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Farm Water Quality Planning
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This Reference Sheet is part of the **Farm Water Quality Planning (FWQP)** series, developed for a short course that provides training for growers of irrigated crops who are interested in implementing water quality protection practices. The short course teaches the basic concepts of watersheds, nonpoint source pollution (NPS), self-assessment techniques, and evaluation techniques. Management goals and practices are presented for a variety of cropping systems.

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Reference:
Groundwater Sampling and Monitoring

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Water quality data are only as good as the water samples from which the measurements are made. Even the most precise laboratory analysis of a water sample cannot compensate for improper or poorly executed sampling procedures or for physical and chemical alteration of a sample due to inappropriate sample collection, transport, or storage. This publication summarizes a number of considerations that you should keep in mind when sampling ground water. The publication is specifically intended for use by farmers and private well owners who are interested in obtaining a proper water sample for screening purposes (bacterial concentration, nitrate, iron, pH, mineral composition, salinity). Public water supply systems are subject to regulation by the California Department of Health Services, which specifies minimum guidelines for sampling frequency and sampling procedures that must be followed by any water system operator.

Many analytical laboratories will provide services to help you sample well water properly and provide you with proper sampling containers. For an accurate determination of the concentration of many pollutants that are regulated at low concentrations under drinking water standards, laboratories use relatively sophisticated sampling methods, so well or water system operators should seek the help and advice of a professional laboratory or consultant.

SAMPLING FREQUENCY

How often you should sample depends on the purpose of the sampling and the depth of the aquifer formations from which the well draws water. When screening the water quality in large *production wells* that pump water from aquifer formations more than 300 feet deep, sampling every year to every few years is sufficient because changes in water quality for such a well will be gradual. Shallower wells, particularly *domestic wells* with smaller pumping rates, should be sampled once or twice a year because they are more prone to short-term variations in groundwater quality and contamination. If problems with well bacteria, well degradation, or iron (from a rusting well casing) have been identified and a well maintenance program has been implemented by a licensed contractor, frequent sampling may be necessary regardless of well depth in order to monitor the success of the well rehabilitation program over an extended period of time. Finally, shallow *monitoring wells* that are installed to monitor a potential pollution source may be sampled monthly, quarterly, or semi-annually. Some monitoring objectives may require more frequent sampling.

SAMPLING PROCEDURES

The collection of water samples from groundwater wells occurs in five steps: sampling preparations, accessing the well before sampling and securing the well after sampling, measuring the water level, purging the well, and collecting and delivering the water sample. These five steps are explained in detail below.

Sampling Preparations

Before you take a water sample, the field sampling equipment should be cleaned and calibrated. Field sampling equipment includes

- pumping or bailing equipment
- water level meter
- water quality measuring equipment (These may include probes and instruments for measuring temperature, pH, electric conductivity, dissolved oxygen, reduction-oxidation potential, etc. Inexpensive meters or test kits are available from hardware and pet supply stores.)
- sample bottles (These are best obtained cleaned and preconditioned directly from the analytical laboratory. If the sample is intended only for analysis of major minerals and nitrate, you can also use a new bottled water container [a 16 to 32 ounce bottle is large enough] as sold in supermarkets. The bottle should be emptied of the original water and dried. For containers for bacteriological samples, consult an analytical laboratory.)
- field sampling labels and forms (see Figures 1 and 2).
- preserving containers (coolers, ice, proper chemicals and tools for field preservation per laboratory instructions)

Figure 1. Prototype sample label.

Field sequence no. ______________________________

Field sample no. ____________________ Date__________ Time________

Sample location ______________________________

Preservative used ______________________________

Analyses required ______________________________

____

Collected by ______________________________

Remarks ______________________________

____

____

Final pH checked ______________________________

Additional preservative used (if applicable) ______________________________

Figure 2. Typical field sampling form.

