SEEKING AN UNDERSTANDING OF THE GROUNDWATER AQUIFER SYSTEMS IN THE NORTHERN SACRAMENTO VALLEY: AN UPDATE

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UNDERSTANDING AQUIFER SYSTEMS

In April 2003, an article titled Seeking an Understanding of the Groundwater Aquifer Systems in the Northern Sacramento Valley was published. It was the first in a series of six articles on groundwater, water wells, and pumps. It was an initial effort to broadly distribute new, science-based information about the aquifer systems in the northern Sacramento Valley. The three-page article highlighted important findings from recent investigations, since 1997, conducted by the California Department of Water Resources, Northern District, Groundwater Section. These investigations have been the first to be undertaken since the 1970's. Article topics included: sound concepts and misconceptions, a description of the methods used in the new groundwater investigations, general information about the hydrogeology in the northern Sacramento Valley, and specific information about the freshwater aquifer systems. Paper copies of the 2003 article are still available in limited quantities. Copies can also be downloaded at http://www.glenncountywater.org (select water education, bottom left menu).

This update is a continuation of our effort to extend science-based information about the groundwater resources in the northern Sacramento Valley. This article is first in a series of five articles scheduled for 2005 / 06. Hopefully, this information will contribute to an improved understanding of groundwater resources and assist with groundwater management that balances the protection and use of the resource. The remainder of this article will summarize the preliminary findings to date.

Continued Research Activity

- Dedicated monitoring well installation
- Evaluation of subsurface geology
- "Age" determination of groundwater
- Groundwater chemistry investigations

Figure 1. Description of some of the on-going groundwater investigations.

DEDICATED MONITORING WELL INSTALLATION

Since 1997, 48 dedicated single or multi-completion monitoring wells have been installed in the northern Sacramento Valley. Their locations are shown in Figure 2. To learn more about dedicated monitoring wells, refer to the fourth article in the last informational series titled Groundwater Level Monitoring, available at the website given above. Funding for these wells was provided by grants awarded to Tehama, Butte, Colusa, and Glenn counties through the AB303 process or other grant sources. At the request of the counties and/or local agencies, Northern District staff provided construction oversight and data analysis for these wells. These new monitoring wells now make it possible to measure groundwater levels and take groundwater samples for laboratory analysis from each of the identified, freshwater aquifer systems. For the first time, it is now possible to measure the potential for water to move in a vertical direction between different aquifer systems. This is important in understanding recharge and three dimensional groundwater flows in the valley. Geologic information collected during well construction also provides important new data that has been used to improve our understanding of the subsurface geology.

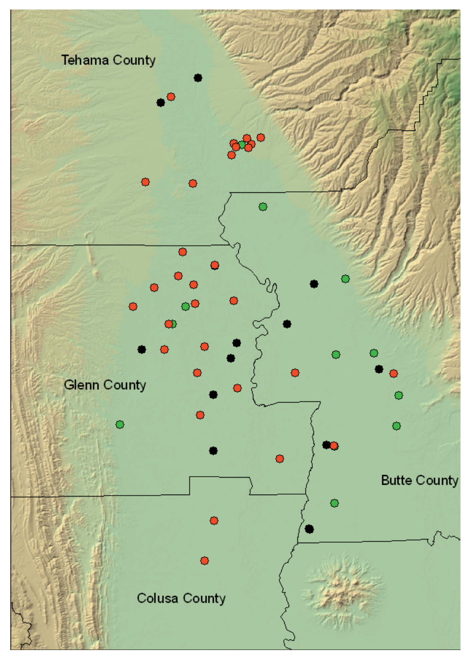

Figure 2. Locations of dedicated monitoring wells in northern Sacramento Valley. The red symbols represent multi-copletion monitoring wells while the green are single completion. The black represent dedicated monitoring wells installed prior to 1997.

One of the early observations made from this dedicated monitoring well network is that the various freshwater aquifer systems appear to behave relatively independent of each other, and that stresses seen in one aquifer system are not readily observable in others. Figures 3 and 4 show the aerial extent of the Tehama, upper Tuscan, and lower Tuscan Formations, three freshwater aquifer systems in the north valley. The figures also show where these geologic formations are buried beneath the valley and where they are exposed above ground. The green contour lines with numerical values shown on the figures are lines of equal groundwater elevation and indicate the elevation that groundwater rises in an open well when constructed in these aquifer systems. The distance between the green contour lines indicates the rate of change in groundwater elevation and directly influences the potential rate of groundwater flow. A larger change in groundwater elevation over a shorter distance between contour lines indicates a steeper gradient and conditions for higher groundwater flow rates. The red arrows show the direction of groundwater flow.

