Dennis Jackson - Hydrologist
2096 Redwood Drive
Santa Cruz, CA 95060
(831) 295-4413
dennisjack01@att.net

March 17, 2010

Evidence of Groundwater Level Decline in the Napa Valley

This is a preliminary study of the record of the water surface elevation of a well is compared to the elevation of the bed of the Napa River to explore the relationship between the water in the river and the groundwater table. This preliminary study has been revised to account for the estimated channel incision near the well that is the source of water level data for this report.

A more in depth version of this preliminary study could be done by making a contour map of the fall groundwater surface and comparing it to the elevation of the bed of the Napa River derived from LIDAR and ground surveying.

The California Department of Water Resources maintains a *Water Data Library* on their web site that stores the water surface observations from a large number of wells in the Napa Valley. The water level record of State Well Number 07N05W09Q002M, near the confluence of Bale Slough and the Napa River, is presented below. Figure 1 shows the location of the well. This well is in the vicinity of the depression in the groundwater surface predicted by Faye's (USGS, 1973) simulation of the groundwater surface at four times the 1970 extraction rate.

The well is reported as not being used so its record is not influenced by its own pumping. It is near two other wells. A total of 489 groundwater-surface-elevation observations were made between October 1949 and June 2009. The well is approximately 1,100 feet west of the confluence of Bale Slough with the Napa River. The ground surface elevation at the well is given as 155 feet above mean sea level (amsl). The 7.5-minute topographic map shows the elevation at the confluence of Bale Slough and the Napa River is about 140 feet amsl. The well studied in this report is located near a portion of the Napa River that has experienced channel incision. The *Napa River Basin Limiting Factors Analysis Final Technical Report* estimated the typical channel incision to be from 4 to 6 feet.

Since 2001, the water surface in State Well Number 07N05W09Q002M has tended to fall below the estimated elevation of the incised Napa River channel at its confluence with Bales Slough sometime between July 11 and August 30. The channel incision is not sufficient to explain the decline in the groundwater surface after 2001 when it tended to be below the estimated elevation of the incised riverbed. It is likely that increased groundwater pumping, discussed below, is a significant cause of the decline of the groundwater surface below the estimated elevation of the incised riverbed.

Figure 2 shows all of the groundwater surface elevation measurements. The elevation data has been adjusted by subtracting 140 feet from the water surface elevation. An elevation of zero on the graph occurs when the water surface in the well is at the same elevation as the estimated elevation of the bed of the Napa River at its confluence with Bales Slough. The elevation data shown in Figure 2 is *relative* to the estimated bed of the Napa River at its confluence with Bales Slough. When the relative elevation of the