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MONITORING WELL SAMPLING DATA **WELL NO:_________**

Project:____

Location descript.:_______________________________ Township:________Range:________Section:_________

Sample no.(s):__________________________________ GPS Lat.:_______________GPS Long.:_______________

Sampling date:__________________________________ Sampled by: ___________________________________

Sampling method:_______________________________ Weather:_______________________________________

Sampling time:_________________________________ Amb. Temp. (°F):________________________________

WATER ELEVATION DATA

Method of measurement: Depth sounder

Other: ____________________

Depth to water [in feet]: _____________________________

Purge method:_________________________________ Depth of pump below top of casing [ft]: ________________

Date:____ Was well pumped dry? _______Yes _______No

Removed (gal) Temp (°C) Cond (FS) pH Eh (mV) DO (% or ppm) Pump rate (gal/min) Color/sediment

Comments: ____
____
____
____
____

Purging/sampling remarks: ____
____
____
____
____

Accessing the Well

Monitoring wells are usually secured with a locking cover or bolted metal housing, either at ground level in a traffic-rated utility or well box (Figure 3) or inside a 2- to 3-foot-tall metal pipe housing. Inside the housing, the actual monitoring well (usually a 2- or 4-inch PVC pipe) is sealed with an expandable rubber plug that can be locked tight. The plug is sealed with a keyed padlock (Figure 3).

Groundwater Monitoring Well

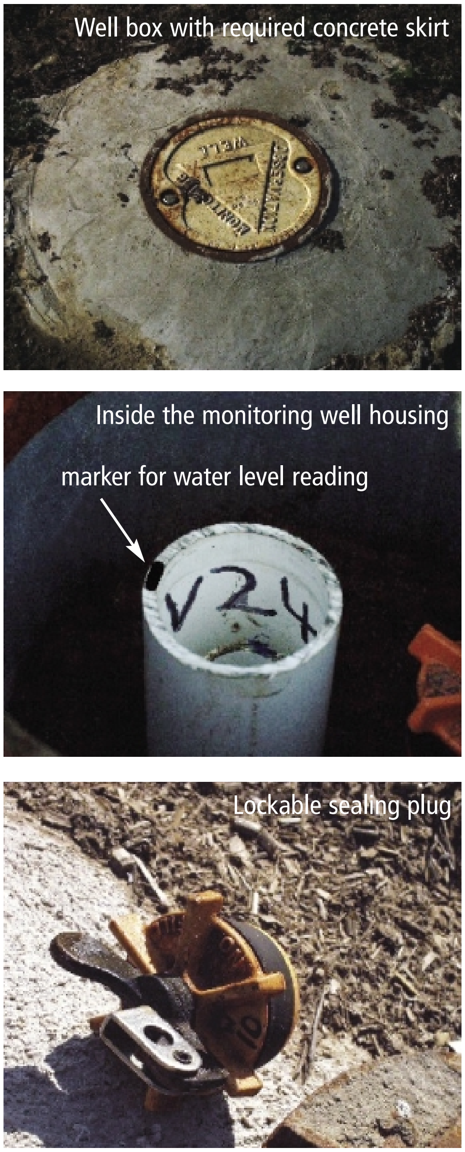

Figure 3. Well box, access pipe with water level measurement mark, and lockable plug of a monitoring well.

Access to production wells can be more difficult. Ideally, a sample valve or spigot will be located in the water pipeline between the wellhead and the water storage or pressure tank. In many domestic wells, however, the closest access to water from the well is at the exit point of the water pressure tank or at a water faucet inside the house. When testing ground water, the water sample ideally should not be collected from the tap. If the house is on a water treatment or water softening system, either of which involves chemical alteration of the water, the sample should be taken at a point in the distribution system that comes before the water enters any treatment and as close to the well as possible. If you can only draw a sample at the outflow of a pressure or storage tank, you should flush the tank prior to sampling (see below).

The easiest access to irrigation wells is often at the flood gates or sprinkler system hookup. Further downstream, water quality changes may result from the water's interaction with irrigation pipe or filtration systems. Major mineral salt content and nitrate are not usually affected by piping or filtration, but pH, bacterial concentrations, iron concentration, and trace constituents may be affected. For this reason, sample water should be collected directly from the well.

In some cases it may be possible to gain access to the well casing through an access pipe. If you are sampling directly from a production well by means of a portable submersible pump, bailer, or other collection device, the production well turbines or pumps must be shut off and considerable care must be taken to avoid tangling or wedging the sampling equipment between the production line, electric cables, drive shaft, and other equipment typically suspended in a well casing.

Measuring the Water Level

After you gain access to the well, your first step is to measure the depth to the water table in the well *(water level measurement)*. Water level information is important because changes in water levels may be directly linked to groundwater quality changes. As a well owner, it is also a good practice to keep a continuous (historical) record of water level measurements together with your well construction file.

