Water Quality Assessment Protocol for the Evaluation of Hydraulic Connection

Oregon Health Division

Background:

The variation in water quality parameters, e.g., temperature, pH, total dissolved solids, etc., in groundwater isolated from the nearby influence of surface water tends to be minimal. The actual variation exhibited decreases with increasing depth of the groundwater. With respect to temperature for example, groundwater that is at a depth of 25 to 50 feet may show a variation of several degrees centigrade throughout the year. Groundwater at a depth greater than 100 feet may vary on the order of one degree centigrade over the same period. Surface water on the other hand, typically has considerably greater temperature variation because of the water being in contact with the atmosphere.

In addition, isolated groundwater undergoes only small variations in water quality parameters such as pH, and dissolved constituents, e.g., total dissolved solids, calcium, chloride, sulfate, etc. Surface water, however, because of differing levels of runoff versus inflow from groundwater, or because of differing levels of biologic activity, may undergo significant variations in these parameters.

Groundwater that is in hydraulic connection, i.e., is recharged in part by water from a surface water source, will show greater variations in water quality parameters than isolated groundwater. Further, variations observed in hydraulically connected groundwater will be correlated to variations in the surface water source. Because of chemical reactions in the subsurface, and because of a time lag due to travel from the surface water to the aquifer, the influenced groundwater will not show the identical variations as the surface water, nor will groundwater's variation occur at the same time. For example, if the temperature of the surface water increases, the temperature of influenced groundwater may not reflect that change for several days to several weeks and then the variation may be significantly less than that observed in the surface water.

In order to evaluate whether or not a particular groundwater source in proximity to a surface water source is hydraulically connected to surface water, periodic monitoring of both the groundwater and surface water must be done. The data for the two should be compared to see if variations that occur in surface water throughout the year are also seen in the groundwater.

Requirement:

At a minimum, the public water system must make weekly determinations of temperature and one other parameter of both the groundwater from the well and the nearby surface water source. The second parameter may be any other water quality parameter approved by OHD, such as conductivity, pH, alkalinity, dissolved species such as calcium (hardness), sodium, alkalinity, chloride (not chlorine), sulfate, etc. A rainfall gage should also be used to measure and record the weekly rainfall.

Measurements must be taken over a period of at least 12 months beginning no later than March 15, 1997 A report of the results for one year must be submitted to OHD by April 1, 1998. If the surface water source dries up, recording of rainfall and sampling of the groundwater source should continue for at least one additional month. Data should be recorded and submitted using the attached form or any other spreadsheet having the same format. Submitting a data file with the same information on disk (in ASCII format) is also acceptable.

In the example given in Figure 1a we have portrayed a groundwater system that is not in hydraulic connection with a surface water source. Groundwater exhibits a small temperature variation that is not related to the significant variation that characterizes the surface water. The example in figure 1b, however, reflects groundwater in hydraulic connection. Note that the conductivity of the groundwater varies in a similar fashion to the surface water source.

Definition of Surface Water Source:

Surface water is defined as any water that is open to the atmosphere and is subject to surface runoff (OAR 333-61-020 (84)). This includes perennial streams, rivers, ponds, lakes and some wetlands, but also intermittent streams and natural or artificial surface impoundments that receive water from runoff.

Intermittent streams may be important sources of recharge to the aquifer when they are flowing. Perennial streams are fed by groundwater (i.e. baseflow) throughout the year. The beds of intermittent streams are above the water table throughout a portion of the year, only flowing when either the water table rises to intersect the stream bed or rainfall occurs at a rate that exceeds infiltration and as a consequence runs off, directed to the channels of the intermittent stream. In either case, infiltration to the aquifer can occur through the stream bed and banks.

Sampling Method:

For the purpose of this study, both the water from the well(s) or spring(s) in question and the potential surface water source(s) will be sampled/measured during the same period of time. In order to adequately assess the potential of hydraulic connection, samples must be carefully and consistently collected. Samples collected from the surface water source must represent the water volume that is in or moving through the source.

Sample Site. Figure 2 is a hypothetical cross section across a stream channel. As indicated, the stream bottom is often irregular in form, consisting of deep pools, the active channel (A) and shallows (B). A sample at point A is more likely to reflect the water that is infiltrating because it is more representative of the bulk of the water that is flowing through the stream or river. A sample from the shallows (B) on the other hand, will potentially be quite different from the bulk of the water in the system owing to more stagnant conditions or higher level of biological activity.