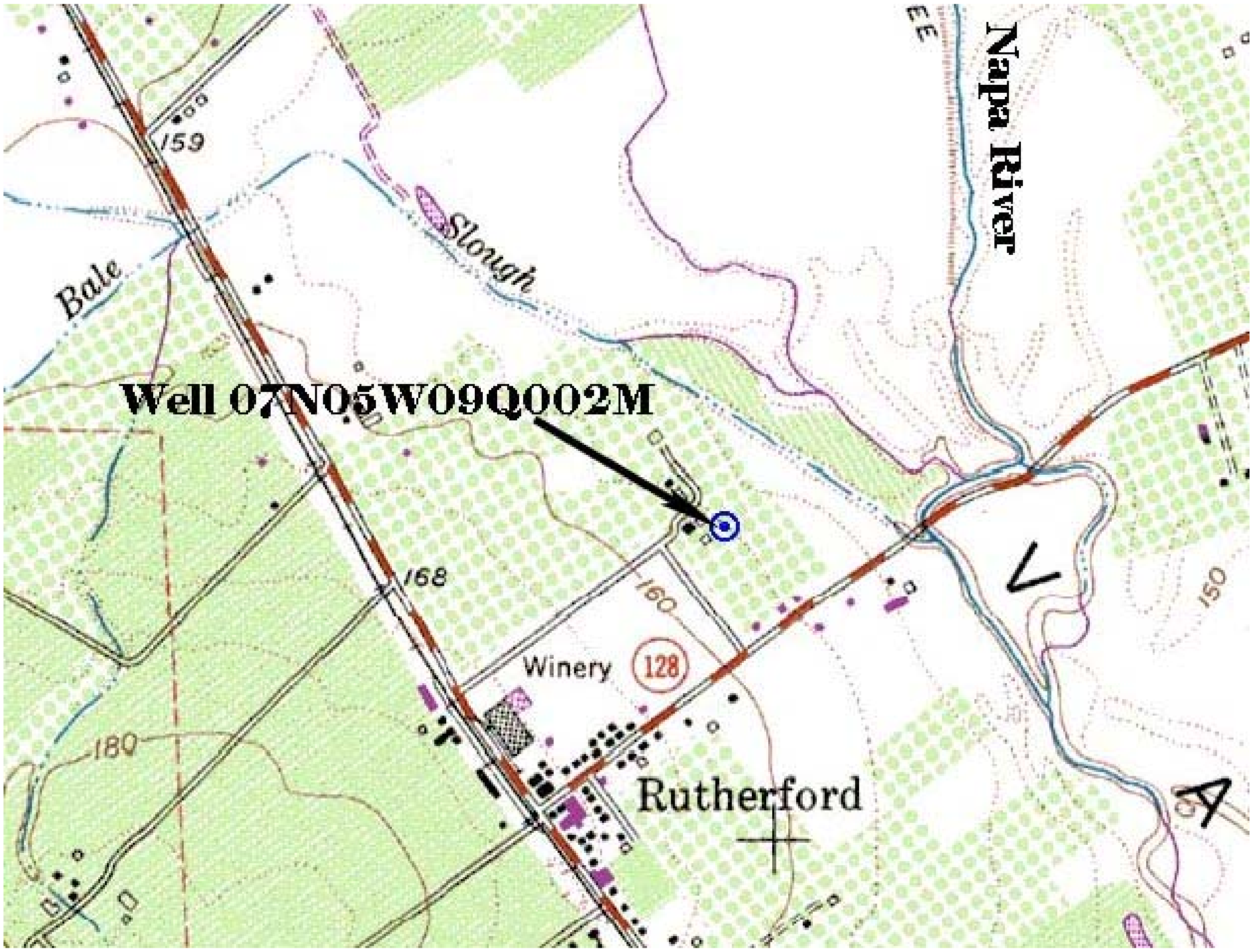

Figure 1. Location of Well 07N05W09Q002M near the confluence of Bale Slough and Rutherford.

