Procedure for Determining Ground Water Under the Direct Influence of Surface Water (GWUDI)

A NOTE ABOUT THIS GUIDANCE: Use of this guidance is not mandatory. This guidance document was originally issued in 1995 under agency standards that have since changed. It was originally expected that GWUDI evaluations in Idaho would be a one-time task, mandated by the Surface Water Treatment Rule, and concluding in 2000 or 2001. Therefore, this document has not been subjected to the legal and managerial review that is currently required (2008) in DEQ prior to issuing official agency guidance.

In spite of earlier expectations, situations involving the potential for direct influence of public water system wells by nearby surface water continue to occur. Some amendments and other edits have been applied to this document over the years in an effort to accommodate growing experience with what works and what does not work with these evaluations. System owners and consulting engineers presented with the task of evaluating surface water influence (or the lack of it) may find useful information in this guidance, but are free to use any other publications or resources that deal with this topic. The legal requirement for providing DEQ with GWUDI information is spelled out in the *Idaho Rules for Public Drinking Water Systems*, Section 503.03.b.vi., cited below:

Evaluation of surface water influence. For all new ground water sources, including but not limited to wells, springs, and infiltration galleries, systems shall supply information as required by the Department to determine if these sources are under the direct influence of surface water. (4-4-13).

Idaho Department of Environmental Quality
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Amendments to the DEQ GWUDI Evaluation Procedure
October, 2004

Introduction

DEQ continues to learn from its experiences in evaluating existing wells for the possibility of direct influence from surface water. Although most sources in the State have been evaluated, at least another year will be required to complete this task. It seems prudent to assimilate the lessons taught by ongoing evaluations and, where possible, to modify the approach in ways that streamline the procedure without losing information or diminishing the value of results. The decision to employ an amendment to the procedure instead of re-writing the original document is based on the following rationale:

1) The original policy contains useful methodologies that remain as viable options for water systems. It also contains discussion of the lines of evidence that should be considered when making GWUDI determinations and provides analytical guidance.
2) The changes proposed in this amendment are direct and relatively simple, which minimizes the need for revamping the entire procedure.

Amendments

Any given source may be examined by following the steps outlined in the original procedure, depending on staff analysis of the site-specific conditions and preferences by the water system. However, it has become increasingly apparent since the last revision of this procedure four years ago that a simpler approach yields equally valid results. The following amendments to the procedure are adopted at this time:

1) Most systems should avoid water quality parameter monitoring (Part 2) and proceed directly to MPA sampling (Part 3). Part 2 studies should be pursued only if DEQ staff can identify a good site-specific reason for conducting the water quality monitoring, and then only if the water system displays a strong commitment to assembling an <u>accurate and complete</u> data set. Experience has shown that these studies generally yield statistical results that are equivocal in nature and are insufficient to eliminate the need for MPA sampling.

2) MPA sampling should be concentrated in the spring and early summer. Two samples, separated by two or three weeks, should be adequate. If risk scores require additional sampling, a decision must be made to either take follow-up samples in the current season or wait until the following year when high water, snowmelt, or other factors indicate highest risk. This decision is unavoidably a judgment call that should be based on the best information available. Where the contributing surface water consists of irrigation works, the MPA samples should be timed to follow the introduction of water to the system by two to four weeks. Autumn samples, which were originally thought to reflect risks associated with low water tables, have proven over the years to be unrevealing in most cases.

Conclusions

The above changes make it possible to complete a GWUDI evaluation in a single season without a loss of confidence in results. DEQ drinking water staff are encouraged to adopt these amendments in most situations, with the understanding that water systems may elect to follow the original procedure if they are convinced on the basis of long-term observations that a hydraulic connection study may reveal an absence of surface influence. A professionally conducted hydrogeologic evaluation remains a preferred option when the water system is able to afford it. Scoring and interpretation of MPA samples will continue in accordance with Part 3 of the original procedure—only the timing of these samples has been modified.

State Office assistance is available in evaluating site specific conditions, making historical comparisons with other studies, and in performing statistical analyses.

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Overview of the GWUDI Procedure

The *Surface Water Treatment Rule,* a primary drinking water regulation, requires that all ground water sources be evaluated to determine if they are ground water under the direct influence of surface water (GWUDI). This policy describes the methods that are being used by Idaho DEQ to fulfill this requirement. *It is important to remember that all ground waters are surface influenced on various temporal and spatial scales. Of concern from the perspective of drinking water safety is ground water which is influenced by surface waters that have traveled a relatively short distance in a brief time period through aquifer materials with large pores or fractures--it is under these circumstances that pathogenic micro-organisms may be transported* ***in a viable state*** *to a spring, infiltration gallery, or well intake.*

The GWUDI evaluation procedure described in this document outlines a means for achieving a scientifically defensible assessment of whether or not a source is surface water influenced**,** while minimizing costs to drinking water systems. A hydrogeological study conducted by a licensed professional is a more certain approach to determining surface water influence. However, such studies are costly and may be beyond the means of many small water systems.

Idaho's GWUDI Evaluation Procedure is based on widely accepted principles and methods. It was developed by a consortium of states in the Pacific Northwest. The current revision makes use of experience gained since 1995 to allow flexibility in the GWUDI analysis where such flexibility is warranted by site-specific circumstances. The procedure may be briefly described as follows:

Part 1-- Field Screening: an on-the-ground evaluation of physical characteristics to determine whether or not the source is at risk for direct surface water influence.

Part 2-- Hydraulic Connection Analysis: If field screening indicates a risk of surface water influence, the system is required to collect water quality data from the source and the nearby surface water for a period of at least six months. Statistical analysis of this data is performed by DEQ to ascertain the presence or absence of hydraulic connection between the water source and the nearby surface waters. Under certain conditions, a water system may choose to proceed directly to Part 3 instead of conducting a hydraulic connection study.

Part 3-- Microscopic Particulate Analysis (MPA): If a hydraulic connection is demonstrated, the system is required to collect two or more MPA samples during periods of the year when the source is believed to be most vulnerable to surface influence. The risk scores obtained from these samples are then used to make a final determination of surface water influence.

Part 4-- Evaluation of New Sources: New sources that are not located at a safe distance from surface water and/or have not been engineered and constructed to prevent surface water intrusion must undergo GWUDI evaluation. This Part describes some approaches for evaluating new

sources.

Part 5-- Treatment Requirements: Finally, if direct surface influence is demonstrated, the State must prescribe the treatment that is to be applied to the source water in order to meet the requirements of the *Surface Water Treatment Rule*. In determining a treatment prescription, the State will take into account the requirements likely to be included in future drinking water regulations, such as the *Enhanced Surface Water Treatment Rule*, the *Disinfection/Disinfection By-Products Rule*, and the *Ground Water Disinfection Rule*.

At each of these steps, DEQ field staff should assemble all available information to aid the evaluation and add certainty to the results that are obtained. Although the procedure is stated in simple and direct terms, the actual process requires the exercise of judgment at nearly every turn. Well logs, hydrogeologic or geologic studies from the scientific literature, system history, records of waterborne disease, and any other available information should be obtained.

Any public water system which is shown on the basis of field evaluation to be at some risk of surface influence may exercise any of the following options at any point in the GWUDI evaluation process:

1) **Continue with any remaining steps of this procedure.**

2) **Commission a private consulting firm to conduct a full hydrogeological study of surface influence.**

3) **Develop a new source located at a safe distance (>500') from surface water.**

4) **Reconstruct the existing source under the personal supervision of a qualified professional so that surface water is excluded from the well's capture zone.**

COMPANION DOCUMENTS

This Procedure provides guidance on the implementation of certain key provisions of the *Surface Water Treatment Rule.* Supporting documents which should be consulted when using this policy are:

1. Code of Federal Regulations, 141.70 through 141.76 (Sub-Part H, *The Surface Water Treatment Rule*)

2. *Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, published by USEPA.

Definitions

Surface Water: Any water that is open to the atmosphere, other than a sealed vessel such as a water storage tank, including lakes, streams, ponds, canals, and ditches, which exists for 60 or more days per year. The sixty days do not have to be continuous.

Distance to Surface Water: The shortest horizontal distance between any surface water body and the ground water source being evaluated.

Groundwater Under the Direct Influence of Surface Water (GWUDI): Any water beneath the surface of the ground with (1) significant occurrence of insects or other macro-organisms, algae, or large-diameter pathogens such as *Giardia lamblia or Cryptosporidium*, or (2) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH, which closely correlate to climatological or surface water conditions. Direct influence must be determined for individual public water sources in accordance with criteria established by the State. This determination may be based on site-specific measurements of water quality and/or documentation of well construction characteristics and geology.

Microscopic Particulate Analysis: A technique for capturing particulates from waters and evaluating the identity of these particulates under the microscope. The types of biological organisms and their abundance are used to establish an assessment of the risk that the sampled waters are directly influenced by surface waters.

Water Quality Parameters: For the purposes of this policy, water quality parameters are physical characteristics such as temperature, pH, conductivity, dissolved solids, turbidity, or dissolved oxygen. These parameters are measured in the ground water source and in nearby surface water. Correlations between the ground water and surface water measurements are statistically tested and, if found significant, are taken as an indication of hydraulic connection.

Peer Review Panel: A group of engineers, regulators, or other specialists assembled for the specific purpose of considering technical issues. Such a group may be convened in situations where evidence supporting a decision or determination is equivocal or conflicting.

