting Squaw Creek?
6. What modifications to Squaw Creek can be made to increase groundwater storage?

Task 3: Develop Groundwater Pumping Guidelines for Olympic Valley

Based on the findings from Task 2, a guideline document will be prepared that outlines different pumping options for different hydrologic conditions in Squaw Creek. The guidelines will be developed with the goal of sustainably using groundwater for water supply purposes, while maximizing aquifer storage and minimizing creek impacts.

The guideline document will include creek mitigation measures that could be implemented to counter pumping impacts. Based on the results of modeling impacts to the trapezoidal channel (Task 2), SVPSD will work cooperatively with the property owner to identify potential mitigation measures that could be considered. Mitigation measures will only be included in the guideline document if they improve annual pumping capacity and in-stream flows.

Task 4: Reporting

Task 4.1: Technical Memorandum on Seasonal Stream/Aquifer Interactions

The data, methodology, and analyses from Task 1.1 will be summarized in a technical memorandum at the conclusion of that task. This memorandum will serve as the task deliverable and to evaluate progress and performance.

Task 4.2: Technical Memorandum on Pumping Impacts on Squaw Creek

The data, methodology, and analyses from Task 1.2 will be summarized in a technical memorandum at the conclusion of that task. This memorandum will serve as the task deliverable and to evaluate progress and performance.

Task 4.3: Technical Memorandum on LLNL Temperature Isotope Tracers as they Relate to Creek/Aquifer Interactions

The data, methodology, and analyses from Task 1.3 will be summarized in a technical memorandum at the conclusion of that task. This memorandum will serve as the task deliverable and to evaluate progress and performance.

Task 4.4: Technical Memorandum on the Groundwater Model Update and Scenario Results

The model update from Task 2 will be extensively documented in this technical memorandum. All changes to the model will be documented and supported by data from Tasks 1 and 2. The model calibration results will be presented in graphical form to show how the modeled groundwater levels and creek flows match measured data. A description of the five model scenarios will be provided, along with the results of each of the simulations.

Task 4.5: Quarterly Reports

Three quarterly progress reports required by DWR will be prepared and submitted under this task. These reports demonstrate that the project is proceeding as planned, and that the grant funding is being expended in accordance with the grant requirements. The reports will include a description of progress made for the reported quarter, an update on the budget for each project task, an update on the status of each project task, and a description of work expected to be completed in the subsequent quarter.

Task 4.6: Final Report

All three technical memoranda from Tasks 4.1 through 4.3 will be included as appendices to the project's final report. Additionally, the groundwater pumping guidelines from Task 3 will be included in the final repot as a separate appendix. The final report will describe all analyses, results and recommendations. A draft will be distributed to the Board of Directors, DWR, and interested parties. After a reasonable review period, comments provided will be addressed and incorporated into the final report.

Task 5: Administration

Task 5.1: Project Management

Project management for the project will include, preparing and submitting monthly invoices, budget and schedule tracking, and day-to-day communication with contractors and partners, as necessary. Most of these management tasks will continue throughout the duration of the project.

Project management will additionally include project progress and percent completion tracking All reimbursable time spent on this project will be recorded in standard accounting software such as QuickBooks, and the project schedule will be updated regularly using Microsoft Project. Any project delays or overruns will immediately be brought to the attention of the State, and the project budget and schedule will be immediately modified to ensure that the project is completed on time and within budget.

Task 5.2: Contract Administration

This subtask ensures close coordination with contractors and partner agencies that receive funding from this grant. Work will involve preparing agreements with all contractors, including HydroMetrics WRI, Dr. Andy Fisher of UC Santa Cruz, and Dr. Jean Moran of Lawrence Livermore Laboratory (LLNL) / California State University East Bay (CSUEB). The task will additionally involve reviewing and approving subcontractor invoices, as they are submitted. Review of subcontractor change orders is also included under this task.

Task 5.3: Meetings

Regular interaction with the District's staff, Board of Directors, GWMP TAG, and DWR staff is needed to ensure the project remains on budget and schedule. This task includes preparation for and attendance at four meetings and/or presentations to keep interested parties apprised of the project's progress.

