GROUNDWATER LEVEL MONITORING: WHAT IS IT? HOW IS IT DONE? WHY DO IT?

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MONITORING ESSENTIAL TO PROTECT GROUNDWATER RESOURCE

The second issue of this groundwater informational series discussed "Incentives for Groundwater Management" illustrating an increasing reliance on groundwater in the northern Sacramento Valley and a growing need to manage the resource. The third issue explored "Possible Approaches to Groundwater Management" and highlighted an approach where monitoring is critical to protect and manage the groundwater resource. This issue (fourth) looks closely at the components of groundwater monitoring, specifically groundwater level monitoring.

Benefits of Monitoring Groundwater Levels:

- ❑ Determine annual and long-term changes of groundwater in storage
- ❑ Estimate recharge rates
- ❑ Determine direction and gradient of groundwater flow
- ❑ Understand how aquifer systems work
- ❑ Gain insight for well construction and where to set pump bowls for efficient extraction

Figure 1. Important benefits from monitoring groundwater levels.

THREE COMPONENTS OF GROUNDWATER MONITORING

Effective groundwater management will protect the quantity of groundwater and ensure a dependable and affordable supply of groundwater into perpetuity. It will also protect the water quality to ensure that the groundwater remains suitable for domestic, industrial, agricultural, and environmental uses and it will seek to prevent land subsidence that can damage expensive public and private infrastructure such as water conveyance and flood control facilities, and water wells.

GROUNDWATER LEVEL MONITORING GIVEN PRIORITY

Monitoring groundwater levels, groundwater quality, and land subsidence is expensive to implement all at once. Since implementation of groundwater management in rural areas of northern Sacramento Valley are in early stages and financial resources are limited, groundwater level monitoring usually takes priority over monitoring groundwater quality and land subsidence. Groundwater level monitoring is a direct indicator of the groundwater supply. Figure 1 highlights important benefits and reasons for monitoring groundwater levels.

Figure 2. Measuring the depth to water table through an entry point in a domestic well with a metal tape.

TECHNICAL ASPECTS OF MONITORING GROUNDWATER LEVELS

There are several aspects that should be considered in the establishment of a groundwater level monitoring program. They include: 1) determination of the elevation of the ground surface at each monitoring location; 2) type of wells to be used in measuring groundwater levels; 3) the level(s) at which the monitoring wells are perforated or screened and whether they represent typical extraction wells in the area; 4) type of well-sounding device(s) to be used to measure the groundwater level; 5) areas to be monitored and the number and locations of monitoring wells; 6) monitoring frequency and time of year; and 7) record keeping.

ESTABLISHING GROUND SURFACE ELEVATIONS

Measuring the depth to groundwater below the ground surface is more informative if the elevation of the ground surface is known. This can either be measured by surveying from a benchmark of a known elevation to a reference point on the well or estimated from topographic maps. The elevation of the groundwater surface then can be calculated by subtracting the depth to groundwater from the ground surface elevation. Then, comparisons of groundwater elevations can be made between monitoring well locations and the direction and gradient of groundwater flow can be determined.

Figure 3. Measuring the depth of water table in an irrigation well with an electric well sounder. Note pipe provides entry into well casing.

USING PRODUCTION OR OBSERVATION WELLS TO MEASURE GROUNDWATER LEVELS

Agricultural and domestic production wells can be used for measuring groundwater levels. Figure 2 shows the groundwater level being measured in a shallow domestic well. Figure 3 shows the groundwater level being measured in a deeper agricultural well. Figure 4 illustrates a dedicated groundwater monitoring well. Domestic and irrigation wells provide an opportunity to monitor groundwater through the well column without the added cost of installing dedicated monitoring wells. Dedicated monitoring wells are designed and

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constructed specifically for measuring groundwater levels. Groundwater is not extracted from a dedicated monitoring well because they are typically too small in diameter to install a pump.

Domestic wells are generally shallow, limited to the top 50 to 100 feet of the Alluvial aquifer system (refer to the first issue of this series titled "Seeking an Understanding of the Groundwater Aquifer Systems in the Northern Sacramento Valley"). Agricultural wells are usually deeper than domestic wells, commonly 200 to 400 feet deep or deeper. The well casing of agricultural wells is often perforated at various depths transmitting water from more than one aquifer system (i.e. the Alluvial aquifer system and the Tuscan or Tehama Aquifer systems depending where the well is located). The effect of groundwater extraction on the groundwater level in the different aquifer systems and their interconnections cannot be evaluated under these monitoring conditions. Measuring groundwater levels from an agricultural production well where the depth of the perforations in the well casing are unknown is even more limited in providing useful information.