Detailed studies of surface water quality generally involve more rigorous methods of sampling in order to more accurately represent the mass of water moving through the stream, e.g. several depth-integrated samples weighted to reflect the various masses of water each sample represents. For this study, however, OHD is requiring only a single sample site, preferably at A.

The mid-channel sample (point A in figure 2) can be collected from a bridge, dock or boat within one mile upstream and 0.25 miles downstream, assuming that no other tributaries enter within that distance. Because you will be comparing the data from the surface water source with water from your well(s), it is very important that once a sample site is selected, that the same site and procedures are used each time. OHD will require that you submit a topographic map showing the well(s) and sampling sites when you submit your data.

Test Equipment. Temperature measurements should be accomplished using a digital thermometer (models are available for less than $30.00) and recorded to the nearest tenth of a degree centigrade. A digital conductivity meter, capable of reporting to the nearest microsiemen (or micromho) per centimeter, over the range of 0 to 2000 µS/cm, and preferably temperature compensated, should be used for conductivity measurements. If you will be using pH as the second required parameter, you must use equipment that provides a digital readout, capable of reporting pH to the 0.1 pH unit.

For the dissolved species such as calcium (as hardness), chloride and sulfate, a visual colorimetric test kit, generally priced less than $250-300 is acceptable. Visual colorimetric kits, because them depend on a color comparison by the analyst, are subjective and the result may depend on the analysts perception of color changes. Consequently, if a visual test kit is used, the analyst must demonstrate how well he or

she can detect variations in concentration and how well measurements can be reproduced, i.e. if a sample is reanalyzed, how close is the repeat analysis to the first. This quality control can be done by analyzing standard solutions and by repeating an analysis of the same sample. To measure rainfall, a simple rainfall gage will be sufficient.

Sample Collection. For temperature, rainfall, and several other parameters, e.g. conductivity, pH, alkalinity, etc., field measurements must be made. For dissolved constituents, samples that are properly preserved and handled can be analyzed later. Preservation procedures depend on the constituent of interest.

Surface Water. Collection of surface water for the purpose of analyzing or measuring the temperature should be done by bailing, using a previously cleaned bucket with a minimum capacity of one gallon. The bucket should be rinsed a minimum of three times in the surface water source and, for the purpose of temperature, be brought to as near as possible to the temperature of the water. [Filling the bucket with the source water, letting it sit for several minutes and then dumping and refilling will accomplish this.] Sampling or bailing should be done in a manner so as not to stir up bottom sediments.

Each measurement event must continue until three successive bails agree within 0.5 degrees centigrade. Similar procedures should be followed for other parameters, including pH, conductivity, etc.. For dissolved constituents, at least two measurements from two separate bails will be made and averaged. Individual analyses and the average should be recorded.

Groundwater. Routine weekly measurements of source water should be accomplished under pumping conditions. If the well is off, it will be necessary to allow it to pump until the well bore is filled with water solely from the aquifer, i.e. purging the well. Normally this is accomplished after pumping an equivalent of three well volumes.

Calculation of the well volume is as follows:

Depth of Water in Well (Dw) = Depth of Well - SWL

where SWL = static water level, the level of water in the well, measured from the surface, when the well is at rest, i.e., the pump has been off for at least 12 hours

Well Volume (in gallons) = Dw x πr^2 x 7.48

where π = 3.14 and r = radius of the well bore in feet.

The time required to pump 3 well volumes is given by

Time (minutes) = 3 x well volume/pump rate (gpm).

Direct Surface Water Influence Determination

The data collected during the study described above will be utilized to determine whether or not the groundwater source for your well(s) or spring(s) is in hydraulic connection with surface water, i.e., it receives a portion of its water from that surface water source. Hydraulic connection, however, does not establish direct surface water influence. If the data suggest that a system is in hydraulic connection, a microscopic particulate analysis will be accomplished at least twice during the year. Additional information will be provided at that time if necessary.

Technical Assistance:

Please send data to the attention of Kari Salis. If you have any questions regarding the sampling procedures discussed above, they may be directed to:

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OR:

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(Same)

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