Licensed or Qualified Professional: As used in this procedure, these terms refer to an engineer, scientist, consultant, or other specialist who has credentials (professional license or extensive experience) in his or her field. Although reports submitted by such professionals are reviewed for content and completeness, DEQ does not place itself in the position of second-guessing conclusions reached by competent professionals unless there is compelling evidence of error, improper methods, or oversight. Liability resulting from these conclusions rests with the professional who prepared the report.

Part 1 -- Field Screening

For the purpose of this evaluation, each ground water source must be inspected in the field.. Information to obtain and record on the Survey Form (Appendix 1) includes:

1) Identify the type of source (well, spring, lake)
2) Identify sources which are open to the atmosphere
3) Identify construction defects which allow surface water to enter the source
4) Location and distance to all surface water within 500' of the source
5) Location and distance to all on-site sewage systems or lagoons within 500'
6) Location and distance to municipal or on-site sewer lines (tight) within 500'
7) Location and distance to other potential sources of *Giardia* or *Cryptosporidium* within 500', such as dairies, livestock confinements, storm water, dry wells, and wastewater land application sites
8) Determine the maximum sustainable pumping rate (a conservative estimate would be the pump capacity)
9) Identify locations where water quality parameters should be monitored if a hydraulic connection study is required
10) Determine the elevation of nearby surface water and corresponding elevation of ground water in the source under maximum pumping conditions

Screening Criteria:

A. Sources open to the atmosphere or subject to direct surface water run-off.

These sources must be classified as GWUDI. No further evaluation is necessary.

B. Springs and infiltration galleries.

All springs and infiltration galleries must be evaluated for hydraulic connection under Part 2, unless they are initially classified as GWUDI.

C. Sources less than 200' from surface water.

These sources must be evaluated under Part 2 and/or Part 3, unless initially classified as GWUDI. See Appendix 6 for optional guidelines on evaluating sources that are equipped with hand pumps. Further evaluation may be waived for sources where the only nearby surface water is in the form of a small irrigation ditch. Studies of such sources over several years have rarely shown statistically significant hydraulic connection and, even when connection has been demonstrated, MPA scores have been very low. It

appears that this type of situation poses a low risk of surface water influence. The following stipulations apply:

1) The ditch must be at least 50 feet away from the well and carry relatively small volumes of water on an episodic basis. Continuous flows warrant evaluation under Part 2.

2) Evidence must be available to demonstrate that the well is properly constructed and sealed, and the intake zone is at least 50 feet deep.

3) The water in the ditch must not be compromised by run-off from livestock holding areas or other obvious sources of microbial contamination.

D. Sources 200' to 500' from surface water.

1. **Community Water Systems with Disinfected Sources:** These must be evaluated under Part 2 **or 3**, unless it can be shown that disinfection was installed solely for distribution system protection and the source has no history of coliform contamination, as indicated by at least one sample taken from the source each month for a period of six months without detecting coliform.

2. **Community Water Systems with Non-Disinfected Sources:** Systems with sources that are not disinfected, but have experienced positive total coliform samples in three or more months during the past three years of routine bacterial monitoring, must be evaluated under Part 2, unless the system can demonstrate that all positive total coliform samples are not a result of source contamination. Systems that have experienced two or fewer months with positive total coliform samples during the past three years may be classified as ground water. Further evaluation of some of these sources may be warranted, as discussed in Section F, below.

   If systems are not complying with coliform monitoring requirements, this criteria is not useful. As a guideline, systems must have collected at least 80% of the required coliform samples over the past three years, or evaluation under Part 2 should be required.

3. **Non-Community Systems:** Whether disinfected or not, non-community water systems may be classified as ground water on the basis of at least six coliform-free samples taken from the source during six consecutive months when the system is in operation. The system may elect to monitor water quality parameters and be evaluated under Part 2 in lieu of the six-month coliform sampling requirement.

E. Sources greater than 500' from surface water.

All sources more than 500' from surface water may be classified as ground water. Further evaluation of some of these sources may be warranted, as discussed in Section F, below.

F. Sources considered to be vulnerable to microbial contamination.

Sources which are initially classified as ground water may nevertheless be at risk of *Giardia* or *Cryptosporidium* or other microbial contamination, even though they are greater than 200 or even 500 feet from surface water if:

1) they have a history of coliform contamination, or,
2) they utilize disinfection due to past source water bacterial contamination, or
3) they are constructed in porous or fractured aquifer materials such as coarse sand, gravel, or volcanic material, or
4) the source is of poor or unknown construction or very shallow (< 50' deep), or
5) they are located near other major sources of microbial contaminants, such as large dairies or livestock feeding operations, or
6) they are pumped at a very high rate, such as 500 gpm or more.

If field staff believe that there is a reasonable likelihood that source with any of these characteristics are at risk of *Giardia* or *Cryptosporidium* contamination, evaluation under Part 2 may be required.

If field staff believe that sources are at risk of microbial contamination, but not from *Giardia* or *Cryptosporidium*, the field screening form should be marked "GW- Further Evaluation". These sources will receive further Ground Water consideration under the *Ground Water disinfection Rule* presently being developed by EPA.

Part 2-- Hydraulic Connection Analysis

Water sources which are not initially determined to be ground water or GWUDI during the field screening process may be evaluated to determine if a hydraulic connection exists between the nearby surface water and the ground water. There are two options for determining hydraulic connection: 1) Water quality parameter monitoring and statistical analysis (directly below) and 2) Hydrogeological assessment (page 11).

If results of a hydraulic connection analysis or professionally conducted hydrogeologic assessment indicate that connection exists, the system will be required to submit microscopic particulate analysis samples, as outlined in Part 3.

Experience has shown that most sources are at their peak vulnerability to surface influence during or shortly following spring snow melt and run-off, during prolonged storm events, or during periods when water tables are depressed (late summer/early fall). In view of this experience, DEQ may allow a water system to forego hydraulic connection analysis and proceed directly to MPA sampling during one or more of these vulnerability periods. DEQ will specify when sampling should occur. Due to the cost of MPA's, most systems will probably wish to conduct a hydraulic connection study first, knowing that finding an absence of hydraulic connection would end the need for further analysis and avoid the expense of MPA sampling.

1) Water Quality Parameter Monitoring: Ground water that is in positive hydraulic connection with surface water will exhibit variations in physical and chemical characteristics in a pattern related to changes in these characteristics that may be observed in nearby surface water. To establish this relationship, concurrent monitoring of parameters in surface water and ground water is required.

A. **Parameters:** Each water system must monitor <u>at least two</u> parameters in both the surface water and the groundwater. If there is no surface water within 500' (some spring sources), measurements from surface water need not be taken. For these sources, it is strongly recommended that daily precipitation and ambient air temperature be recorded at the source site, or assembled from weather records if a nearby official weather observation station is available. Total discharge volume of the spring, in gallons per minute, is extremely useful when analyzed together with other physical parameters. It is important that total discharge be measured, not just the portion of the spring's flow that is used by the water system.

1. Water Temperature- Required in all studies.

2. Second parameter- Conductivity is strongly recommended, but pH, dissolved oxygen, or other parameters may be allowed on a case-by-case basis, on approval by DEQ or Health District. Use of pH is discouraged because it is highly sensitive to regular

instrument calibration. Turbidity variations in ground water can be occasioned by many factors other than hydraulic connection with surface water. Use of this parameter is also discouraged.

B. **Frequency:** These parameters should be monitored five to seven days per week, but lesser frequencies may be allowed by DEQ or the Health District. It does not seem unreasonable to ask the system to monitor each day that the operator visits the source (1-7 days per week), with the intent being to obtain as much data as possible with a minimum of extra effort. Monitoring once per week may be allowed with adequate justification. However, the system should keep in mind that the underlying assumptions of the statistical procedures that will be used to evaluate the monitoring data **make it critical that at least one observation per week be taken.** Missing observations create analytical difficulties and, if allowed to happen frequently, may render the data useless. An analysis that is made on fewer data points increases the risk that a hydraulic connection will be inferred on the basis of outlying or unusual measures. Despite the inconvenience, it is to the water system's advantage to assemble the largest and most consistent data set possible over the six month monitoring period.

C. **Duration:** A minimum of six months of observations must be made. If the data available at the end of this period are not sufficient for analytical purposes, an additional period of monitoring, up to a total of one year, may be required.

D. **Measurement methodology: Careful attention to these guidelines will benefit the water system by avoiding variations in the data which may suggest surface influence but are actually a result of measurement error.**

1. Field measurements:

   Temperature, pH, dissolved oxygen, and turbidity must be measured in the field. Conductivity and hardness may be measured in the field or in a laboratory.

2. General sample collection guidelines:

   a. Measurements should be taken at approximately the same time each day.
   b. Use the same instrument throughout the study if at all possible.
   c. Instruments must be calibrated according to the manufacturer's instructions. pH meters, in particular, need frequent and precise calibration.

3. Instrument specifications:

   a. Instruments should be capable of the following accuracy:

Temperature	0.5^{o} F or $.1^{o}$ C
Conductivity	1 umho/cm; over 1-20000 umho/cm range
Turbidity	0.1 NTU
pH	0.1 pH unit
Dissolved Oxygen	0.1 mg/l

Note: Because one step in the analytical procedures makes use of percentages, it is recommended (not required) that Fahrenheit thermometers be used.

b. Hand held (pocket pen type) instruments are acceptable for temperature conductivity, and pH. Digital displays are usually easier to read. Larger water systems which have more accurate equipment available should measure parameters following the procedures outlined in the latest edition of *Standard Methods.*

4. For all sources:

   a. Collect samples in a clean container, one gallon or larger, to make measurements.
   b. Rinse the container three times in the water to be sampled to allow it to equilibrate before taking temperature measurements.
   c. Make measurements in the center of the container.
   d. Do not record the results until measurements have stabilized. It is suggested that measurements be repeated until three successive readings are in close agreement.

