

Utah Division of Drinking Water
Protocol for Determining Ground Water Under the Direct Influence of Surface Water

INTRODUCTION

In recent years, we have undertaken a number of initiatives to better protect the public from waterborne disease. One of these initiatives centers upon controlling *Giardia lamblia* and *Cryptosporidium parvum* levels in drinking water delivered to consumers. Both of these organisms are intestinal parasites that often cause severe symptoms in infected individuals.

Giardia lamblia and *Cryptosporidium parvum* breed and multiply in the intestines of infected hosts. The host sheds *Giardia* cysts or *Cryptosporidium* oocysts in feces. The cysts or oocysts find their way into surface waters, such as a lakes or streams. A direct, insufficiently filtered connection may exist between a surface water body and a well or spring. Under these conditions, persons consuming water from one of these wells or springs may become infected with one of these parasites. This protocol attempts to outline the method by which the Utah division of Drinking Water determines which subsurface water sources may possess significant risk of such contamination.

The United States Environmental Protection Agency states, in the Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water, "Only those subsurface sources which are at risk to contamination from *Giardia* cysts will be subject to the requirements of the Surface Water Treatment Rule. ...Subsurface sources which may be at risk to contamination from bacteria and enteric viruses, but which are not at risk from *Giardia* cysts, will be regulated either under the Total Coliform Rule or forthcoming disinfection treatment requirements for ground waters." The Interim Enhanced Surface Water Treatment Rule expands the contaminant list for which this protocol applies to include *Cryptosporidium*.

We have divided this document into five sections, as follows:

1. Introduction This section provides rationale for identifying surface water influence, and provides an overview of the program.
2. Screening This section provides a method to rapidly determine which sources may require detailed analysis to evaluate. This step will usually involve a file search and review of construction plans or source protection plans. Sources that "pass" Screening can be considered ground water. The screening step will sometimes identify remedial measures a system can take to eliminate surface water from their water supply.
3. Intermediate Analysis This section provides means to obtain missing data for screening, and, in some cases, identify where influence may originate. Intermediate Analysis may also provide clues about how much surface water a source receives relative to the ground water component. Intermediate Analysis can provide significant data to supplement Final Analysis in making determinations where unclear conditions prevail. For example, if several microscopic particulate analyses produce indeterminate results (moderate risk), and no analysis clearly indicates surface water influence, Intermediate Analysis may provide the required clarity.
4. Final Analysis For most sources that fail Screening, this step will prove most useful. Final analysis relies primarily upon microscopic particulate analysis, augmented by information gathered during Screening and Intermediate Analysis. You may elect to skip Intermediate Analysis, and proceed directly to Final Analysis without loss in most cases.
5. Remedies This section discusses options systems have if we declare one of their sources to be under the direct influence of surface water.

ACRONYMS

DDW	Utah Division of Drinking Water
GW	ground water
GWUDI	ground water under the direct influence of surface water
MPA	microscopic particulate analysis, consensus method
SS	sanitary survey
SW	surface water
TOT	time of travel

DEFINITIONS

1. Ground water under the direct influence of surface water

Any water beneath the surface of the ground with (1) significant occurrence of insects or other macroorganisms, algae, or large-diameter pathogens such as *Giardia lamblia*, 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 sources in accordance with criteria established by the State. The State determination of direct influence may be based on site-specific measurements of water quality and/or documentation of well construction characteristics and geology with field evaluation.
2. Surface water

DDW uses distance to surface water as a key criteria at the screening level of the GWUDI protocol. The following definition and examples apply:

EPA defines surface water as: "...any water open to the atmosphere and subject to surface runoff..."

DDW interprets this to include the following, as a minimum:

 - all perennial surface waters including lakes, streams, ponds, creeks, rivers, ditches, drains, etc.
 - intermittent surface waters such as ponds, streams, ditches, drains, etc.
 - wastewater treatment lagoons
 - other natural or manmade lagoons, ponds, or reservoirs

For determining distances between the surface water and the groundwater source, measurements should be made from the annual high water level.
3. Source of *Giardia* Contamination

At the screening level, nearby sources of contamination may trigger a more detailed (Intermediate) evaluation. The following is a partial list of *Giardia* contamination to consider:

 - surface water
 - Livestock
 - on-site sewage systems
 - Feedlots
 - injection wells
 - sewage sludge pits

SCREENING

Obvious surface waters. All surface water sources must comply with the SWTR.