Figure 4. Using an electric well sounding device to measure the depth of groundwater at a triple completion, dedicated observation well.

Figure 4 shows a triple completion observation well inside a protective housing constructed of large diameter pipe with a lid. The three cement posts in the foreground protect the monitoring well from passing farm equipment and traffic. Inside this particular housing, three separate, two-inch diameter well columns extend to three different depths, about 200, 700, and 1000 feet deep, to the Alluvial, Upper Tuscan, and Lower Tuscan Aquifer Systems, respectively. Each well column is constructed with perforated well casing near the bottom of the well so groundwater levels within each of the aquifer systems can be measured independently of the other. The advantage of using dedicated groundwater monitoring wells is that they can determine the effects of groundwater extraction on each aquifer system and determine interconnections and vertical gradient between them.

Farmers are interested in the measurement of pumping lift because it has important implications on the cost of extracting water. However, a measurement of pumping lift is not a reliable indicator of the overall condition of the groundwater aquifer systems. The pumping lift can increase inside a well due to pump and well design factors not related to groundwater levels outside the well column. Therefore, measurements from a dedicated monitoring well or static (non-pumping) water levels inside a production well will better reflect conditions of the groundwater aquifer systems.

WELL SOUNDING DEVICES

Three types of devices are available to measure groundwater levels. Figures 5a, 5b and 5c show typical sounding devices: a metal tape, an electrical well sounding device, and a pressure transducer, respectively. A metal tape can be used to measure groundwater levels by inserting it between the well casing and pump column until it contacts water. The use of chalk on the lower part of the tape improves the visibility of the water line and helps verify that it has contacted the groundwater surface. The depth of water is then determined by subtracting the length of tape that was submersed in water from the total length of tape inserted in the well. An electric well sounding device is a simple continuity detector. The length of cable lowered down the well when continuity occurs is then noted as the depth to groundwater. Pressure transducers can be connected to a datalogger enabling continuous groundwater level measurements, although this method is more expensive.

Figures 5a, b, c. Devices to measure groundwater a) metal tape; b) electric sounder; and c) pressure tranducer with datalogger.

DETERMINING WHERE TO MONITOR GROUNDWATER LEVELS

Hydrologic, geologic, and land and water use settings will all influence where and how many locations are established for groundwater level monitoring. Hydrologic factors such as presence of surface water supplies for irrigation, sole reliance upon groundwater for irrigation, or a combination of both surface water and groundwater should be considered. Geologic factors should be considered such as known characteristics of the aquifer system being monitored and presence of geological fault lines that may influence groundwater movement. Changes in land and water use such as new residential, industrial, agricultural, environmental uses, and participation in water transfer programs are examples of land and water use considerations that may influence where and how many locations are established for groundwater level monitoring.

As an example, Figure 6 shows the general locations of groundwater level monitoring in Glenn County during 2002. There were a total of 136 monitoring wells used to measure groundwater levels across Glenn County. The neighboring counties of Tehama, Butte, and Colusa had 187, 89, and 67 groundwater level monitoring locations, respectively during 2002. As experience with groundwater level monitoring is gained, improvements in the groundwater level monitoring grid can be made.

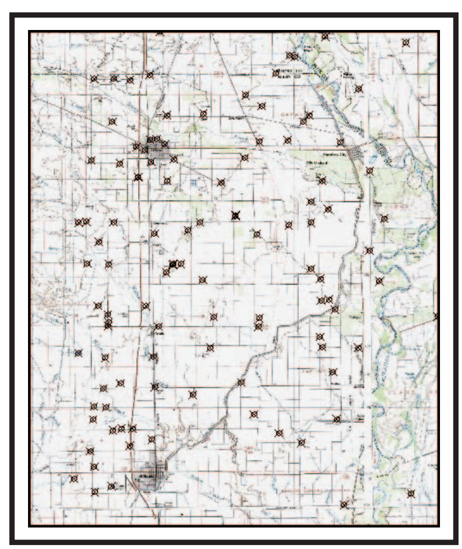


Figure 6. General locations of groundwater level monitoring in Glenn County during 2002.