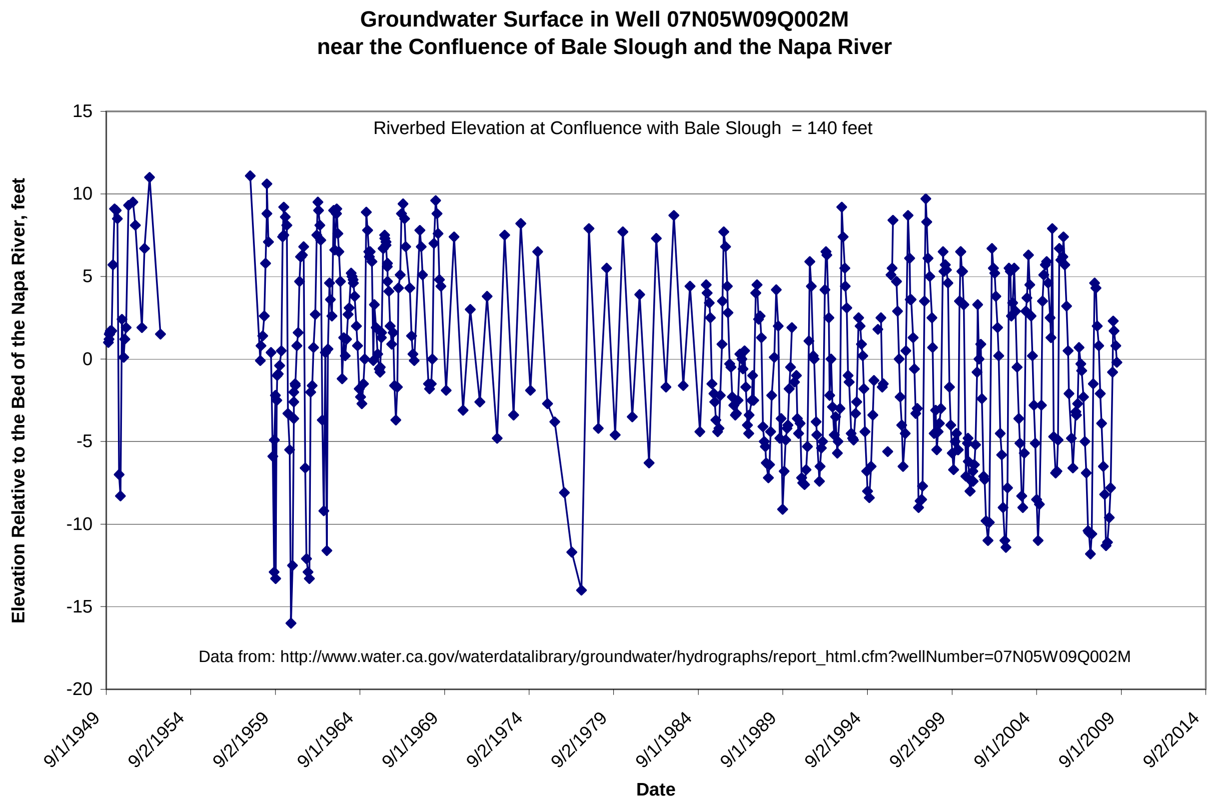

Figure 2. The complete record of groundwater surface elevations from Well 07N05W09Q002M. The elevation data has been adjusted by subtracting 140 feet from the water surface elevation. An elevation of zero on the graph occurs when the water surface in the well is at the same elevation as the estimated elevation of the bed of the Napa River at its confluence with Bales Slough. The well is about 1,100 feet from the confluence.