Performance of the Project

Schedule and Budget Management

The budget for this project will be tracked at two levels: SVPSD will track budgets in their internal accounting system, and SVPSD's groundwater consultant will track budgets independently. Budgets and schedules will be updated monthly based on the consultant's monthly invoices. Budget and schedule management additionally tied to the quarterly reporting plan. The quarterly reports will identify progress to date, compare actual progress with the anticipated schedule, identify where the schedule and budget have slipped, and propose methods for addressing and problems with budget or schedule.

Project Deliverables

As outlined in the Scope of Work, project deliverables that can be used to assess project progress and performance will include the following:

- Technical Memoranda. At the conclusion of Tasks 1.1, 1.2, 1.3 and 2, technical memoranda will be prepared that provide the data, methodology, and analyses for each task.
- Quarterly Report. Given the expected project schedule of 46 weeks, three quarterly progress reports will be prepared and submitted. The reports will demonstrate that the project is proceeding as planned, and that the grant funding is being expended in accordance with the grant requirements. The report will include a description of progress made for the reported quarter, an update on the budget for each project task, an update on the status of each project task, and a description of work expected to be completed by the end of the project.
- Final Report. To mark the completion of the project, a final report will be prepared that contains the three previously completed technical memoranda and pumping guidelines.

Permitting and Access Agreements

Well permitting, well installation, monitoring equipment purchase and installation, aquifer testing, and data collection were all completed in Phase I. A CEQA categorical exemption was filed during Phase I, which covers the entire project, including all tasks and activities described in this grant application.

All necessary land use agreements were finalized during the previous project phase. The land use agreements were necessary for the well installation and data collection activities. The land use agreements remain in effect, and no additional land use agreements are needed for this phase.

Ongoing Use

The updated groundwater flow model will be used for ongoing groundwater management of the basin. Examples of where it will be applied in the future include: planning new pumping locations and volumes taking into account impacts on Squaw Creek and basin storage, and evaluating potential stream modifications.

After the project is completed, stakeholders who want to use the model to evaluate changing groundwater pumping strategies will be responsible for funding those particular model runs. This use of the model is a certainty due to planned development in the valley. The model will be updated every three to four years, and this will be funded by SVPSD.

Information Dissemination

Information and documents generated from this project will be disseminated at SVPSD Board of Director meetings, GWMP Technical Advisory Group (TAG) meetings where all stakeholders are represented, and through SVPSD's website where the public will have access to the reports. Hardcopies will also be made available at SVPSD's offices.

Collaboration with Stakeholders

The GWMP has a number of stakeholders who are active in groundwater management of the Olympic Valley. These stakeholders are: Friends of Squaw Creek, SVMWC, Ski Corp, Lahontan Regional Water Quality Control Board, Resort at Squaw Creek, and PlumpJack Inn. The stakeholders have various groundwater interests in the valley: some are concerned with restoring Squaw Creek; others want to know how much they can pump without impacting the creek.

As part of the GWMP, a Technical Advisory Group (TAG) which has representatives from the stakeholders meets at least annually to spearhead and direct GWMP initiatives. This project has been discussed at these meetings. The TAG will meet more regularly while the project is underway in order to keep all parties appraised and involved.

References

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Hill, M.C., and C.R. Tiedeman. 2007. *Effective groundwater model calibration; with analysis of data, sensitivities, predictions and uncertainty*. John Wiley & Sons, Inc., Hoboken, NJ, 455 p.

Hydrometrics Water Resources Inc. 2007. Olympic Valley Groundwater Management Plan. Prepared for Squaw Valley Service District. May. http://www.svpsd.org/pdffiles/GMP%20Files/OV_GMP_Final_rev1_06-01-07.pdf

Murray-Darling Basin Commission. 2000. Groundwater Flow Modeling Guideline, Aquaterra Consulting PTY LTD, Project No. 125, 72 p.