Both domestic and irrigation wells should have a small access tube to the inside of the well casing through which a water level meter can be inserted. Groundwater levels are measured to an accuracy of one one-hundredth of a foot (0.01 ft) using a survey-grade groundwater level meter. For less precise measurements, homeowners without a meter can use a long measuring tape marked with chalk (lower the tape until it is well into the water table, measure the depth, then subtract the wetted length of the chalk to compute actual depth to water) or a pair of shielded wires with an ohmmeter attached (when the stripped tips of the two wires touch the water table, a small current begins to flow that can be registered with the ohmmeter). Whichever measuring device you use, it must be properly decontaminated before use and between sampling locations, especially when you are sampling for contaminants at very low concentrations. For water level readings, measure the depth to water from a fixed and identifiable reference point at the top of the well. For a monitoring well, the standard reference point is the north side of the top of the PVC casing rather than the top of the protective housing around the PVC pipe. Reference points should be marked to ensure consistency between sampling times (Figure 3). For production wells, the reference point can be the top of the access tube or access hole to the well casing.

When taking water level measurements in a production well, the pump plant inside the casing must be turned off and great care must be taken not to tangle the measuring tape on the drive shaft or production line or on other cables suspended in the casing. If you are at all unsure about whether there is enough space in which to operate, use a sturdy string to lower a weighted styrofoam cylinder of the same size as the water level meter into the casing to test accessibility.

Purging the Well

Before you collect a groundwater sample, purge the well to remove any stagnant water in the well casing and to ensure that at least 95 percent of the water sample originates from the aquifer formation being sampled. As a rule of thumb, a minimum of three to five well volumes of water are purged (Figure 4). If you sample at the outlet of a water tank, additional purging may be necessary to remove the stagnant water in the tank. Purging continues until temperature, electric conductivity, and pH level readings stabilize. The readings should be taken and logged every few minutes and recorded in a field log book together with the pumping method and the volume of water pumped (Figure 2).