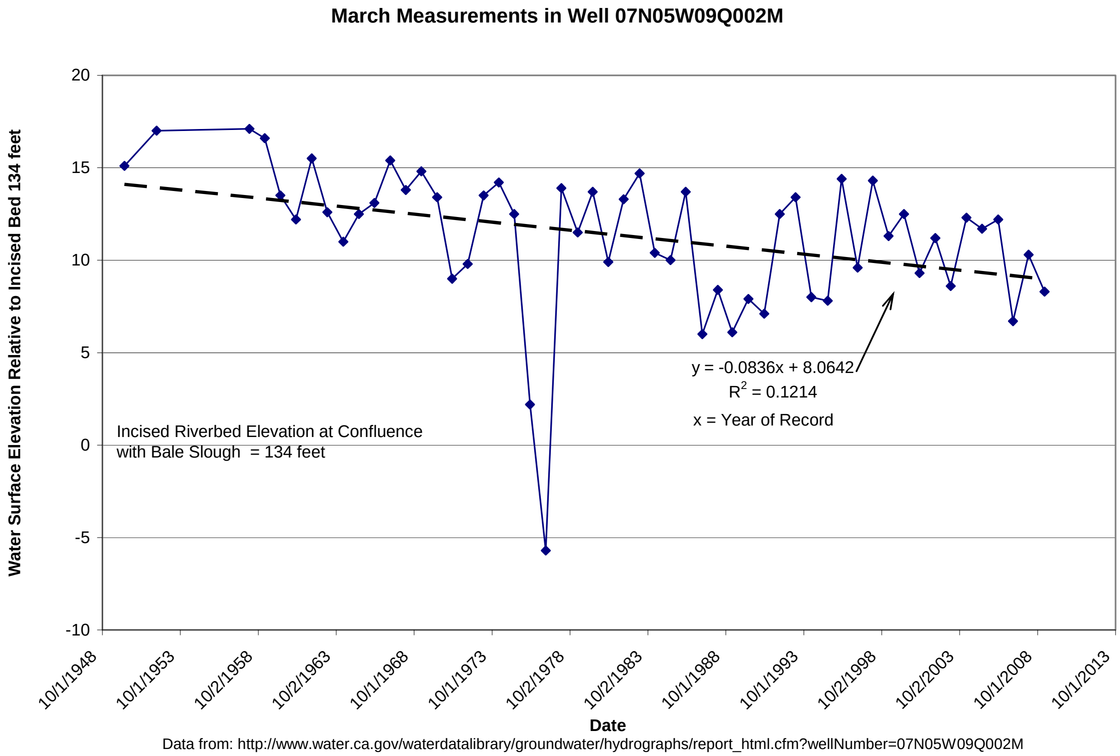

Figure 3. The March water surface elevations in the well are declining over time. A linear regression line was fit to the data using the year of record as the independent variable. The year of record is used as an index of change over time. Both the coefficient and intercept are statistically significant at alpha = 0.05. The regression explains only 12% of the variation in the March water surface elevations. However, regression line indicates that the March water surface elevation is declining over time since the coefficient is negative. A stronger regression relationship can be obtained if the March 1977 observation is excluded. The riverbed elevation at the confluence with Bales Slough was estimated from the topographic map to be 140 feet above sea level. The Napa River Basin Limiting Factors Analysis Final Technical Report estimated the typical channel incision to be from 4 to 6 feet. The elevation of the incised riverbed might be up to six feet lower than estimated from the topographic map or 134 feet.