5. Surface water sampling:

   Rivers/streams:

   a. Collect samples in free flowing areas, preferably in the middle or deepest part of the stream.
   b. If possible, sample in straight reaches of the stream.
   c. Collect samples as close as possible to the ground water source.

   Lakes/ponds: Large water bodies often develop temperature stratification during summer and winter. Technical assistance may be needed to determine the best method and location for sampling lakes.

   a. Collect samples at least ten feet from the shore, if possible.
   b. If possible, do not sample shallow areas; attempt to collect from a foot or more below the surface.
   c. Collect samples as near to the ground water source as is practical.

6. Groundwater sampling: **Careful measurements are essential, because variations in water quality parameter values may be very small.**

a. Measurements must be made in a manner that reflects aquifer conditions. Wells used regularly should be purged for five to fifteen minutes, or until temperature measurements have stabilized.
b. Sources used infrequently should be purged for thirty minutes or more before measurements are taken.
c. Sources used seasonally should be in operation for at least one week prior to beginning measurements.

E. **Reporting Results:** Data should be recorded in a legible and consistent format. This will help prevent errors when entering data to the computer for analysis.

F. **Analysis of Results:** Water quality data will be evaluated statistically. Appendix 2 provides a step-by-step procedure for this analysis using the WQHYDRO statistical package. Appendix 2 also provides insights into the power of the various statistical procedures and their proper interpretation. The steps in the analysis are outlined below. These methods were developed by the Oregon Health Division and reviewed and agreed upon by the Idaho, Washington, and Alaska drinking water programs. USEPA Region 10 and consultants familiar with GWUDI evaluation procedures have reviewed and accepted these methods. The use of statistical procedures is designed to introduce a measure of objectivity to the analysis and provide an estimate of the confidence that can be taken in inferences made from the data. However, the use of these procedures should be tempered by a consideration of all available information about the water source. An inclusive view of both the source characteristics and the monitoring data may suggest that some of the following guidelines should be adjusted. For example, temperature can probably be measured routinely with less error than a parameter like conductivity or pH.

Step 1-- Evaluate variations in data from the ground water source. In general, "true" groundwater, that is, water that has resided in the subsurface for an extended period, will exhibit only slight variations in quality parameters through time.

A. 1) Plot each parameter against time to facilitate observation of changes that occur.
2) Calculate the variation within the data set for each parameter as a percentage variation from the minimum value recorded:

$$\frac{\text{Max - Min}}{\text{Min}} \quad \text{X} \quad 100$$

If all ground water parameters exhibit less than 10% variation by this calculation, the source may be designated as groundwater and no further analysis is required. As indicated above, this guideline may be adjusted when all available information is considered. If this figure exceeds ten percent, proceed to B. The criterion of 10%

variation was chosen to filter out variations due to measurement errors alone.

B. Using the Kruskal-Wallis procedure, determine for each ground water parameter if there is significant (non-random) variation among monthly medians or rank means at the 90% confidence level.

C. If both ground water parameters show no significant variation using the above procedures, the source may be considered not in hydraulic connection with surface water, and will be classified as ground water.

D. If the variation in ground water data is significant using the above procedures, proceed with Step 2.

Step 2-- Visually examine time series plots of ground water and surface water data and note whether or not the ground and surface waters appear to be correlated. Note whether the correlation appears to be continuous or episodic. Proceed to Step 3.

Step 3-- Evaluate cross-correlation between surface water and ground water parameters.

A. For each parameter, calculate the cross-correlation function of paired ground water and surface water parameters.

B. If any cross-correlation coefficient for lags up to six months is greater than or equal to .5 at the 90% confidence level, hydraulic connection exists. Based on currently available information, correlations at longer lags are not believed to be important in terms of contamination by *Giardia* and *Cryptosporidium*, as these organisms become non-viable after about six months.

C. If the cross-correlation coefficient is less than .5, or is not statistically significant at the 90% confidence level, hydraulic connection probably does not exist and the source may be classified as ground water. In some studies, smaller coefficients that are nevertheless highly significant statistically may be worth further study and evaluation, particularly when accompanied by site specific data that is broadly indicative of surface water influence.

D. If a hydraulic connection exists, time-of-travel may be estimated by observing the lag time between changes in surface water data and the corresponding change in ground water data. If the data do not exhibit regular variation, estimating time-of-travel by this method may not be possible.

2) **Hydrogeologic Assessment:** This option requires the services of a professional geologist, hydrogeologist, or engineer with appropriate experience. A determination of surface water influence (or the lack of it) should include, but is not necessarily limited to a consideration of the following factors:

Well Characteristics:

Well depth
Screened/perforated interval
Grout seal

Aquifer Characteristics:

Thickness of the unsaturated zone
Hydraulic conductivities of the unsaturated zone and aquifer
Presence of low permeability layers in the unsaturated zone.
Degree of connection between the surface water and the aquifer (does the surface water body penetrate the aquifer?)

Hydraulic Gradient

Vertical gradient under pumping conditions
Horizontal gradient between the aquifer and the surface water under pumping conditions
Variation of static water level and surface water level with time

Groundwater Flow

Does the well's steady state capture zone intersect the surface water source?
What is the estimated time of travel for water between the surface water source and the well?

If the hydrogeologic assessment indicates to DEQ's satisfaction that the water source is not in connection with surface water, the water system will not be required to perform any further analysis. DEQ may solicit assistance from hydrogeologists within the agency, or may convene a peer review panel to evaluate such assessments..

Part 3 -- Microscopic Particulate Analysis (MPA)

The existence of a hydraulic connection between ground water and nearby surface waters does not mean in every instance that the ground water is susceptible to contamination by pathogenic organisms from the surface. These organisms persist for a limited distance as they move in the subsurface, depending on physical characteristics of the aquifer matrix, temperature, and chemistry. However, the existence of hydraulic connection does indicate a clear risk that the ground water may be contaminated with pathogens. Microscopic particulate analysis is a method for assessing the number and kinds of surface organisms that exist in the ground water. A relative risk factor is assigned by the analyst, based on a consensus method developed by scientists and other specialists.

MPA samples may also be required if:

1. It is unclear whether or not a hydraulic connection exists.
2. The source is a spring, is locally recharged or very shallow, or is near a major source of *Giardia* and *Cryptosporidium.*

The MPA procedure was not intended by its developers to be a stand-alone diagnostic tool. However, MPA samples may sometimes be used on a stand-alone basis for GWUDI determinations under the following special conditions:

1. Wells that are surrounded by surface water during flood events or spring snow melt. In these situations, monitoring of nearby surface water (if it exists in non-flood conditions) may be inconclusive or irrelevant.

2. Springs which have no nearby surface water and for which a suitable water quality parameter monitoring study is impractical or unrevealing.

3. When a water system chooses to forego hydraulic connection studies and DEQ agrees that the period of vulnerability for a particular source is well enough understood to justify proceeding directly to MPA sampling.

The number of MPA samples required in stand-alone studies, and the interpretation of results may vary from case to case. In most situations, the steps outlined below should be followed. A peer review panel may be convened to consider stand-alone MPA evaluations. Technical assistance may also be sought from USEPA or others with specialized knowledge of MPA analysis..

MPA samples are to be taken and interpreted as follows:

A. **Number of samples:** A minimum of two MPA samples are required.

B. **Timing of sample collection:** Samples must be collected at times when the source is most likely to be influenced by surface water and under peak pumping conditions. It is recommended that sources be pumped at peak capacity for a minimum of two weeks prior to collecting the sample. If analysis of water quality data (Part 2) indicated that the ground water source was affected episodically, for example, after heavy storms or following high flows in a nearby stream, then samples should be taken during these episodes, or shortly afterward, the lag period being based on the hydraulic connection analysis. Unless water quality monitoring or other information suggests more appropriate times, collect samples:

1. During a period of high water table, such as in the spring during snowmelt runoff, or during the summer if water tables are elevated from irrigation.

2. During a period of low water table, such as in the late summer or fall.

Because MPA samples need to be taken during periods of aquifer vulnerability, the timing of samples may be modified by DEQ in order to avoid missing the best opportunity for sampling and finding it necessary to wait for a full year before concluding the analysis. This may include asking the water system to collect MPA samples prior to the conclusion of the hydraulic connection study, if warranted by preliminary results or other evidence.

C. **Laboratories:** MPA samples must be analyzed by labs recognized by the USEPA as being qualified to perform this procedure. A list of laboratories is provided in Appendix 3.

D. **Collection procedures:** Samples must be collected before any treatment is applied to the water, and must arrive at the lab within 48 hours from the time collection is completed. Procedures for collecting MPA samples are listed in the USEPA Consensus Method.

E. **Interpretation of sample results:** The following interpretive procedures were developed and accepted by the Idaho, Washington, Oregon, and Alaska drinking water programs. Refer to the flowchart in Appendix 3 for a graphical presentation of the information listed below.

1. Collect a minimum of two MPA samples.

   If any result is ≥ 20, the source is GWUDI.

   If both samples are ≤ 9, the source is ground water.

   If results fall between these limits, go to the next step.