DECIDING WHEN TO MONITOR GROUNDWATER LEVELS

Sound reasons exist for measuring groundwater levels in the spring, mid-summer, and in the fall. There are valid reasons for measuring static, pumping levels outside of a well with dedicated monitoring wells, and pump lift inside a well while in use, and there is an advantage of more frequent measurements. Realistically, limited financial resources to support groundwater level monitoring will likely require that some choices need to be made.

Spring and fall measurements generally occur before or after most of the irrigation season so static groundwater levels are usually measured in production wells. Because static levels are measured, elevation gradients between monitoring wells can be determined as well as groundwater flow direction within the aquifer systems. Springtime measurements also indicate the extent that the storage in the aquifer systems has recharged from winter precipitation. Static, fall groundwater levels may or may not correlate with mid-summer pumping levels but give insight about the amount of groundwater removed from aquifer storage during the irrigation season. Typically wells that are used to measure groundwater levels are in operation during mid-summer so pump lifts are often measured instead of static groundwater levels. Measurement of mid-summer pump lifts primarily help growers determine overall pump efficiency and pumping costs and have little relationship to long-term regional groundwater levels. Measurement of mid-summer groundwater levels in dedicated monitoring wells enable early detection of impacts from groundwater extraction related to water transfer programs.

Important Groundwater Records

- ❑ Name of well
- ❑ Location of well
- ❑ Ground surface elevation
- ❑ Date of measurement
- ❑ Depth to groundwater
- ❑ Elevation of groundwater surface
- ❑ Document reference point from which to consistently measure depth of groundwater
- ❑ Note well status (pumping or non-pumping) and any surrounding conditions that might affect groundwater levels

Figure 7. Important records that must be kept to effectively monitor the groundwater resource.

RECORD KEEPING

Record keeping can sometimes be overlooked as an important aspect of groundwater monitoring. However, without a commitment to record keeping to facilitate data analysis, the value gained from efforts to monitor groundwater may greatly diminish. Figure 7 highlights eight important groundwater records that need to be recorded and saved each time new groundwater measurements are taken.

APPLYING GROUNDWATER LEVEL MONITORING RESULTS

Figure 8 gives an example of how groundwater level monitoring data can be applied to help understand and protect the groundwater aquifer systems. The colored contour lines represent the groundwater elevations and show higher elevations in the northwest and lower elevations in the southeast. The red arrows indicate the direction of groundwater flow from northwest to southeast. The dashed box encompasses an area with a groundwater pumping depression. Comparisons of groundwater elevations and groundwater flow directions on an annual, semi-annual, or more frequent basis can identify early indicators of changes in the groundwater resource and help understand how to protect against or correct unwanted impacts. Hydrographs shown in previous issues of this information series (Figure 3 in Issue #2 and Figure 2 in Issue #3) are examples of other applications of the monitoring data. They can be used to set basin management objectives and to understand changes in the groundwater resource over time resulting from changing water and land uses, hydrology, and climate.

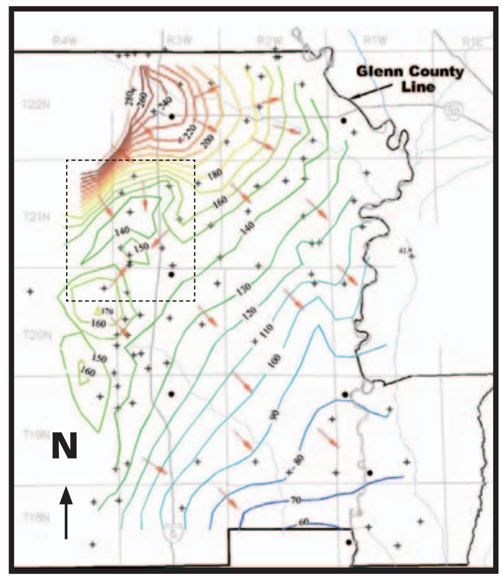
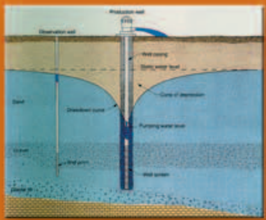


Figure 8. Example groundwater map for Glenn County. Contour lines show areas of equal groundwater elevation. Arrows show the direction of groundwater flow, and the dashed box shows a local pumping depression.

NEXT ISSUE

The past four issues of this series have emphasized topics related to protecting and managing the ground water resource from a broader, community perspective. The next issue will focus on water well design and construction, a topic of interest to the individual landowner and groundwater user.



This newsletter is the fourth in a series of six discussing topics related to groundwater, water wells and pumping plants.

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