Waterborne disease outbreak related to surface water. Systems which have experienced outbreaks of *Giardiasis*, *Cryptosporidiosis*, or other diseases caused by pathogenic organisms strictly associated with surface water are automatically classified as GWUDI sources unless the source has been modified since the outbreak, and testing has shown that the source is no longer directly influenced by surface water. Bacterial and viral outbreaks are not exclusively associated with surface water, so they should not automatically trigger the GWUDI determination, but should trigger at least an Intermediate level analysis.

Springs and infiltration galleries. Due to the more vulnerable nature of these sources, we must complete Intermediate and/or Final level analysis before making a final determination.

Wells.	<200' to SW	EPA guidance indicates that sources less than 200 feet from a surface water are more susceptible and should undergo a more detailed evaluation. This requires Intermediate and/or Final level analysis prior to making a determination.
	<100' deep	EPA guidance and DDW experience indicates these sources are more vulnerable than deeper wells; therefore, staff should review these sources even if they are <200' from surface water to determine whether to conduct an Intermediate level analysis. Make depth measurements from the ground surface to the first screened or perforated interval.
	Problems	<p>If staff are aware of previous problems with any source, regardless of location, which could indicate surface water contamination, we will conduct an intermediate analysis. Such problems could include, but are not limited to, the following:</p> <ul style="list-style-type: none"> - sanitary defects in source construction - bacterial and virus outbreaks not necessarily related to surface water contamination - coliform occurrence of the source (Staff will judge relevance of these occurrences) - <i>Giardia</i> sources nearby (see listing) - elevated or fluctuating turbidity - significant changes in flow rate

Due to general nature of the criteria above, some sources greater than 200 feet from surface water may still be at risk of *Giardia* contamination due to high aquifer porosity and flow rates. At their discretion, field staff may perform further evaluation of these sources using any of the steps outlined later in this document.

Hydrogeologic evaluation. At their discretion, the system may choose to document that the source is not subject to surface water influence due to confining layers, hydraulic barriers, gradients, etc. DDW may use any information the System elects to submit, including Drinking Water Source Protection Plans. DDS may also perform its' own analysis. In either case, a hydrogeologist must prepare the report. The hydrogeologic evaluation may prove sufficient for final determination of source status, or may be supplemented with other tests. In cases where MPA results disagree with hydrogeologic analysis, the MPA results will receive preference.

DECISION CRITERIA (use the form on the following page):

1.	Screening score less than 40	GW
2.	Screening score near or equal to 40, or screening incomplete	Intermediate Analysis
3.	Screening score much greater than 40	Final analysis

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF DRINKING WATER

**SUBSURFACE WATER SOURCE ASSESSMENT FOR SURFACE WATER INFLUENCE
SCREENING CRITERIA**

SYSTEM INFORMATION: NAME _____
 NUMBER _____ COUNTY _____ CLASSIFICATION _____

SOURCE INFORMATION: NAME _____
 TOTAL INDEX POINTS _____ CLASSIFICATION _____

CLASSIFICATION CRITERIA: INDEX POINTS:

- A. TYPE OF SUBSURFACE WATER SOURCE (CIRCLE ONE)
 - DEEP WELL (PROTECTED AQUIFER)..... 0
 - SHALLOW WELL (UNPROTECTED AQUIFER)..... 5
 - SPRING OR TUNNEL..... 5
 - INFILTRATION GALLERY..... 10

- B. MICROBIOLOGICAL HISTORY (CIRCLE ALL THAT APPLY)
 - SUSPECTED/CONFIRMED SURFACE WATER RELATED PATHOGENIC ORGANISM
OUTBREAK WITH CURRENT SYSTEM CONFIGURATION..... 50
 - TOTAL COLIFORM ACUTE MCL VIOLATIONS OVER LAST THREE YEARS..... 30
 - TOTAL COLIFORM MONTHLY MCL VIOLATIONS LAST THREE YEARS (CIRCLE ONE)
 - ONE MONTH..... 5
 - TWO MONTHS..... 10
 - THREE MONTHS..... 20
 - VERIFIED COMPLAINTES ABOUT TURBIDITY OR SUSPECTED WATERBORNE DISEASE 10