2. Collect two additional MPA samples (during two separate critical time periods), and have these split for immune fluorescent antibody analysis for *Giardia* and *Cryptosporidium*.

   If either protozoan is confirmed in the sample, the source is GWUDI.

   If any MPA result is ≥ 20, the source is GWUDI.

   If two or more of the four samples that have been taken are ≥ 15, the source is GWUDI.

   If all samples have scores < 15, the source is ground water.

   If one of the samples is ≥ 15 (but < 20), further evaluation may be required in the future.

Part 4 -- Evaluation of New Drinking Water Sources

Overview: Idaho's Drinking Water Rules require the submission of plans for review and approval prior to the construction of a new drinking water system or any substantial modification of an existing system. The reviewing agency, DEQ or District Health, should attempt to prevent the construction of a new source in a location where there is a risk of surface water influence. When this is not possible, the source should be located as far as possible from surface water and should be constructed under the personal supervision of a licensed engineer to ensure that casing, well seal, and position of the intake zone are all placed in a manner that will exclude surface water influence. If this latter process is followed *and documented* to the satisfaction of DEQ or the District Health Department, GWUDI evaluation will not be required.

As a general policy, water from new sources at risk of surface influence may not be served to the public until it has been treated as required by the *Surface Water Treatment Rule*, or has been clearly shown not to be GWUDI.

Exceptions: New sources that are at risk of surface influence may pose an unknown and potentially greater threat to public health than existing sources, simply because they lack a history of use. Existing wells usually have an extensive record of public use without documented waterborne disease. Additionally, such sources have been routinely sampled for bacteria for a number of years. This sampling history can provide some assurance that the water is safe for public consumption.

However, when a new groundwater source for a new or existing public water system is installed near surface water without regulatory agency review and approval, or when local hydrogeologic factors make it impossible to locate the source more than 500' from surface water, the source must be evaluated to determine if it is GWUDI. The following approaches may be considered, in order of decreasing preference:

A. Wells that are located within 500' of surface water and have not been engineered and constructed as described in the opening paragraph above, must be evaluated under Parts 1-3 of this Procedure. As noted in the Overview beginning on page 1, the water system may elect any of several options at any point in the GWUDI evaluation, including contracting for a professionally conducted hydrogeologic assessment. **These requirements should be met prior to serving water to the public.**

B. Pumping a new well to waste for six months or more while completing a hydraulic connection evaluation can sometimes present severe financial and logistical challenges. In certain settings, such as highly permeable riverine deposits, this procedure may be inconclusive due to feedback effects from the water pumped to waste. In an effort to recognize these difficulties and achieve practical solutions, DEQ has the latitude to consider alternative evaluation methods. These methods are likely to be a combination of

hydrogeologic assessment and MPA sampling. Their purpose is to provide a **preliminary** assessment of the risk of surface water influence. When this risk can be shown to be acceptably low, the water system may be allowed to serve water to the public while conducting a more definitive GWUDI evaluation. The following outline presents one possible approach to such a risk assessment. Due to the uncertainties involved, it is strongly recommended that DEQ convene a peer review panel to consider evaluations of this type.

This type of evaluation is only permitted during periods of the year when the source in question is at greatest risk of surface water influence (See Part 3B, on page 14).

1. Under the direction of a registered professional geologist or professional engineer, a pump-drawdown test would be conducted to establish the amount of time required for the well's cone of depression to reach equilibrium. Measurement of temperature, conductivity, dissolved oxygen, or even tritium may be conducted by the supervising professional during the pump test to provide additional information about the ground water. Consideration may be given to static pressures of the production aquifer. If this measurement is substantially greater than upper aquifers or of the nearby surface water, then a reduced risk of surface influence may be assumed.

2. After pumping under equilibrium conditions for several hours to days (based on the supervising professional's assessment of aquifer characteristics), take an MPA sample.

   If the MPA score is ≥ 20, the source is GWUDI.

   If the MPA score is ≥ 10 but less than 20, the system should take a second MPA sample a few days later, following the same pumping schedule.

   If the second MPA is ≥ 10, the system would be required to proceed with a plan to pump to waste until a full hydraulic connection study (Part 2) could be carried out, or a definitive hydrogeologic assessment completed.

   If the second score is <10, the system may be allowed to serve water to the public while completing a definitive GWUDI evaluation under this procedure.

Cautions:

1) **The above evaluation can be described as a partial hydrogeologic assessment of surface water influence. The water system may find that for little additional cost, a full assessment may be completed and submitted in lieu of MPA testing.**

2) **A study of this kind provides a "snapshot" of water quality under <u>initial</u> pumping conditions. Changes in aquifer pressure and gradient may be caused by pumping for**

an extended period, resulting in the eventual migration of surface water to the source over a period of days to weeks. Such longer term effects would not be detected by this type of evaluation.

3) **DEQ may wish to negotiate an agreement with the water system, possibly formalized as a voluntary consent order, to provide public notice as a means of reducing the liability associated with this kind of evaluation. The language in the public notice should report that the water source is undergoing GWUDI evaluation and the risk of surface water pathogens cannot be ruled out until the evaluation is complete.**

4) **If the water system has a shortage of water and must use the new source on an emergency basis, a boil water advisory should be issued. An aggressive plan for completing the GWUDI evaluation should be agreed upon and documented in a voluntary consent order.**

Part 5 -- Treatment Requirements

Regulatory Background: The *Surface Water Treatment Rule (SWTR)* subjects GWUDI sources to the same requirements as surface water. Systems must install treatment sufficient to achieve 99.9% (3-log) removal or inactivation of *Giardia lamblia* cysts. This level of treatment for *Giardia* is considered capable of providing equal or greater inactivation of other microbial contaminants of concern (viruses, *Legionella*). Disinfection and filtration or disinfection alone may be used to meet these performance requirements, depending on source water quality and site-specific conditions. The *SWTR* invokes a "multiple barrier" approach to protecting drinking water from microbial contamination. These barriers consist of:

1) All surface water and GWUDI sources must provide disinfection.
2) All surface and GWUDI water systems must have a qualified operator.
3) Filtration is required, unless certain criteria to avoid filtration can be met. These criteria (items 4-8 below, and presented in more detail in Appendix 4) essentially amount to demonstrating the presence of additional barriers.
4) Source waters must meet turbidity and coliform limits on a continuing basis.
5) An effective watershed control program or wellhead protection program must be in place.
6) The system must not be identified as a source of a waterborne disease outbreak.
7) The system must be in compliance with the coliform MCL.
8) Systems serving more than 10,000 people must comply with the total trihalomethane MCL.

No surface water systems in Idaho have been able to avoid filtration. However, it is widely recognized that ground water sources which are surface water influenced usually produce a higher quality water (less turbid, fewer micro-organisms) than is obtainable from strictly surface bodies such as lakes or streams. This is due to "natural filtration", the process by which suspended particles, including microbes, are physically removed as water moves through aquifer materials en route to the well, infiltration gallery, or spring. Unfortunately, natural filtration is a highly variable process from place to place. In spite of considerable research effort, no reliable means has been found for assigning natural filtration "credit" based on simple tests and observations. For example, attempts to correlate MPA scores with distance from surface water have not yielded results that are linear and consistent enough to use as guidelines. Additionally, the factors which influence natural filtration are subject to constant change as rivers alter their course, add or remove deposits, and receive varying inputs from evolving land use practices. Lakes and springs are also subjected to subtle changes through time. **As a consequence, the effectiveness of natural filtration must be determined on a site-specific basis.**

Rationale for Regulating Systems with GWUDI sources: Idaho DEQ will not attempt to assign log removal credit for natural filtration strictly on the basis of results obtained from hydraulic connection studies, MPA analyses, or other elements of the GWUDI evaluation.

However, DEQ will acknowledge that natural filtration is an inherent trait of subsurface flow systems and is acting in virtually all GWUDI settings. An integrated approach will be used to determine treatment requirements. This approach will recognize the generally higher quality of GWUDI sources, yet fit within the multiple barrier regulatory framework of the *SWTR*. Factors to be considered include:

1) The full array of information assembled during the GWUDI evaluation.
2) Site-specific water quality.
3) Ability of the system to meet at least some of the criteria to avoid filtration.
4) Evaluation of watershed risk factors and potential effectiveness of protection efforts.

A. Assignment of Risk Category

1) Low risk sources:

a. **All MPA scores < 20.**
b No confirmed *Giardia* or *Cryptosporidium* in any sample.
c. Source water turbidity .5 ntu or less in 95% of monthly samples.
d. No total or fecal coliform positive samples from the source.
e. Contributing surface water is amenable to an effective protection program.

2) Medium risk sources:

a. **All MPA scores <20.**
b. No confirmed *Giardia* or *Cryptosporidium* in any sample.
c. Source water turbidity 1.0 ntu or less in 95% of monthly samples.
d. No fecal coliform positive samples from the source.
e. Contributing surface water amenable to an effective protection program.

3) High risk sources exhibit any of the following characteristics:

a. **Any MPA score ≥20**.
b. *Giardia or Cryptosporidium* confirmed in any MPA sample..
c. Source water turbidity > 1.0 ntu in more than 5% of monthly samples OR exhibiting excursions above 2.0 ntu under circumstances that are not exceptional or unusual.
d. Significant sources of microbial contamination within one-year time of travel of wellhead, spring, or infiltration gallery.
e. Contributing surface water not amenable to an effective protection program due to numerous microbial sources, short time of travel, or other factors which cannot be readily controlled or managed.