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Figure 3 shows that the Tehama Formation aquifer system extends from Tehama County in the north to beyond Colusa County to the south. From Tehama County south to the town of Orland, the groundwater flow in the Tehama aquifer system is easterly, toward the Sacramento River. South of Orland, the groundwater flow is in a more south easterly direction. The groundwater flow velocity is higher north of Orland and slows in the southern portion of the mapped area.

Figure 4 shows that the Tuscan aquifer systems (upper and lower formations) extend from Tehama County in the north, through Butte County, into Sutter County in the south. The formations also extend west of the Sacramento River into Glenn and Colusa Counties. From Tehama County south to the city of Chico, the groundwater flow direction in the lower Tuscan is westerly toward the Sacramento River. South of Chico, the groundwater flow changes to a southwesterly direction along the eastern margin of the valley and to a southerly direction in the central portion of the Butte Basin. It is interesting to note that groundwater elevations up gradient of the Butte Basin, in the lower Tuscan aquifer system, are higher than the ground surface elevations in the south-central portion of Butte Basin. This creates an artesian flow condition when wells in the central Butte Basin are drilled into the lower Tuscan aquifer.

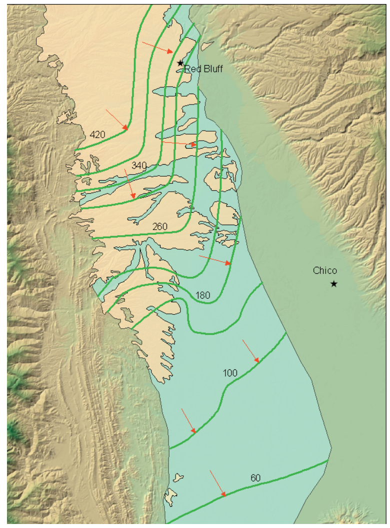


Figure 3. Aerial extent of Tehama Formation aquifer system. Light yellow areas show where the Tehama Formation is exposed at the ground surface and the blue areas show the approximate buried extents.

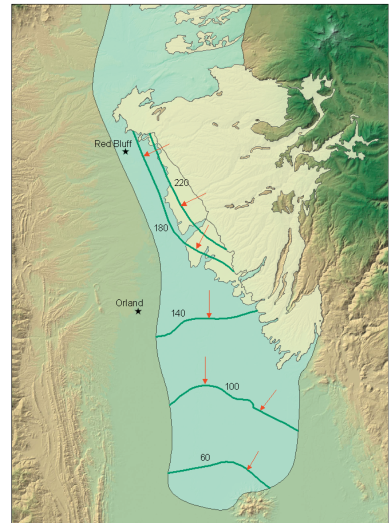
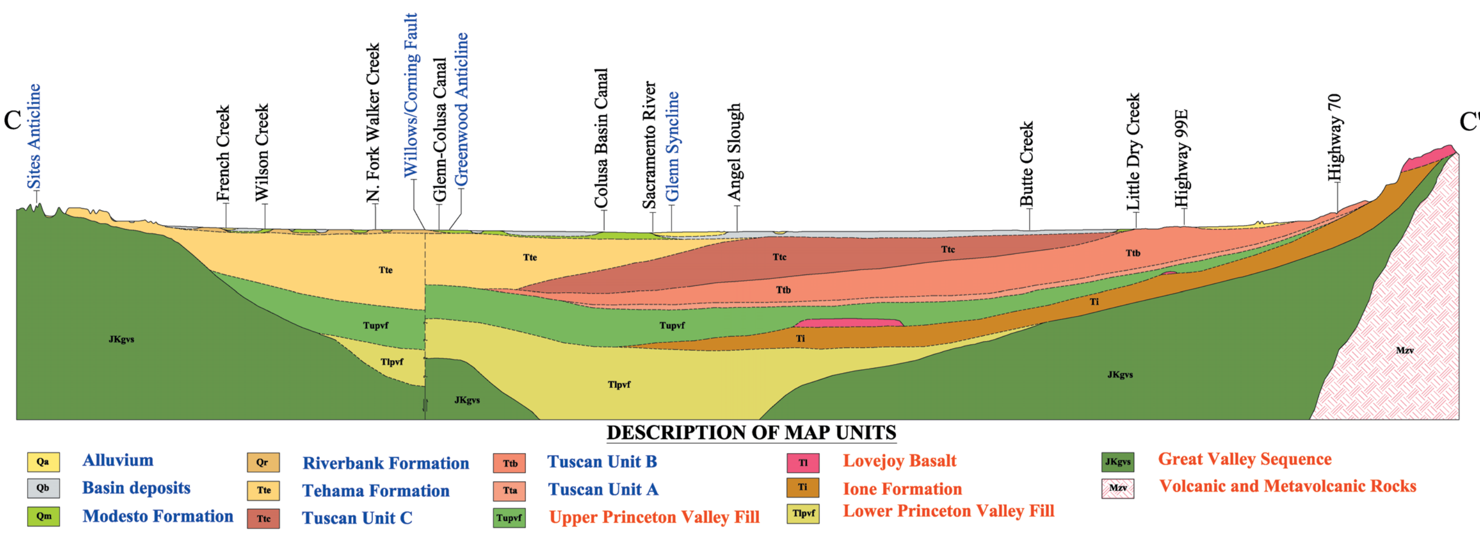