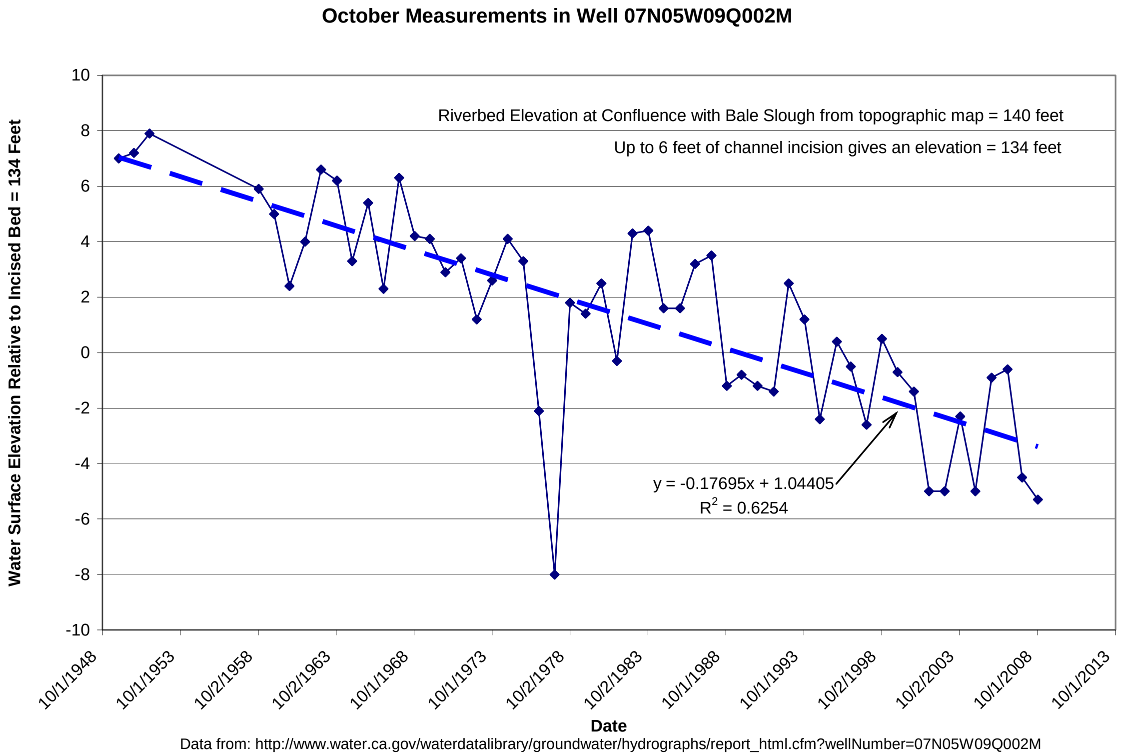

Figure 4. The October water surface elevations in the well are declining over time. A linear regression line was fit to the data using the year of record as the independent variable. The year of record is used as an index of change over time. Both the coefficient and intercept are statistically significant at alpha = 0.05. The regression explains 62% of the variation in the October water surface elevations. The regression line indicates that the October water surface elevation is declining over time since the coefficient is negative. The riverbed elevation at the confluence with Bales Slough was estimated from the topographic map to be 140 feet above sea level. The Napa River Basin Limiting Factors Analysis Final Technical Report estimated the typical channel incision to be from 4 to 6 feet. The elevation of the incised riverbed might be up to six feet lower than estimated from the topographic map or 134 feet. Since 1999, the October water surface elevation in the well is below the estimated elevation of the incised bed of the Napa River at its confluence with Bales Slough (134 feet amsl). The channel incision is not sufficient to explain the decline in the October water surface after 1999 when it was consistently below the estimated elevation of the incised riverbed.