Some of the attributes used to assign risk are quantitative, while others are subjective and will

require the exercise of judgment. DEQ will attempt to be as flexible as possible, but will emphasize protection of public health in all cases. Water systems seeking a lower risk rating than that determined by DEQ must assume the burden of documenting why such a reduction in risk is justified.

B. Regulatory Approach: All public water systems with GWUDI sources must meet the disinfection requirements of CFR 141.72(a) or (b). These requirements are outlined in Appendix 5. All systems must have a qualified operator, as determined by the state. DEQ will determine disinfection performance criteria for each system.

1) **<u>Low risk sources</u>:** Systems with low risk sources are assumed to be experiencing some level of natural filtration and will be treated as "filtered" sources for regulatory purposes. **No log removal credit will be given unless the system submits a study conducted by a qualified professional which quantifies natural filtration for their source.** Detailed requirements of such studies will be worked out between DEQ and the system, or their consultant, on a case by case basis. One standard requirement will be to document how the system intends to stabilize the physical environment around their source to ensure that natural filtration efficiencies will not be modified by erosional or depositional processes.

a. The system will be required to meet the monitoring and performance criteria for filtered systems (Appendix 5). Natural filtration will be considered an "alternative technology" for the purpose of determining monitoring and performance requirements.

b. The system will be required to implement a wellhead protection program, or a modification thereof for springs or infiltration galleries. The state may conduct an annual site visit for the purpose of assessing the effectiveness of the protection program. In addition, the system must not be identified as the source of waterborne disease outbreak, must comply with the coliform MCL, and must meet the total trihalomethane MCL if it serves more than 10,000 people.

2) **<u>Medium risk sources</u>:** Systems with sources in this category will be treated as filtered sources for regulatory purposes. **No log removal credit will be given unless the system submits a study conducted by a qualified professional which quantifies natural filtration for their source, as described under low risk sources.** Because of increased risk, these systems will be required to enhance the effectiveness of other barriers to microbial contamination.

a. The system must meet the same monitoring and performance criteria as systems with low risk sources.

b. The system must implement a wellhead protection program **plus** a watershed control program for **critical areas** in the watershed. DEQ will delineate critical areas and specify the level and type of controls required through field evaluations carried out in cooperation with the drinking water system. The state will conduct an annual review of the effectiveness of the source protection program efforts. The system must meet all other conditions described in 1(b) for low risk sources.

c. DEQ may require medium risk systems to conduct bacterial or MPA sampling of their source if turbidity performance criteria are exceeded. The system must inform DEQ of any significant changes in land use practices or other circumstances within their source protection area which could reduce the effectiveness of protection efforts.

3) **<u>High risk sources</u> are required to install filtration unless they can meet all of the criteria to avoid it (Appendix 4).** Systems in this risk category may apply for a reduction in risk category by submitting a professionally conducted study which demonstrates that the system can reduce risk by re-constructing their source, enacting measures to improve the quality of the contributing surface waters, or other scientifically defensible strategies acceptable to DEQ. A peer review panel may be convened to consider information submitted for this purpose.

C. Treatment Alternatives

1) **Installation of Filtration:** Any system with a GWUDI source may install filtration in lieu of the approaches described above. Slow sand filtration and various "package plants" may be both affordable and relatively easy to operate and maintain for most small drinking water systems. Having filtration in the treatment train positions the system favorably with respect to future drinking water regulations (see discussion below).

2) **Meeting criteria to avoid filtration:** Any system with a GWUDI source may elect to meet all of the criteria to avoid filtration and conduct the ongoing turbidity and bacterial monitoring that this requires. This is an alternative to being treated as a "filtered" system and meeting the associated monitoring and performance criteria. This alternative has few, if any, apparent advantages, but it is a regulatory option. Of course, systems with high risk sources are required to adopt this course of action if they wish to remain unfiltered.

3) **New Source:** a water system may choose to construct a new source that is not at risk of surface water influence.

D. Future Regulations and Other Considerations

1) The Interim and Final *Enhanced Surface Water Treatment Rules*: At the time the *SWTR* was being developed, the threat of *Cryptosporidium* in drinking water was poorly known. Unlike *Giardia lamblia*, Crypto cannot be readily inactivated by disinfectants. A possible exception is ozone, but this disinfectant is generally not considered appropriate for small drinking water systems because of cost and operational complexity.

The *Interim Enhanced Surface Water Treatment Rule* was promulgated by EPA on December 16, 1998. Among other provisions, this rule requires surface water and GWUDI systems serving > 10000 customers to demonstrate 99% **removal** of Crypto sporidium through their treatment processes. This requirement is almost certain to be extended to smaller systems in the next phase of the enhanced *SWTR.* **Water systems in the low and medium risk categories should be strongly cautioned. Choosing to remain unfiltered and provide the necessary Giardia and virus inactivation through disinfection alone will not meet the Crypto removal requirements of the enhanced rules as presently understood. Unless EPA approves the use of treatment technology that is capable of reliably inactivating this organism, systems using GWUDI sources may be required to filter.**

2) The *Disinfectants/Disinfection By-Products Rule*: This is a phased rule that is linked to the interim and final *ESWTR's*. In briefest terms, it is designed to address the complex trade-offs that occur between a) the inactivation of microbes by disinfection and b) the formation of potentially harmful by-products by reactions between those disinfectants and certain organic chemicals commonly found in surface water. **This rule could affect systems with GWUDI sources that use disinfection alone to achieve the inactivation requirements of the *SWTR*, if these systems happen to have DBP precursors in their source water.** DEQ can provide technical assistance to systems that wish to characterize their sources for these compounds prior to making final treatment choices.

3) Other Considerations: Systems that choose to develop a new source instead of assuming the regulatory burden associated with a GWUDI source should locate that source with the requirements of the future *Ground Water Disinfection Rule* in mind. DEQ can provide information on the status of this rule and the requirements that are likely to be a part of it.

Appendix 1-- GWUDI Field Screening Form

GWUDI FIELD SURVEY

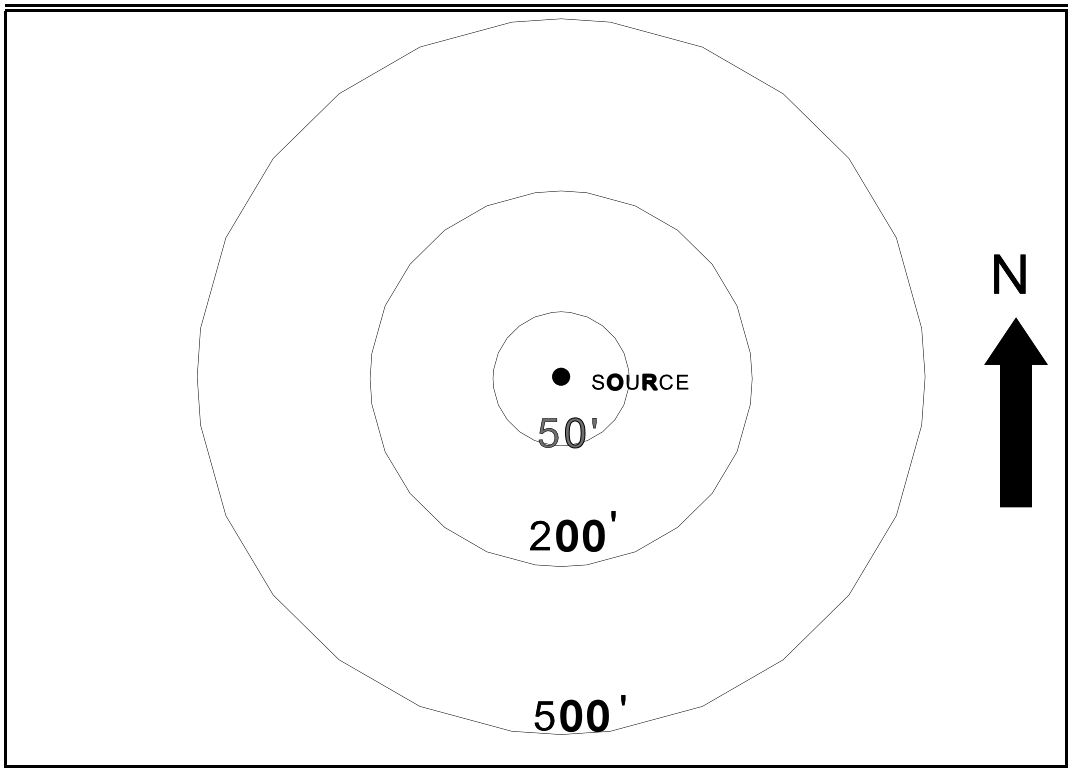
PWS # __|__|__|__|__|__|__

System Name:_____ Source Name_____

Source Type:_____ Maximum Pumping Rate:_____
(spring, well, infiltration gallery)

System Representative:_____ Date:_____

MAP OF SOURCE VICINITY



Please draw in and label all items from the checklist below

Map Checklist:

___ Surface water within 500'

___On-site sewage systems or lagoons within 500'

___Municipal or on-site sewer lines within 200'

___Dairies or livestock feeding operations within 500'

___Stormwater disposal systems within 500'

___Injection Wells within 500'

___Other sources of contamination within 500'

OFFICE USE ONLY

Determination: ☐Ground Water ☐Influenced by Surface Water ☐Ground Water - Further Evaluation

DEQ or HD Representative_____Date_____

EVALUATION COMMENTS ON REVERSE SIDE

Form: SW-303 October 14, 1994

COMMENTS

Water elevations (optional):	Source _____	Source _____	Source _____
	Elevation_____	Elevation_____	Elevation_____
	Date _____	Date _____	Date _____
Pumping Rate:	_____	_____	_____

Note: *Measure the water surface elevation of groundwater under maximum pumping conditions. Record the water elevation at maximum drawdown*

Months with total coliform positive samples in past 3 years: _____

Depth of Source (feet) _____

Minimum Distance to Surface Water (feet) _____

Is disinfection used for this source? ☐ Yes ☐ No

Construction problems allow surface water influence? ☐ Yes ☐ No
(Briefly describe:)

_____

_____

_____

Water quality monitoring required (6 mo. min.)? ☐ Yes ☐ No

Positive hydraulic connection established? ☐ Yes ☐ No ☐ NA

MPA Sample Scores:

DATE	SCORE	DATE	SCORE
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Form: SW-3-3 October 14, 1994

Appendix 2 -- Statistical Analysis

A "recipe" for conducting a statistical analysis of water quality monitoring data, as described in Part 2 (beginning on page 7). These instructions are written in very informal language, and are intended to be useful to a person sitting at a computer which is running the WQHYDRO software package.