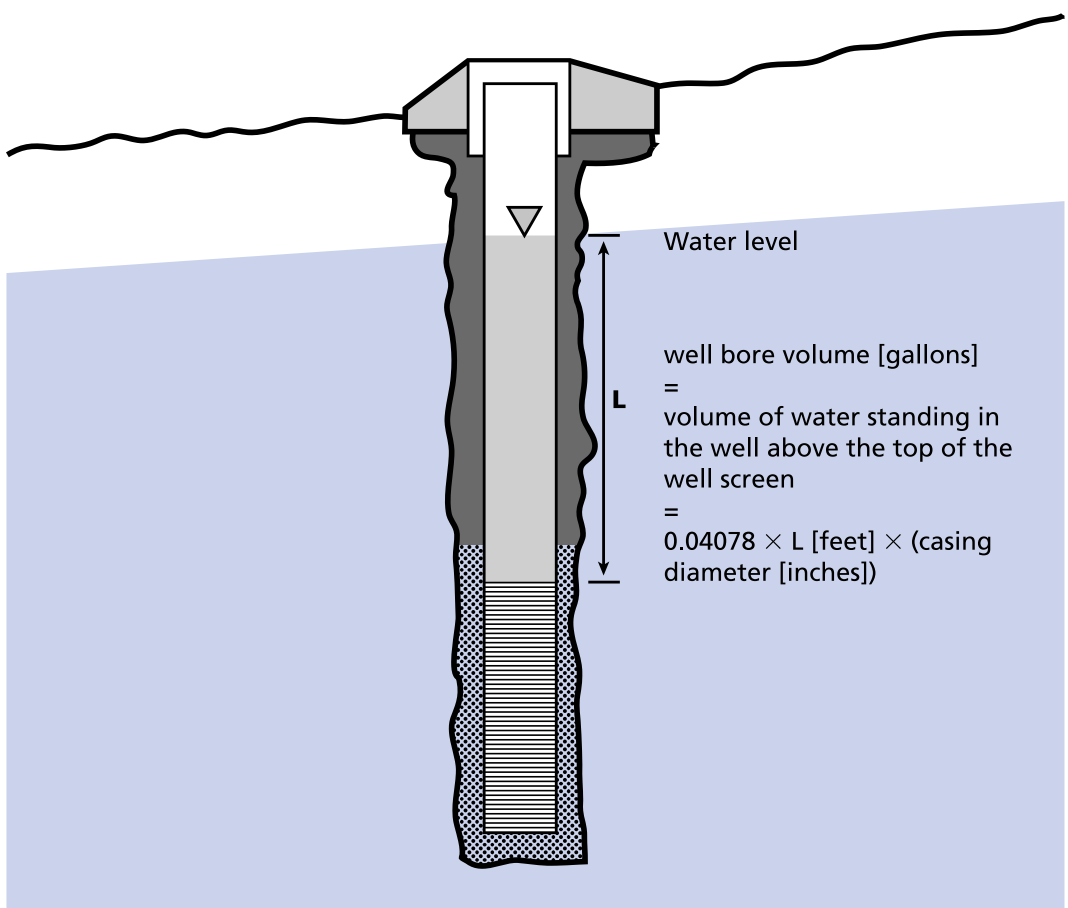

Figure 4. Well volume.

In production wells, the purging is carried out by the production pump. In a domestic system without a treatment or filtration system, all faucets should be turned on and left running until the necessary well, tank, and distribution system purging has occurred (this can take several hours). In a monitoring well, several different types of portable pumps are available for purging:

- *Electric submersible pumps.* Available in plastic materials and stainless steel for 2- and 4-inch wells, with constant or variable speed; pumping rates range from 100 ml/minute to 10 gal/min, and lift ranges up to 300 feet.
- *Hand pumps.* Inexpensive, available for small-diameter wells.
- *Peristaltic pumps.* For small-diameter wells with water table depths of less than 20 feet.
- *Air-lift samplers.* Device pressurizes the well casing to force a water sample to the surface; not suited for volatile compounds.
- *Gas-operated bladder pumps.* For small-diameter, deep wells; needs a source of nitrogen gas.
- *Bailers.* Inexpensive, available in a wide variety of materials and diameters, but low-volume removal, degassing and aeration is possible though problematic for many trace constituents.

The analytical laboratory will provide advice on appropriate sampling methods, and may be able to send qualified, properly equipped technicians to collect the sample.

Collecting and Delivering the Water Sample

The water sample must be collected within six hours of purging, and usually is collected immediately after purging. If an adjustable-speed pump is used, the pumping rate is lowered prior to sampling to avoid degassing or aeration of the water sample. Similarly, a faucet or valve should be turned down after purging such that the water will flow slowly and without aeration. Before the sample containers are filled, they should be properly labeled (Figure 1). A sample is collected directly from the bailer, pump discharge, faucet, or valve. The sampling container should be completely filled, and then capped and properly stored. Finally, the sample log (Figure 2) should be completed and all locking covers, locks, and housing covers should be secured safely to ensure protection of the well.

Since water samples are not immediately analyzed in the field, they typically require preservation. Proper preservation ensures that the water quality of the sample does not change between the time of collection in the field and the time of analysis in the laboratory. Preservation methods suppress chemical reactions that can occur in sample water due to degassing (lower partial pressure of dissolved oxygen, CO_2, etc.) or to exposure to heat and light. Which preservation method is best suited to a given sample depends on the water quality parameters to be measured and the amount of time between collection and analysis. It is best to consult the analytical laboratory about what preservation measures are necessary. Laboratories can provide properly cleaned and preconditioned sampling containers that already contain the chemicals necessary for preservation. Detailed instructions for sampling, storage, and delivery will be provided by the laboratory and should be strictly followed. If a water sample is analyzed for multiple parameters that require different preservation methods, it may be necessary to take several samples using separate containers.

Preservation usually also includes cooling the sample to 4°C (40°F). Samples must remain cool during shipping and storage. It is best to deliver the samples to the laboratory within one to two days of sampling.

If samples are shipped, the sealed sample containers are put into ice chests that are then packed with ice and transported to the analytical laboratory by express delivery service. At the laboratory, the samples are logged in, given sample ID numbers, and kept cool until they can be analyzed.

FOR MORE INFORMATION

You'll find detailed information on many aspects of field crop production and resource conservation in these titles and in other publications, slide sets, CD-ROMs, and videos from UC ANR:

Nutrients and Water Quality, slide set 90/104

Protecting Groundwater Quality in Citrus Production, publication 21521

Sediments and Water Quality, slide set 91/102

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