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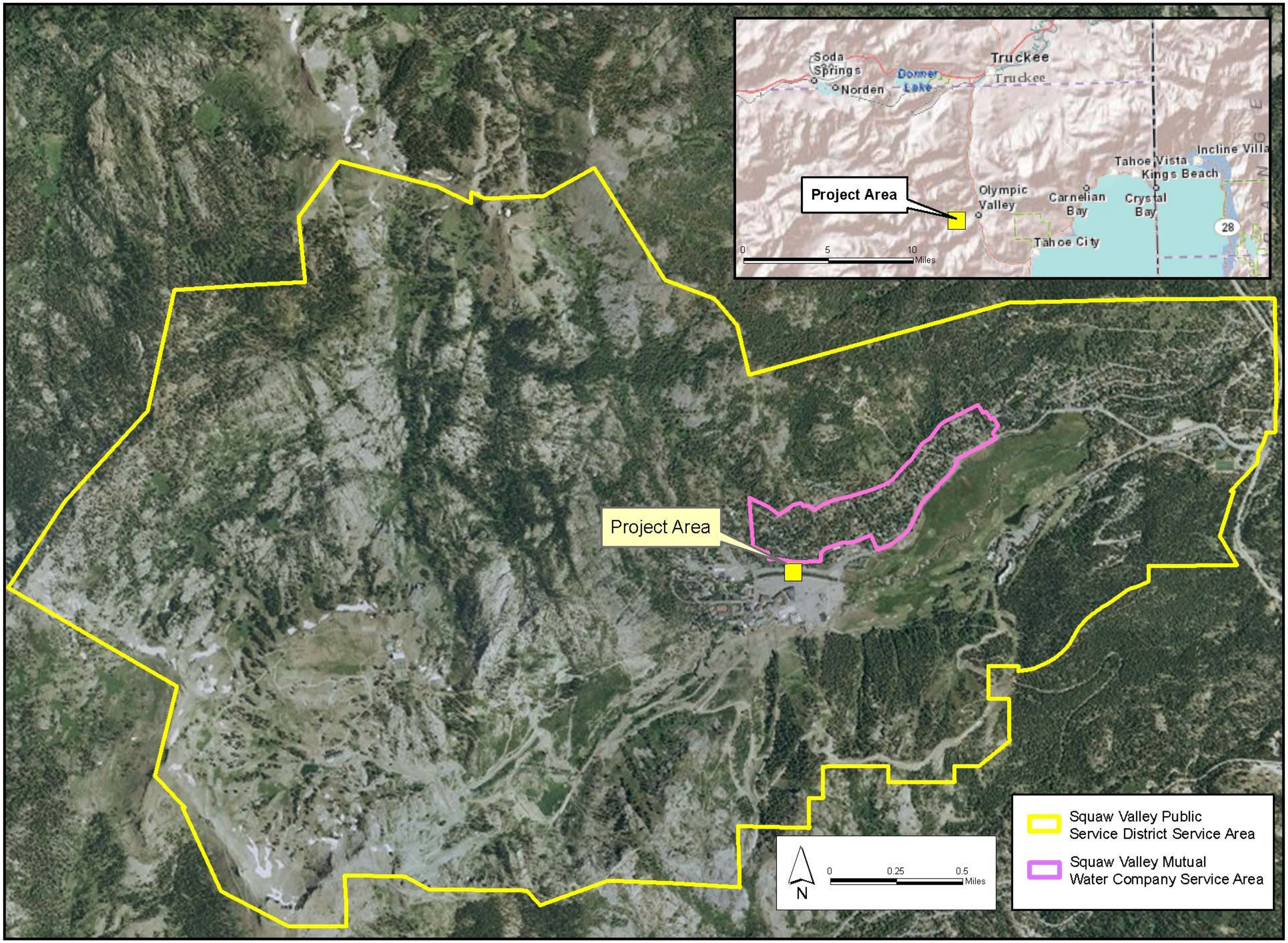

Figure Att5-1: Project Location and Water Purveyor Boundaries