APPENDIX 2 -- GWUDI ANALYSIS RECIPE

These instructions are intended to provide a "recipe" for using WQHYDRO to determine whether or not a ground water source is in hydraulic connection with nearby surface water. Pages 10 and 11 of DEQ's GWUDI Evaluation Procedure describe the process to be followed and should be referred to when using these instructions.

General Tips

1. Keep a pad and pen handy when working with WQHYDRO. The software expects the user to keep track of certain information, which will be noted in these instructions. For the first few passes, it will be essential to write down various pieces of information or you may not be able to proceed to the end of the analysis. This includes things like file names, default settings, column numbers within data files, and so on. With experience, much of this will become automatic.

2. The main menu (abbreviated MM in this document) does not require you to press ENTER after making a selection. Once you have passed from the MM to a program module (abbreviated P in this document), you will need to press ENTER after each selection. There is usually no way to back out of a program module once you are in it. You must make a selection at each menu until the procedure is complete. Most menus are structured so that pressing the ENTER key will accept default settings and proceed to the next menu. Pressing ESC or Ctrl-C may cause errors or erratic program behavior which could require you to reboot your machine.

3. This recipe is only useful as a "hands-on" exercise. That is, it makes sense only if you are reading it as you proceed through a WQHYDRO analysis. It is also important to carefully read each screen that appears within a WQHYDRO module. The menus are chained together based on the selections the user makes. Moving too rapidly is a fatal error when learning this software, as it may cause you to make erroneous menu choices and wander off into deep space.

Entering Data

Data will be collected by the public water systems and sent to DEQ in handwritten form. It must then be entered in a format usable by WQHYDRO. A file called "riggins.dat" is being sent along with this document and will be used as the basis for the following examples. It contains considerably more than the six months of data that we would ordinarily have to work with under the GWUDI procedure. Two editors are provided with WQHYDRO. From the main menu screen (MM), select the option that says "call the editor", or, if you prefer the second editor, you may type the letter "Q". Creating a WQHYDRO data file is described on pages 12 and 13 of the WQHYDRO manual. The riggins.dat file can be used as a model. Some hints:

1) When you call an editor, you will be prompted for a file name. Both editors provide a pick list of files that are in the WQHYDRO directory. Unfortunately, these editors are public domain software and have no documentation with them. A little hunting and pecking will usually get you started moving around. Subsequent functions are fairly intuitive. I prefer the Q editor for readability and other features, but both are acceptable. Note: In Q-Edit, hit escape to reach the pull-down menus. In the E-88 editor, use F1 for this purpose. If you are starting a new data file, name it in a manner that will enable you to connect it with the water system, then hit ENTER. You will be presented with a blank

file.

2) Use the first line of the file to include headers for the columns and comments describing the nature of the data. This will enable you to remember what the file contains at any time in the future.

3) Enter a dummy number at the upper left hand corner of the file to signify the number of records. You will need to come back to this number and change it to reflect the actual number of lines of data after it has all been entered. This figure must be edited anytime more data is added.

4) Once the number of records and the column headers have been positioned on the first line, you may hit ENTER and proceed to enter the numbers. Data entry is tedious and must be subjected to QA/QC procedures. Two people can often work together to simplify and streamline the process, but even under the best of circumstances this will be the least appealing and most time consuming part of using the software.

5) You can separate the columns by using the tab key. This will speed the entry process. Be sure to leave at least six spaces per column, so that the null value 999999 can be inserted for missing data. There must always be **at least one space** separating columns.

1- Evaluate variations in the source data (P. 10 of GWUDI Procedure)

Before analysis can begin, WQHYDRO must know where to look for data. In the Main Menu, press ENTER to "reselect input file". You will be prompted for a data file name. Enter "riggins.dat" or whatever data file you are using. You must be aware of the column numbers of the data you intend to analyze.

It may be useful initially to examine a simple plot of the data through time. The following instructions describe how to create a plot of two parameters on the same graph (ground water and surface water temperatures). A number of other options exist and can be discovered by experimenting with the same menu used in this illustration.

Select MM#4-- Time Series. From the "Time Series Plots, Trend Tests, & T.S. Analysis" menu that pops up, select #2 and press ENTER. You will be asked if you wish to strip out null values or leave them in. Select ENTER to leave them in. The next menu is the "Data and Plot Options Menu". This is a very useful menu and you will benefit by experimenting with many of its options. Select #1 to plot the actual data points. If you are working with a very large data set, you may wish to plot a line without the data points so that the resulting graph is less cluttered.

When you press ENTER, the "no" default setting for item #1 toggles to "yes". This entire menu works the same way. Certain features are linked, so that when you select one of them, the other automatically toggles with it.

In our example, we will also choose #5, which allows us to plot more than one time series. When finished with selections from this menu, hit ENTER to leave it and proceed with the analysis. The program will then ask how many time series (up to three) we wish to plot. For GWUDI studies, we are often comparing ground water and surface water series on the same variable, so we choose two time series. The graph may be difficult to read if more than two series are are plotted, but this depends on the range of variation in each variable, and the scale chosen for the y-axis.

After the number of time series has been specified, the next menu will provide options for labeling the horizontal axis. Press ENTER to accept the default.

WQHYDRO will assign the name **time** to the plot file unless you specify otherwise. Throughout the program, this same logic will be repeated. Using default file names helps to avoid filling up your disk with files that you may not need or be able to remember. For now, just press ENTER to accept the default name.

You will then be prompted for the data file columns in which the parameters appear. Ground water temperature appears in column 4, the date in column 9. Surface water (Main Salmon River) temp is in column 6, and the date again in column 9.

Select #5 at the next menu, which will send the plot to your computer screen (VGA).

A series of labeling options will then be presented. Labeling is important in making the plot readable and identifying the name of the water system it represents. You may wish to start out by typing in detailed labels in each field and then back off to simpler schemes when you gain experience. The selections for "Line 1 Legend" and "Line 2 Legend" are critically important in the present example, because we are plotting two time series. WQHYDRO will use a solid line for the first parameter we selected, and a dotted line for the second parameter. Unless we provide legends, such as "Riggins Well #2" and "Main Salmon" for these two lines, it may be difficult or impossible to interpret the plot.

A final menu will provide "Standard/Criteria Line Options". These refer to hydrographic studies, so we will press ENTER to select none of them.

The main menu screen will appear. The plot that we have just created may be viewed by pressing selection #9. If you are satisfied with the graph in regard to labeling, scale on the y-axis, and other features, then the next step would be to convert it to a HP Graphics file and save it to disk for later export to Word Perfect. Alternatively, if you have a printer connected directly to your computer, you could use MM#8 to generate a full-page print of the graph. Hit any key to leave the plot display and return to the main menu.

To export the file to Word Perfect, or simply prepare it for that purpose and store it in the WQHYDRO directory on your hard disk, select "P" from the Main Menu.

You will be asked to enter the prefix of the file to be exported. Remember, **time** is the default in this instance. If you named the file something different, you must now remember it or else refer to your notepad. When you enter the prefix, the program may say "time.plt already exists!". You have the option of pressing ENTER to delete the old file and create a new one of the same name, or you can back out of the routine. It is usually best to delete the existing file and proceed with the creation of a new one. Press ENTER. The program will jump to a text editor and display the contents of **time.plt**. The second line of the file will contain the numbers 486 0 1. Arrow down to that line and change it to read 7550 0 1. Press F1 and then "E" to end the edit and save this file.

You will then be presented with the "Time.out Menu". Use either item 2 or item 3 to get the file to Word Perfect. I find it easier to select 3, which allows you to save the file to your hard disk. You can then import it from within Word Perfect.

It is usually best to go to Word Perfect and perform the import as soon as you have saved this file to disk. As noted above, WQHYDRO will write over the file next time we run this same plot routine. Moving the file to Word Perfect involves the following steps. **Note**: WQHYDRO can only call WP if you are running Word Perfect 5.1. If you have a newer version, it will be necessary to exit WQHYDRO after saving the plot file and start WP independently to perform the import. Although specific keystrokes (or mouse clicks) will differ, the logic of importing the file will be very similar to what follows.

