Executive Summary

HydroMetrics WRI was retained by the Squaw Valley Public Service District to complete a Squaw Creek/Aquifer interaction study. This study enhances the District's understanding of the Valley's hydrology, and provides guidance on how to avoid negative impacts to Squaw Creek. Direct drivers of the study included:

- Satisfying California's State Water Resources Control Board Resolution 2007-0008 that, "Directs the Lahontan Water Board to continue to support the efforts of entities pumping groundwater to … conduct a study of potential interaction between groundwater pumping and flows in Squaw Creek."
- Addressing Element 2.2 of the *Olympic Valley Groundwater Management Plan,* which identifies the need for a stream/aquifer interaction study.
- Responding to demands by some members of the Squaw Valley community to gain a better understanding of the hydrologic relationship between pumping in the aquifer and flows in Squaw Creek.
- Providing the basis for a Pumping Management Plan, so the District can perform its operations with informed, best practices.
- Implementing the District's mission statement of " ... [providing] leadership in maintaining and advocating for needed, high-quality and financially sound community services for the Valley … while protecting natural resources and the environment."

The study was designed to better understand the relationship between shallow groundwater and flows in Squaw Creek. The analysis evaluated impacts of municipal well pumping on shallow groundwater adjacent to Squaw Creek, and assessed the quantity of water lost from the shallow aquifer into Squaw Creek.

The study was completed in two phases. Phase I comprised instrumentation, testing, and data collection. Phase II included analyzing data, quantifying the flows between Squaw Creek and the shallow aquifer, integrating information from multiple studies, and updating the groundwater model. The study is based on data collected through 2011, and therefore does not analyze groundwater pumping proposed in the *Village at Squaw Valley Specific Plan* (Squaw Valley Real Estate LLC, 2014). The analyses of streamflow capture was, however, applied to 2012 and 2013 Squaw Creek flow data in order to illustrate how the study's results are applicable to recent data.

The study established that water seeps both from the shallow aquifer into the trapezoidal channel, and from the trapezoidal channel into the aquifer. The direction and amount of seepage depend on both the time of year and location in the trapezoidal channel. The middle of the trapezoidal channel, near the Village East Bridge, gains water from the aquifer during spring and early summer, and then starts to lose water to the aquifer in middle summer. During late summer and early fall, the creek is dry and neither gains nor loses water to the aquifer. In autumn, the creek fills quickly, and begins to gain water from the aquifer again. The eastern edge of the trapezoidal channel, near Papoose Bridge, appears to always lose water to the aquifer. The maximum estimated creek inflow rate (creek gain) is 0.18 cubic feet per second (cfs) for each 1,000 feet of trapezoidal channel. The maximum estimated creek outflow rate (creek loss) is 0.27 cfs for each 1,000 feet of trapezoidal channel.

The two aquifer tests performed on well SVPSD#2 allowed us to estimate the amount of depletion in Squaw Creek's flow due to pumping. Streamflow depletion due to pumping changes over time. When a well is first turned on it pumps water out of the aquifer immediately adjacent to the well. As pumping continues, the well draws water from areas closer to the creek. Therefore, creek depletion from pumping is small initially, and grows over time. During an eight hour pumping cycle, well SVPSD#2 captures an average of 1.12% of its total discharge from Squaw Creek. Assuming an average pumping rate of 300 gpm, well SVPSD#2 captures an average of 3.4 gpm, or less than 0.008 cfs during a customary 8-hour pumping cycle.

The results from the well SVPSD#2 aquifer tests were applied to all active SVPSD pumping wells to obtain similar well depletion estimates. The total streamflow depletion from pumping the four SVPSD wells ranged between 0.005 cfs and 0.017cfs during water years 2012 and 2013. These relatively small stream depletion rates mean that wells only capture a significant portion of streamflow during extremely low creek flow periods. During most times, wells capture one percent or less of streamflow. In water year 2012, wells captured one percent or less of measured streamflow in 337 of the 365 days. In water year 2013, wells captured one percent or less of measured streamflow in 348 of 365 days.

In mid-summer, there are only three to seven days when pumping captures more than one percent of streamflow. Therefore, District pumping may cause the trapezoidal channel to dry out between three and seven days earlier than it would with no pumping. Lack of streamflow in western Olympic Valley is therefore not primarily caused by municipal pumping, although its onset may be hastened by approximately one week by pumping. This is supported by historical photographs that show how western Squaw Creek dried out prior any significant development.

The same pumping and streamflow capture calculations show that approximately 2% of SVPSD's total pumping is derived from reduced streamflow. This number does not account for groundwater that may be flowing towards the trapezoidal channel, but is intercepted by wells before it gets there.

The interaction between Squaw Creek and the shallow aquifer was further informed by studies conducted by Lawrence Livermore National Laboratory (LLNL) and California State University East Bay (CSUEB). The LLNL studies focused on groundwater/creek interactions in the meadow section of the Valley. Results of these studies suggested the following:

- Groundwater discharge in the meadow constitutes between 5% of total stream discharge near the peak of spring snowmelt, to nearly all of the observed flow during late summer in the meadow portion of Squaw Creek.
- Groundwater inflow into Squaw Creek is not localized in discreet areas in the meadow, but is distributed evenly throughout the meadow. Groundwater flow along geologic structures such as faults is not a significant component of the groundwater inflow to Squaw Creek.

The LLNL studies furthermore concluded that groundwater moves through the meadow much more slowly than it moves through the western portion of the basin. This has two important implications.

1. There is limited time to respond to groundwater quality threats in the western portion of the basin because groundwater moves quickly towards municipal wells. Therefore, recharge areas in the western basin should be protected from potential groundwater quality impacts. Additionally, because of the high susceptibility of municipal wells to any groundwater contamination, a secondary source of supply should be investigated to provide reliability and redundancy.
2. Groundwater pumping in the meadow has a slower, but more prolonged impact on creek flows than pumping in the western basin. Groundwater pumping in the meadow may, therefore, have a more significant impact on baseflow than pumping in the western basin.

Isotope data collected by LLNL demonstrate that most water pumped by SVPSD's municipal wells is recharged along the edges of the Valley floor, rather than through the creek bed. The average elevation of the recharge zone is approximately 6,300 feet msl. This elevation is generally found just above the Valley floor. This furthermore suggests that limited groundwater is derived from deep fracture flow entering the Valley.

Based on the results of the Creek/Aquifer interaction study and the LLNL studies, we suggest that the District prepare a pumping management plan that incorporates the data and results from the Creek/Aquifer study. This plan will allow the District to provide municipal water supplies while minimizing environmental impacts. This plan should identify pumping strategies that can be implemented with the anticipated wellfield that may result from new development in the Valley, and should guide new well placement. This plan will set guidelines for how pumping could be moved around the Valley throughout the year to minimize environmental impacts.

The District should furthermore map and protect the primary groundwater recharge zones. This mapping is a recent requirement of Groundwater Management Plans. The LLNL studies suggested that most recharge occurs at an average elevation of 6350 feet. Mapping recharge zones is an inexact exercise, but additional mapping efforts may help locate important recharge areas. The mapped recharge zones should be maintained as protected, and potentially enhanced, recharge areas.