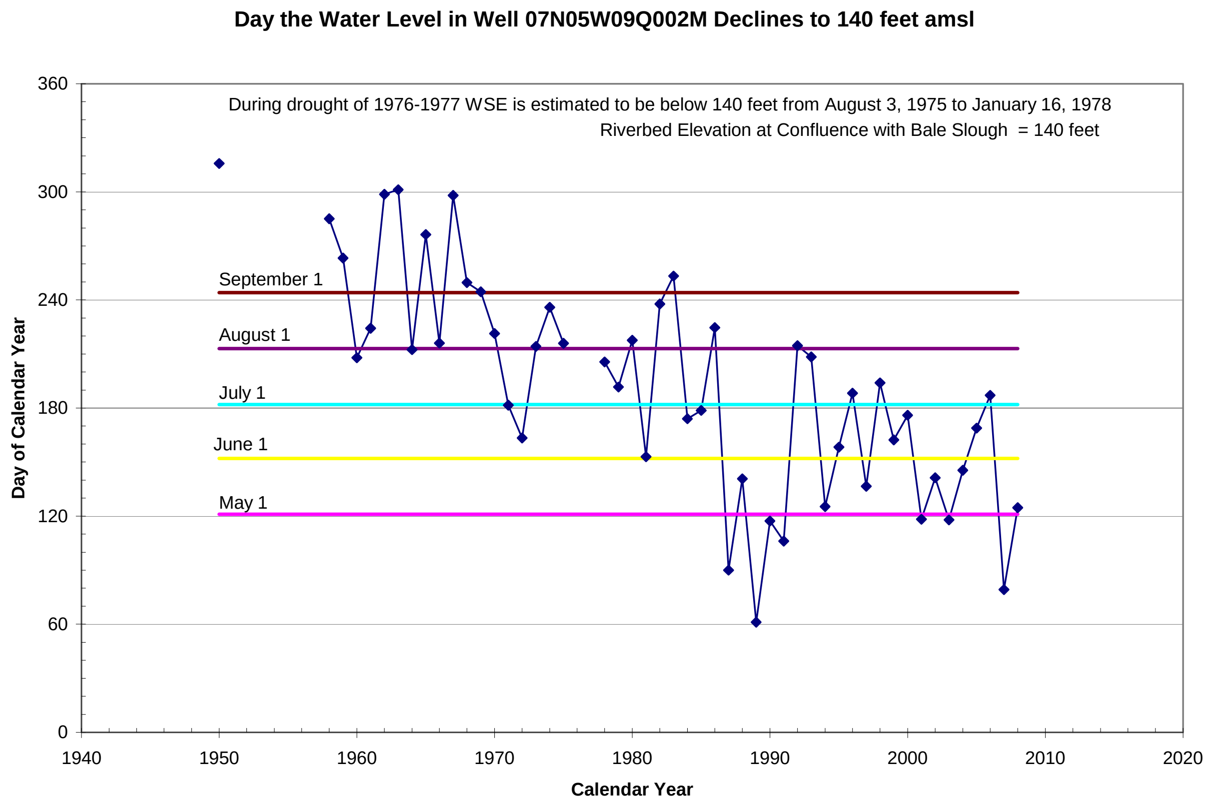

Figure 5. Estimate of the calendar day that the relative water surface elevation in the well declined to zero. The estimate was made by calculating the daily decline in the groundwater surface as explained in the text. Prior to 1970, the relative water surface in the well declined to zero sometime after August 1. In most years after 1986 (17 out of 22), the relative elevation of the water surface in the well declined to zero by July 1.

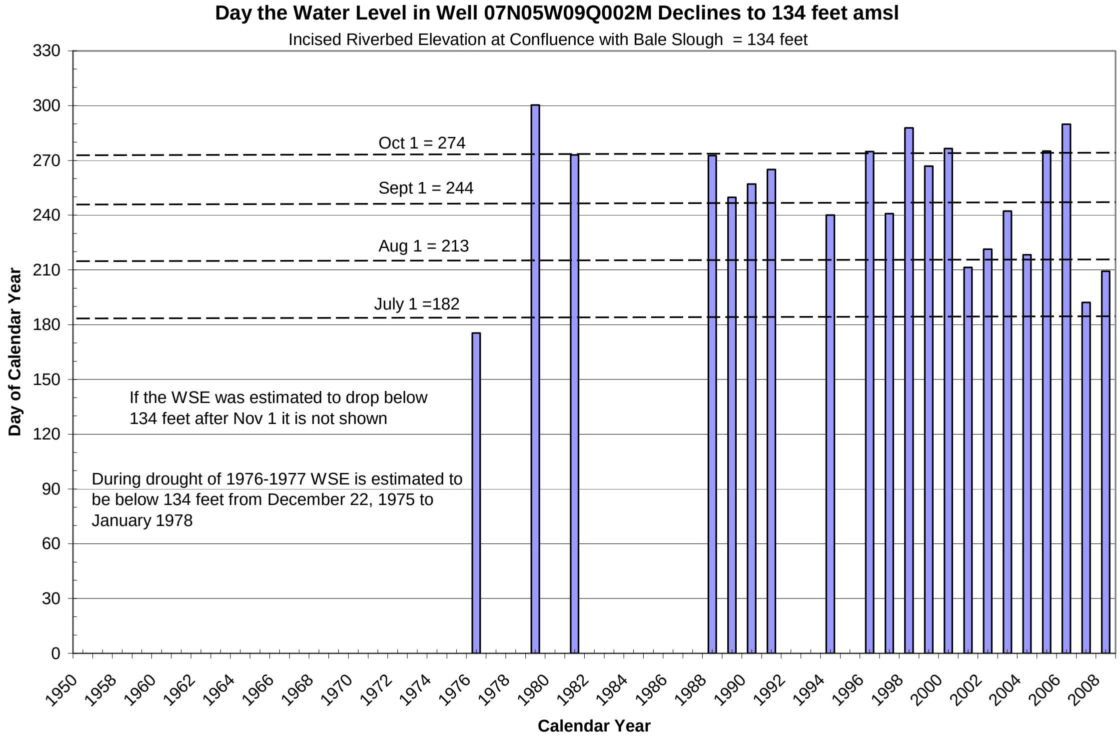

Figure 6. Estimate of the calendar day that the relative water surface elevation in the well declined to 134 feet, the estimated elevation of the incised riverbed at the confluence with Bales Slough. The estimate was made by calculating the daily decline in the groundwater surface assuming a linear decline between the March and October measurements. From 2001 through 2008, the relative elevation of the water surface in the well declined to 134 feet by September 1. In five of those years the WSE declined to 134 feet on or before August 9.

water surface in the well is greater than zero, groundwater from near the well is assumed to be flowing into the river. When the relative elevation of water surface in the well is less than zero, water is assumed to be flowing out of the river and entering the groundwater system. The Napa River at Bales Slough changes from a gaining-stream to a losing-stream when the relative water-surface-elevation in the well declines to zero.