- C. HYDROGEOLOGICAL FEATURES (CIRCLE ALL THAT APPLY)
 - DISTANCE FROM SURFACE WATER SOURCE TO CASING/COLLECTOR LATERAL
OVER 200 FEET..... 0
 - 100 TO 200 FEET..... 5
 - LESS THAN 100 FEET..... 10
 - INTAKE LOCATED ON FLOOD PLAIN AT APPROXIMATE ALTITUDE OF STREAM 20
 - SURFACE RUNOFF DRAINS TOWARD INTAKE..... 15
 - SUPPLY AQUIFER IS EXPOSED, AND IS COARSE ALLUVIAL, CAVERNOUS OR
FRACTURED..... 15

- D. WATER INTAKE STRUCTURE (CIRCLE ALL THAT APPLY)
 - POORLY CONSTRUCTED COLLECTION CHAMBER OR UNCASSED/POORLY GROUTED
WELL..... 15
 - POOR SANIARY SEAL, SEAL WITH UNACCEPTABLE MATERIAL..... 15
 - INTAKE OPEN TO ATMOSPHERE..... 15
 - LEAKES IN SOURCE COLLECTOR ALLOWING ENTRY OF SURFACE WATER..... 15

TOTAL INDEX POINTS _____

COMMENTS: _____

DATE: _____ ANALYST: _____

INTERMEDIATE ANALYSIS

DDW may choose to proceed directly to Final Analysis prior to implementing any part of the Intermediate Analysis.

Sanitary Survey: A recent sanitary survey or one conducted within the past 2 years should be used to:

- identify obvious surface water influence, i.e. whether construction of the source allows surface water intrusion etc.
- identify potential *Giardia* sources in the vicinity
- verify distances to surface water and *Giardia* sources.
- Gather information about relevant water quality parameters and monitoring locations.

Water Quality Parameter Monitoring: The following list includes parameters THAT DDW may monitor. Ideally, DDW will monitor for one year to establish seasonal variations, but may monitor for shorter periods.

Total/fecal coliforms:

- Collect samples once per week.
- Collect samples from the source prior to any treatment.
- Use only State-certified laboratories coliform analysis.
- Report results as densities rather than present or absent.

Temperature:

- Take measurements daily; minimum of 4 out of 7 days per week.
- Monitor the source and nearest surface water (no more than 1,000 feet distant)
- A mercury thermometer or electric probe may be used.
- Use an instrument capable of reading 0.5° F or C increments.
- Use the same instrument for all readings.

Conductivity:

- Take measurements once per week minimum.
- Monitor the source and nearest surface water (nor more than 1,000 feet distant)
- Calibrate the instrument per manufacturers recommendations, or submit to a State-certified laboratory.

Turbidity:

- Take measurements daily; minimum of 4 out of 7 days per week.
- Monitor the source and nearest surface water (no more than 1,000 feet distant)
- Use an instrument capable of reading 0.1 NTU increments.
- Standardize and calibrate instrument per manufacturer's recommendations.

Specific ions:

Ions known to differ in concentration between the surface water ground water.
DDW will determine applicability of these analyses.
Establish frequency, accuracy and calibration requirements on a case by case basis.

Plot data to show variations between source water and surface water characteristics over the sampling period. For specific ions, use a "radar plot" showing both surface and ground water test results. Until development of a more refined method, inspect graphs for rapid changes and obvious similarities or differences between the surface water and groundwater source data.

DECISION CRITERIA:

1.	Survey shows SW influence	GWUDI
2.	Survey ok; no other problems; monitoring shows potential influence	Final Analysis
3.	Survey ok; other problems exist; monitoring shows potential influence	Final Analysis
4.	Survey ok; other problems exist; monitoring okay	GW
5.	Survey ok; no problems; monitoring okay	GW

FINAL ANALYSIS

Use the following criteria, along with all other information generated to this point, to render the GWUDI determination.

MPA results form the most conclusive evidence for determining GWUDI. If MPA results conflict with hydrogeologic analysis or water quality parameter monitoring results, use the MPA results. However, systems with coliform contamination which test negative for GWUDI under MPA must disinfect. The MPA, likewise, cannot be used to overrule the 5 NTU ground water turbidity standard.