Select "Word Perfect" from the WQHYDRO Main Menu ("W"). In WP, select Alt-F9 for graphics. Select 1 for "figure", 1 for "create", and 1 for "filename". The program will prompt you for the file name. Type "\wqhydro\time.out" and press ENTER. WP will read the file and notify you when it is finished. You may then change the size of the figure, select horizontal or vertical placement, and any other features ordinarily used within WP. Unless you intend to print the file without saving it, you should probably rename the plot file. In keeping with the logic used within WQHYDRO, it may be best to simply print the file and then exit WP without saving. This will avoid filling up your WP directory with plot files that may not be useful and may be hard to recognize without viewing them individually.
As you gain experience with these procedures, you will find that they flow very rapidly and that it is often easier to reproduce a plot than it is to manage a steadily growing directory of plot files. If you adopt this approach, your wqhydro directory will always contain the last version of each default plot file that you created. It will contain numerous data files, which are of course the heart of the analysis and can be used to generate all of the WQHYDRO outputs at any time. However, choose what works best for you.

Exit Word Perfect and return to WQHYDRO.

Next, we will assess the amount of variation occurring in the ground water parameters.

Select MM#2 (Descriptive Statistics). From the Sample Statistics Module select "1" and hit ENTER. From the Computational Options Menu hit ENTER to accept default settings. You will then be prompted for the column to read for the parameter you are analyzing. Enter "4" for Riggins Well #2 temperature.

A column of descriptive statistics will be displayed. Included are the maximum and minimum values. Use these values to calculate the index described at the top of page 9 in the GWUDI procedure. **If this figure exceeds 10%, proceed to the next step**. If the variation is less than 10%, you may proceed to the next ground water parameter (conductivity, etc.) and repeat this process. If all ground water parameters show less than 10% variation by this calculation, the source may be designated ground water and no further analysis is required. If you feel that the parameters have been measured with better than ten percent accuracy, or if there is any other information about the system which indicates that the 10% guideline should be adjusted, then proceed to the next test..

2- Kruskal-Wallis Test for Seasonality (Page 10 of GWUDI Procedure)

Select MM#6 for a boxplot, then P#6 for "Seasonal Boxplot- 1 Station". This procedure will create a boxplot of the data and will also perform the Kruskal-Wallis test. WQHYDRO will create a file called **splot** which you can send to a printer or export to Word Perfect. You will need to remember the name of this file. Each time this procedure is executed, a new splot file will be created and the old one overwritten. If you like, you may choose to name the plot file something different so that it will not be overwritten. Write down the name of the file.

You will be prompted for the column number of the parameter you are plotting. Enter "4" for Riggins Well #2 temperature. You will be prompted for the column number of the date. In riggins.dat, the date is in column 9. At the Seasonal Box Plot Menu, select "1" to aggregate the data by months.

The Kruskal-Wallis test will be performed and the results displayed on the screen. If the test shows a significant difference between at least one monthly mean and the others at 90% or higher significance, you will proceed to the next step at the conclusion of this procedure.

At the "Plot Options Menu" hit ENTER to accept the default settings. At the "Box Plot Options Menu again, hit ENTER to accept the defaults. As you gain experience, you will want to experiment with some of the options in these menus, but for now we'll stick to the recipe.

At the "Destination Menu" select "5" for VGA.

You will be prompted for Title Line #1. Enter "Riggins Well No. 2" and press ENTER. If you wish, you can enter Title Line #2, for example, "Temperature", or you may just press ENTER and leave the second title line blank.

You will then be prompted for a Y-Axis Label. You can enter "Temperature Deg F", or just leave it blank. The program will then display the plotting limits it intends to use and ask you if you wish to change them. Hit ENTER to decline the offer. At the "Standard Criteria Plotting Options" menu, again hit ENTER to select none of the options.

The program will return to the Main Menu. You may immediately view the plot just created by selecting option 9. Hit any key to return to the main menu. If you are satisfied with the plot, you may convert it to a graphics file and store it to disk for subsequent use in Word Perfect, as described in the preceeding section. The default file name for this routine is **splot.**

3- Cross-Correlation Analysis (Page 11 of the GWUDI Procedure)

You should be at this step only if one or more of the ground water parameters exceeded the 10% variation criteria or exhibited a significant Kruskal-Wallis result, or both.

For each parameter, calculate the cross-correlation coefficient between paired ground water and surface water data sets. This is Main Menu Item #4 (Time Series). A Time Series Plots Menu will appear. Select #9 and "Cross Correlation Correlogram- 2 Time Series" and press ENTER. You will be prompted to specify the plot file prefix. **Time** is the default. As with **splot** in the seasonal box plot routine, you may wish to select another name, or just hit ENTER to accept **Time** as the default. At the next menu select Weekly Time Series #4. **This procedure will automatically edit the data file to insert null values and dates for missing data. There is no need to pre-process the file to add null entries.**

At the next menu, press ENTER.

At the Data Thinning Options menu, select number 4. Enter the column to read for the first parameter. **In this procedure, the first parameter should always be the surface water parameter**. The reason for this is that we are hypothesizing that the ground water will lag behind the surface water, not vice-versa. Column 6 is the Main Salmon temperature in riggins.dat. Column 9 is the date.

At the Transformation Options Menu, press ENTER. At the next menu select #1 to substitute ranks for the data.

You will then be asked for the name of the file in which the second parameter is to be found. In this case, simply press ENTER to stay with riggins.dat. Column 4 is the Riggins Well No. 2 Temperature and column 9 is the date.

Repeat the Transformation selections as above.

A table of cross correlation coefficients will be displayed. Scan this table for the highest values. At the top of page 10, the GWUDI procedure specifies that a coefficient greater than .5 and statistically significant at 90% confidence or higher is evidence of hydraulic connection. You may print this table of coefficients using the "printscreen" key, or simply write down the lags at which the coefficient exceeds .5. See comments below for further interpretive tips.

Select item 2 at the bottom of the screen containing the table of coefficients. This will create a file called "lag.dat", a two column file in which the values for the Main Salmon and Riggins Well #2 will appear side by side **but offset by the lag with the highest correlation coefficient** (in this case, eight weeks). This file will later be used to test the correlation for statistical significance. You are given an opportunity to accept the lag with the highest coefficient by pressing ENTER, or to specify a different lag based on your examination of the table of coefficients and your knowledge of the hydrogeology or other factors. In this example, we choose ENTER.

At the Destination Menu select 5-- VGA. Enter Titles when prompted. For example, line 1 could read "Main Salmon vs. Riggins Well #2". Line 2 could specify "Temperature".

The program will return to the main menu, where you may view the plot by selecting item 9. At this point you will probably want to edit the file and save it to disk for later use in reporting, as described for plots in preceeding sections.

From the Main Menu, choose ENTER to reselect the data file. When prompted, enter "lag.dat".

Choose MM #5 (Regression). When the next menu appears, select #1 to read data from the disk. You will be asked if you want the program to read only selected seasons. Press ENTER to tell it no. Enter column 1 for the first parameter and column 2 for the second. A menu titled "Regression Models, Lowess, etc." will appear. Select #6 for nonparametric correlation analysis. You may then select any number of correlation analyses. The Kendall Tau and Spearman Rho are two good choices. The results of the correlation will be displayed and the statistical significance indicated. As indicated above, if the highest lag (>.5) is significant at 90% or higher, this will be taken as a firm indication of hydraulic connection.

Coefficients less than .5 may be worth further evaluation. The .5 guideline is somewhat arbitrary in the sense that it is not based on any statistical convention. If a smaller coefficient at a reasonable lag is tested and found to be significant at the 99% level, it almost certainly says something about the relationship between the ground water and surface water. It is up to the analyst to determine just what that might be. The use of guidelines and statistics will not completely eliminate the need for judgment, nor should it.

At this point, press ENTER a couple of times to return to the main menu.

Conclusions

In the example just completed, it is clear that Riggins Well No. 2 meets all of the criteria for a source that is hydraulically connected to a nearby surface water, as outlined in the GWUDI procedure. Specifically:

1) The ground water temperature exceeded twenty percent variation.

2) The Kruskal-Wallis procedure indicated a significant month to month variation at the 99% level.

3) The correlogram revealed a number of coefficients near or above the .5 guideline. From the file lag.dat, we were able to demonstrate a highly significant (99%) correlation between the well and the river at an eight week lag. Although we didn't test other lags, there is little doubt that some of them would also be significant.

This same sequence of procedures should be performed for each ground water parameter that exceeds 10% variation from the minimum or has a significant Kruskal-Wallis test for month to month variation. When an analysis demonstrates hydraulic connection, we would then ask the water system to proceed to the collection of MPA samples, in accordance with Part III of the GWUDI procedure.

Appendix 3

Laboratories Qualified to Perform MPA Analysis

There is no certification process for recognizing laboratories that are qualified to perform MPA Analysis. The laboratories listed in this Appendix have demonstrated that they have the necessary equipment and have a staff person or persons who have completed an EPA-sponsored MPA training course.

LABORATORIES PERFORMING MICROSCOPIC PARTICULATE ANALYSIS (MPA)

(September 13, 1999)****See Note next Page**

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Lillian M. Stark, PhD (2,3)
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(1) Only accepting samples from within their state.

(2) Also performs Giardia/Cryptosporidium analysis by EPA/ASTM method.

(3) The following analysts have completed the trianing workshop on the MPA at the EPA Region 10 Laboratory. The course was instructed by Stephanie Harris, DVM at the EPA facility. Course completion does not imply certification in this method, nor does it indicate a preference for these laboratories over those that have not taken the course and were involved in the development of the analysis.

**As of October 2004, it is not known if all of the above listed laboratories continue to provide MPA analyses. In Idaho, only Analytical Laboratories remains in this business.