Figure 3 shows that the March water surface elevations in the well are declining over time. A linear regression line was fit to the data using the year of record as the independent variable. The year of record is used as an index of change over time. Both the coefficient and intercept are statistically significant at alpha = 0.05. The regression explains only 12% of the variation in the March water surface elevations. However, regression line indicates that the March water surface elevation is declining over time since the coefficient is negative. A stronger regression relationship can be obtained if the March 1977 observation is excluded.

Figure 4 shows that the October water surface elevations in the well are declining over time. A linear regression line was fit to the data using the year of record as the independent variable. The year of record is used as an index of change over time. Both the coefficient and intercept are statistically significant at alpha = 0.05. The regression explains 62% of the variation in the October water surface elevations. The regression line indicates that the October water surface elevation is declining over time since the coefficient is negative. In most years, the October water surface elevation in the well is below the estimated elevation of the bed of the Napa River at its confluence with Bales Slough (140 feet amsl).

The day that the relative water surface elevation in the well declines to zero (day of zero elevation) can be estimated by assuming that the change in the groundwater surface is linear. Dividing the total decline from the March reading to the October reading and dividing by the number of days between the readings gives the rate of daily decline of the groundwater surface.

Figure 5 shows the estimate of the day-of-the-year that the relative water surface elevation in the well declined to zero (day of zero elevation). The estimate was made by assuming the daily decline in the groundwater surface was linear. Prior to 1970, the day of zero elevation occurred sometime after August 1. In most years (17 out of 22) after 1986, the day of zero elevation occurred by July 1.

Figure 6 shows that since 2001, the Napa River tends to become a losing stream at Bales Slough in August or July. Only in 2005 and 2006 was the water surface elevation in the well above the estimate elevation of the incised riverbed prior to September 1.

The water surface elevation data from well 07N05W09Q002M show that water table surface is progressively lowering under the Napa River to the point where the Napa River loses water to the groundwater system each year. And that the date on which the Napa River changes from a gaining stream to a losing stream is happening at an earlier date.

The estimated channel incision of 6.0 feet is not sufficient to explain the decline in the October water surface after 1999 when it was consistently below the estimated elevation of the incised riverbed. It is likely that the increased groundwater pumping documented by Yost is causing the decline of the fall groundwater level below the estimated elevation of the incised Napa River channel at Bales Slough.

Increased Groundwater Extraction

Faye (USGS, 1973) simulated groundwater levels in the Napa Valley groundwater basin. His simulation model used the distributions of wells in 1970 and the estimated 1970 pumping rate of 5,900 acre-feet. Simulations of critical drought conditions with four times the 1970 pumping rate (4 x 5,900 af = 23,600 af) showed that:

> The pumping depression near Maple Lane would expand and another depression would develop directly east of it. In the center of the valley, between Rutherford and Oakville, much of the upper 50 feet to 70 feet of the alluvial aquifer would be dewatered and a cone of depression would extend northward towards the periphery of the valley. Also, dewatering of the upper part of the alluvial aquifer would occur between Yountville and Oak Knoll Avenue. In the vicinity of Oak Knoll Avenue, large simulated withdrawals made between Highway 29 and the Napa River would cause a cone of depression to extend westward towards the periphery of the valley. South of St. Helena, relatively shallow wells having depths of 60 feet or less would be dry under such conditions.

West Yost and Associates Technical Memorandum 6 (2005) estimates that the groundwater extraction rate in 2005 was 24,856 acre-feet or 4.2 times the 1970 extraction rate. Faye (USGS, 1973) concludes that:

> (1) groundwater levels should not decline significantly until groundwater pumpage exceeds 24,000 acre-feet per year; (2) after two consecutive years of little to no recharge, groundwater withdrawals in excess of 24,000 acre-feet per year could cause significant declines in groundwater levels and significantly redistribute the hydraulic gradients in the valley between Zinfandel Lane and Oak Knoll Avenue; and (3) the alluvial aquifer and the stream system can provide water sufficient to meet most projected groundwater requirements, even under protracted, adverse climatological conditions.