Figure 4. Aerial extent of Tuscan Formation aquifer systems. Light yellow areas show where the upper and lower Tuscan Formations are exposed at ground surface and the blue areas show the approximate buried extents.

IMPROVED UNDERSTANDING OF THE SUBSURFACE GEOLOGY

Since 1997, one product of the investigations has been an initial set of geologic cross-sections depicting the subsurface geology of the freshwater and saline aquifer systems. The initial cross-sections were developed using more than 150 existing electrical resistivity logs and previously published information of the region. Actual samples of the subsurface geologic material were very limited and not available when the initial cross-sections were developed.

The installation of dedicated monitoring wells throughout the north valley has provided actual sample material from the subsurface geology, allowing for more geologic correlation and description than was previously possible. Also, consultation with researchers focusing on the geology of the Sutter Buttes and field evaluations examining the sequence of sedimentary and volcanic rock exposed on the flanks of the Buttes have led to additional refinement of the Sacramento Valley subsurface geology.



Note: Due to interfingering relationship and uncertain contact between the Tuscan and Tehama Formations, the contacts should be considered diagramatic.

Figure 5. Revised geologic cross-section C-C' of the freshwater and saline groundwater aquifer systems in the northern Sacramento Valley. Cross-section C-C' is one of four east-west cross-sections developed for the northern Sacramento Valley. Cross-section C-C" represents the subsurface geology between Table Mountain along the east side and Stony Gorge on the west side of the Sacramento Valley. The major freshwater or non-marine formations (map units in legend labeled in blue) overlie saline, marine formations (map units in legend labeled in red). The approximate contact between fresh and saline groundwater occurs at a depth ranging from 1500 to 3000 feet.

As a result, there are some changes that have been made to the initial geologic cross-sections. With respect to the freshwater aquifer systems in the north valley, it was determined that the Tehama Formation is not likely to be as thick as previously described and shown in the initial cross-sections. Also, the extent of the upper Tuscan and lower Tuscan aquifer systems have been expanded to the west and southwest. Finally, with respect to the saline aquifer systems, examination of geologic units exposed around the Sutter Buttes has revealed that the formation previously correlated with the Neroly Formation is likely to be part of the Upper Princeton Valley Fill. These changes can be seen on the revised geologic cross-section shown above in Figure 5.

Figure 5 (on previous page) also shows that the Tehama Formation, the upper Tuscan Formation, and the lower Tuscan Formation are the predominant freshwater aquifer systems in the north valley. Whereas, the Alluvium deposits, the Basin deposits, and the Riverbank and Modesto Formations make up a relatively shallow aquifer system overlying the Tehama and Tuscan Formations. Figures 6 a, b, and c show the geologic materials typically found in the Tehama and Tuscan formations.

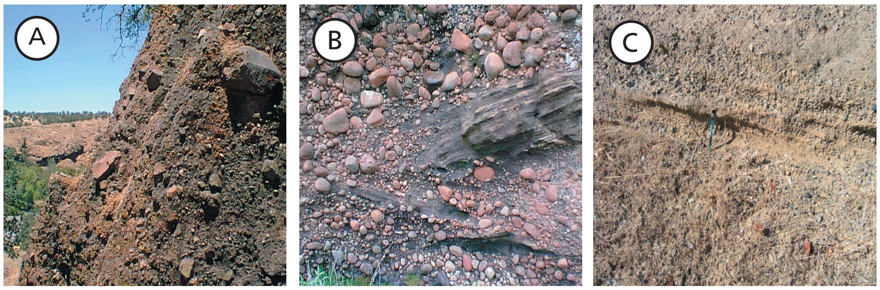


Figure 6. A) Consolidated rocks and finer grain silt and clay typical of the upper Tuscan Formation usually found at a maximum depth of 800 feet below ground in the east-central portion of the valley, B) gravel, sand, and silt typical of the lower Tuscan Formation found below about 800 feet in the east-central portion of the valley, and C) clay, sand, and gravel material typical of Tehama Formation usually found at a maximum depth of about 1,000 feet on the west side of the valley.