Appendix 4 -- Criteria to Avoid Filtration

The criteria for avoiding filtration are briefly summarized in the following pages. More detail is available in EPA's **Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.** ***Refer to Chapter 3 of that publication.***

Criteria to Avoid Filtration

A. Source Water Quality

1. Coliform limits (prior to disinfection)

a. Fecal coliform ≤20/100 ml in at least 90 percent of samples taken, or total coliform ≤100/100 ml in 90 percent of samples taken.

b. Minimum sampling frequency based on system size as follows:

Population Served	Coliform Samples Per Week
≤500	1
501-3300	2
3301-10,000	3
10,001-25,000	4
≥25,001	5

c. Compliance is based on monitoring during the previous six months.

2. Turbidity limits (prior to disinfection)

a. Turbidity ≤5 ntu

b. Compliance based on measurements taken every four hours.

B. Disinfection Criteria

1. Level of disinfection

a. Disinfection is required and must achieve 99.9% inactivation of *Giardia* cysts and 99.99% inactivation of viruses.

b. Disinfection effectiveness must be demonstrated each day the unfiltered system delivers water to consumers by meeting minimum CxT values specified in the rule. Filtration is required if the system fails to meet this requirement on more than one day in one month during two or more months within a consecutive 12-month period.

2. Point-of-entry disinfection

a. The disinfectant residual in water entering the distribution system cannot be <0.2 mg/l for >4 hours. Any time the residual falls below 0.2 mg/l, the system must notify the state of such occurrence by the end of the next business day.

b. Systems serving >3300 persons must monitor continuously. If the continuous monitoring equipment fails, grab sampling every four hours is allowed for up to five working days for equipment repair.

c. Systems serving ≤3300 people may monitor continuously or take grab samples as follows:

Population Served	Samples per Day
≤500	1
501-1000	2
1001-2500	3
2501-3300	4

d. If the disinfectant residual concentration falls below 0.2 mg/l at any time in a system using grab sample monitoring, the system must continue to take a grab sample every four hours until the disinfectant residual is ≥0.2 mg/l.

3. Distribution system disinfection.

a. The disinfectant residual in the distribution system cannot be undetectable in >5 percent of the samples in a month for any two consecutive months that the system serves water to the public.

b. A system may measure the heterotrophic plate count (HPC) in lieu of disinfectant residual in the distribution system. A sampling site with an HPC level of <500 colonies/ml is considered to have a "detectable" residual for compliance purposes.

c. Disinfectant residual (or HPC) monitoring is required at the same frequency and locations as total coliform sampling under the Total Coliform Rule.

d. The state may allow systems that use both surface water and groundwater sources to take disinfectant residual (or HPC) samples at points other than the total coliform sampling locations if it determines that such points are more representative of disinfected water quality within the distribution system. .

e. If, based on site-specific considerations, the state determines that a system that cannot meet item a., (above) has no means for having a sample transported and analyzed for HPC by a certified laboratory within the requisite time and temperature conditions, but that the system is providing adequate disinfection in the distribution system, this requirement (item a., above) does not apply to that system.

C. Site-Specific Criteria

1. Watershed control-- an effective watershed control program must be established and maintained.

2. On-site inspection

    a. An annual on-site inspection conducted by the state or by a third party approved by the state, is required.

    b. The inspection will determine if the system is maintaining an adequate watershed protection program and reliable disinfection treatment.

3. Absence of outbreaks of waterborne disease

    a. The system cannot have been identified as the source of an outbreak of waterborne disease.

    b. If the system has been identified as the source of an outbreak of waterborne disease, then the system must have been modified sufficiently to prevent another outbreak.

4. Compliance with MCL's

    a. The system must comply with the total coliform MCL.

    b. The system must comply with the total trihalomethane MCL. Currently this applies only to systems serving >10,000 people, but future regulations may apply this requirement to smaller systems.

Appendix 5 -- Monitoring and Performance Criteria for Filtered Systems

Water systems using filtration must demonstrate on a continuing basis that they are achieving the 3-log inactivation of* Giardia *required by the SWTR.

Monitoring and Performance Criteria for Filtered Systems

A. Turbidity Monitoring Requirements

1) Turbidity measurements must be made every four hours by grab-sampling or continuous monitoring. The state may reduce this requirement to once per day for systems using slow sand filtration or other technologies approved by the state. For systems serving fewer than 500 people, this requirement may be reduced to once per day regardless of the type of filtration being used. In both cases, the state must determine that the reduced monitoring frequency is sufficient to indicate effective filtration performance.

2) Turbidity samples must be representative of the system's filtered water.

B. Turbidity Performance Criteria

1) Filtered water turbidity must at no time exceed 5 ntu.

2) Filtered water turbidity must meet the turbidity limits in at least 95% of the measurements taken every month as follows:

Technology	Turbidity Standard ntu	State Allowable Exception
Conventional or Direct Filtration	0.5	1
Slow Sand	1	5
Diatomaceous Earth	1	
Other Technologies	1	5

On a case by case basis, the state may permit turbidity levels above 1 ntu if it determines that the system's total treatment train is achieving the minimum overall disinfection performance criterion at a higher turbidity level.

C. Disinfection Monitoring Requirements

1) Continuous monitoring of disinfectant residual at the point of entry to the distribution system is required.

2) If the continuous monitoring equipment fails, grab-sample monitoring every four hours is allowed for up to five working days for equipment repair.

3) Systems serving ≤3300 people may take grab samples in lieu of continuous monitoring

as follows:

Population Served	Samples per Day
≤500	1
501-1000	2
1001-2500	3
2501-3300	4

Grab samples must be taken at different times during the day.

4) Monitoring of the disinfectant residual concentration in the distribution system is required at the same frequency and locations at which total coliform samples are taken under the Total Coliform Rule. The state may allow systems that use both surface water and groundwater sources to substitute sampling sites that are more representative of the treated surface water supply.

D. Disinfection Performance Criteria

1) Disinfection must ensure that the total treatment process of the system (including filtration) achieves at least a 99.9% removal or inactivation of *Giardia* cysts and a 99.99% inactivation of viruses. The state must specify what level of disinfection is required for each system to meet this criterion.

2) The disinfectant residual concentration in water entering the distribution system must not be <0.2 mg/l for > 4 hours. If at any time the residual falls below 0.2 mg/l, the system is in violation.

3) The system must demonstrate detectable disinfectant residuals or HPC levels of 500 or fewer colonies/ml in at least 95% of the samples from the distribution system each month for any two consecutive months.

Appendix 6 -- Guidelines for Evaluating Sources with Hand Pumps

Sources that are equipped with hand pumps and located less than 200 feet from surface water pose challenges for GWUDI evaluation. In particular, MPA sampling may be impractical.

Appendix 6-- Guidelines for Evaluating Sources with Hand Pumps

Introduction

A number of wells exist that are equipped with hand pumps. These are located primarily in campgrounds and parks operated by State or Federal agencies. They are nearly always transient systems which operate only for a few months during the warm season of the year. The following characteristics make GWUDI analysis difficult for these sources:

1) Only small volumes of water are extracted at any given time, due to the effort required and the small capacity of these pumps.

2) Withdrawing water for purposes of MPA sampling would be extremely laborious, if possible at all, and could create a zone of contribution around the well intake that is not at all representative of normal circumstances.

For these reasons, sources of this type must be evaluated somewhat differently than other wells.

Proposed Guidelines

These guidelines apply only to hand-pumped wells located less than 200 feet from surface water. **A well log or other reliable source of knowledge about the subsurface is required**. Modeling of ground water patterns around wells of this type has shown that the zone of contribution is sensitive to three main influences:

1) The thickness of the water bearing formation or screened interval, whichever is less. **For the following guidelines to apply, this figure must be at least five feet.**

2) The aquifer gradient (slope). The water table is generally viewed as a "muted reflection of surface topography". While exceptions are frequent, it should generally be possible to infer from surface topography whether or not the water table is flat, sloped toward surface water, or sloped away from surface water and toward the well. If there is reason to believe the latter condition prevails, the guidelines in this Appendix do not apply and a formal hydrogeologic investigation will be necessary. A relatively steep gradient toward surface water would ensure that all water drawn by the well would arrive from upgradient and would not be under the direct influence of the nearby lake or stream.

3) An assumption is made that usage will not exceed 1 gallon per minute for 10 hours a day (600 gallons a day) and may often be much less than this.

A professional hydrogeologic study of these sources would be desirable and may be required if the above conditions cannot be established with reasonable certainty. It has been stressed throughout the GWUDI evaluation procedure that the analysis should take into account any and all pertinent information that may be available. This is true in regard to hand-pumped sources as

well. For example, if a well has been implicated as a source of waterborne illness, application of the guidelines in this Appendix would be inappropriate.

A. Sources Developed in Porous Sand and Gravel Aquifer

1. If topography suggests aquifer gradient is toward the lake or stream, the well may be declared ground water if it is fifty feet or more from the surface water body.

2. If topography suggests a flat water table or only a slight gradient from surface water to well, the source may be declared ground water if it is 100 feet or more from the surface water body.

B. Sources Developed in Fractured Rock Flow Systems

1. If topography suggests aquifer gradient is from the well to the lake or stream, the well may be declared ground water if it is one hundred feet or more from the surface water body.

2. If topography suggests a flat water table, or any gradient at all from the surface water to the well, it cannot be reliably inferred that the zone of contribution will be less than 200 feet. The source is either GWUDI, or further study will be required.