The actual groundwater extraction in 2005 exceeded 24,000 acre-feet per year views as the threshold when groundwater levels would begin to decline. Faye (USGS, 1973) notes that;

> At the present time (1972), the Napa River is a gaining stream and contributes little recharge to the water table. Even during years of limited rainfall, when the river flows intermittently, water is discharged from the aquifer in those reaches where the river is flowing and water recharges the alluvium in reaches where the river channel is dry; thus net recharge to the alluvial aquifer is negligible.

The Napa River was a gaining stream in 1972 meaning that groundwater flowed into the river from the water table. Faye's (USGS, 1973) conclusions (1) and (2) and his simulation of pumping rates equal to four times the 1970 pumping rate show that groundwater extraction of more than 24,000 acre-feet has the potential to dry up portions of the Napa River during low rainfall years. The 2005 groundwater extraction rate of 24,856 acre-feet exceeded Faye's threshold of 24,000 acre-feet.

Groundwater extraction from the Napa Valley groundwater basin in excess of Faye's threshold of 24,000 acre-feet is likely to contribute to dewatering portions of the mainstem of the Napa River in dry years. Steelhead trout, a federally listed species, are known to inhabit the mainstem of the Napa River so dewatering portions of the mainstem of the Napa River by groundwater pumping would be a very significant adverse impact.

Faye (USGS, 1973) notes that groundwater levels may significantly decline during dry years when extraction rates exceed 24,000 acre-feet per year but that after a year with normal rainfall groundwater levels would recover. Faye's conclusion (3) ignores the very significant adverse environmental effects that groundwater pumping has on the flow of the mainstem of the Napa River and that diminished summertime flow in the river has the potential to result in juvenile steelhead trout mortality. Therefore, while the Napa River groundwater basin has a large capacity only a limited amount of pumping can occur before falling groundwater levels lead to diminished streamflow and potentially adverse impacts to juvenile salmonids.

Conclusion

The large municipal reservoirs and the numerous small farm ponds in the Napa River watershed have played a significant role in the incision of the Napa River. Direct changes to the riparian corridor, such as straightening the channel and the installation of levees and filling of sloughs, have also contributed to the channel incision of the Napa River. In turn, the channel incision of the Napa River has contributed to a decline in the elevation of the fall groundwater surface. However, the groundwater surface has tended to fall below the estimated elevation of the incised riverbed since 2001. Increased groundwater extraction, documented by Yost in 2005, is likely responsible for the decline of the groundwater surface below the incised riverbed.

Sincerely,

Dennis Jackson
Hydrologist

References

Faye, Robert E., November 1973, Ground-Water Hydrology of the Northern Napa Valley, U.S> Geological Survey, Water-Resources Investigations 13-73.

West Yost & Associates, Gerry Nakano, J. J. Westra, October 19, 2005, TECHNICAL MEMORANDUM NO. 1. for Napa County Flood Control and Water Conservation District, http://www.napawatersheds.org/docs.php?ogid=10610

West Yost & Associates, Gerry Nakano, J. J. Westra, October 19, 2005, TECHNICAL MEMORANDUM NO. 3. for Napa County Flood Control and Water Conservation District, http://www.napawatersheds.org/docs.php?ogid=10610

West Yost & Associates, Gerry Nakano, J. J. Westra, October 19, 2005, TECHNICAL MEMORANDUM NO. 5. for Napa County Flood Control and Water Conservation District, http://www.napawatersheds.org/docs.php?ogid=10610

Index of Wet Yost and Associates Technical Memorandums

TM 1: Review of 1991 and 1992 Studies
TM2: Napa County Municipal and Industrial Demands, Incorporated Areas
TM 3: Unincorporated Water Demands
TM 4: Napa County Incorporated Area Water Supplies
TM 5: Unincorporated Area Water Supplies
TM 6: Comparison of Demand Projections and Supply Capabilities
TM 7: Potential Local and Regional Water Supply Projects