"AGE" DETERMINATION OF GROUNDWATER

Work is also underway to estimate the age of groundwater using naturally occurring chemical isotopes found in groundwater. This information is helpful in estimating flow velocity and identifying possible recharge areas for the various aquifer systems. In cooperation with Lawrence Livermore National Laboratory, DWR Northern District Groundwater Section staff collected groundwater samples from many of the dedicated monitoring wells shown in Figure 1. These monitoring wells allow for the collection of samples from the individual aquifer systems at each monitoring site. The samples were analyzed at Lawrence Livermore National Laboratory for a number of chemical characteristics including an estimation of groundwater "age" (the amount of time since the water entered the aquifer system). Utilizing the Tritium (H3) Helium-3 (He3) ratio, the age of each sample was estimated. Test results indicate that the "age" of the groundwater samples ranges from less than 100 years to tens of thousands of years. In general, the more shallow wells in the lower Tuscan Formation along the eastern margin of the valley have the "youngest" water and the deeper wells in the western and southern portions of the valley have the "oldest" water. The youngest groundwater in the lower Tuscan Formation is probably nearest to recharge areas. Ages of groundwater in the Tehama Formation are typically less than 3,500 years old. Figure 7 shows the sample locations and the estimated age for groundwater sampled from the Tehama and lower Tuscan Formations at different sites in the north valley.

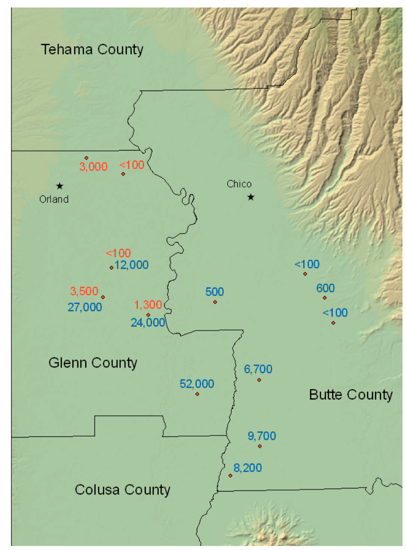


Figure 7. Sample locations and estimated age of the groundwater at various monitoring sites in the north valley. Age is estimated in years; dark blue values represent groundwater in lower Tuscan Formation and red values represent groundwater in Tehama Formation.

GROUNDWATER CHEMISTRY INVESTIGATIONS

A standard groundwater chemistry investigation is also in progress. The first step of this investigation is to compare concentrations of natural occurring chemical constituents such as calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, and sulfate between the known freshwater aquifer systems. The chemical make-up of the geologic material that groundwater comes into contact with, the extent of the contact surface area, and the time groundwater is in contact with geologic material influences the natural groundwater chemistry. It is possible that there are distinct chemical "signatures" associated with the different freshwater aquifer systems. This comparison of cation and anion equivalent concentrations is beginning to provide some very interesting results and will be discussed in greater detail in an upcoming issue of this informational series on groundwater quality in the northern Sacramento Valley.

FURTHER INVESTIGATIONS

A lot has been learned about the freshwater aquifer systems in the past few years and more information is needed to assure that the groundwater resources are managed responsibly. Testing is needed to measure the aquifer parameters by conducting aquifer performance testing. Studies are needed to better understand recharge mechanisms and rates for the freshwater aquifer systems in the north valley, particularly in the lower Tuscan Formation. Several plans are under consideration to study aquifer recharge. In the coming years, the Northern District Groundwater Section also plans to look in more detail at the Tehama and upper Tuscan aquifer systems.

This article is the first in a series of five to be published in 2005/06 discussing topics related to groundwater and water wells in the northern Sacramento Valley.

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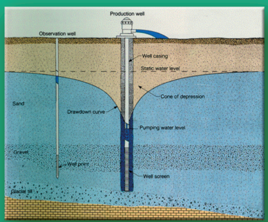

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