Certain organisms and debris occur primarily in surface water. Rarely, if ever, will you find these organisms in groundwater. Examples include *Giardia*, coccidia (the family which includes *Cryptosporidium*), diatoms, rotifers, insect parts, and chlorophyll containing algae. For that reason, the EPA definition states that the "significant occurrence of insects or other macroorganisms, algae, or large-diameter pathogens such as *Giardia lamblia*" may be used to show a groundwater is directly influenced by surface water". MPA involves filtering 500 to 1000 gallons of water to collect and concentrate organisms and debris. MPA is the best tool available for determining GWUDI. Consider MPA results conclusive.

EPA published a consensus method for collecting, analyzing and interpreting MPA results (EPA, 1992). All MPA samples used in the Final analysis must adhere to this protocol. Collect all filter samples prior to disinfection and prior to blending with other waters. Also, collect the sample as close to the source as possible since the particulates may settle out in reservoirs, or defects in the system may contribute particulates. Both situations could result in incorrect source classification. Submit analyses thus collected to the Utah Division of Laboratory Services.

If you cannot collect the MPA from the source prior to blending with other waters, you must exercise care in interpreting the results. If the blend includes surface water, you will likely see large numbers of algae in the filter sample. If the blend includes ground water, you will see dilution of the sample, and may not be able to clearly identify which source contributes the indicator species.

In the consensus method, EPA has developed a procedure to quantify and interpret MPA results using "risk factors". Risk factors depend on the concentration of the organism and the significance of that type of organism, e.g. The presence of even a few *Giardia* is more significant than high numbers of algae. The risk factors were assigned based on the cumulative experience and judgement of the microbiologists who developed the consensus method (see pp. 30 & 31 of the Method). Based on the sum of the relative risk factors for a sample, the consensus method ranks the risk of surface water contamination as high, moderate, or low. However, the method does not indicate at what relative risk a source should be classified as GWUDI. **DDW considers a source to be GWUDI if any MPA sample has a relative risk score of ≥ 20 .**

DECISION CRITERIA:

1.	MPA score < 10 (low risk)(minimum 3 analyses preferred)	GW
2.	MPA score between 10 and 19 (moderate risk)	Repeat analysis; Perform Intermediate Analysis if not already done*
3.	MPA score >20 (high risk)	GWUDI

* Some cases may require numerous MPAs and extensive Intermediate Analysis. This will usually occur if the MPA results consistently show moderate risk of surface water influence, or some show moderate risk while others show low risk. Clearly, the presence of indicator species sufficient to rate the risk as moderate will occur only if the source has a defect somewhere. In the absence of compelling evidence to the contrary, these sources should receive classification as GWUDI after the third round of MPA sampling.

REMEDIES

Surface water influence is a serious concern. Therefore, if we declare your source GWUDI, you must act quickly to prevent potential waterborne disease. You cannot predict when an infected animal may traverse your watershed. Even though you may have never observed waterborne illness in your community, one sick animal could change that in a big way.

Upon receiving a Notice of Finding of Surface Water Influence, you must **IMMEDIATELY** begin disinfecting sufficiently to inactivate 99.9 per cent of the *Giardia* your water may contain. We can provide assistance in determining the required disinfectant dose. You must provide us with a report by the tenth of the month detailing the degree of inactivation provided each day of the preceding month. Again, we will assist you with this. Your chemical monitoring schedule for this source will also change. Alternatively, you can turn the source out of the system.

By law, within eighteen months of the date of notification of a finding of surface water influence, you must have fully remedied the problem. The remedy must remove the threat of *Giardia* and/or *Cryptosporidium* contamination, and must take one of three forms:

1.	Permanently abandon the source as a part of your drinking water supply.
2.	Locate where the surface water intrusion occurs, and eliminate it from the source.
3.	Install and operate conventional complete treatment facilities, or their equivalent. Conventional complete treatment includes coagulation, flocculation, sedimentation, filtration and disinfection.

Whichever option you choose, consult with us. A number of issues exist, including plan review, which you will need to consider as you attempt to correct a surface water influence condition.

REFERENCES:

EPA 1989. Federal Register. 54 FR 124, pp. 27486-27541. June 29, 1989.

EPA 1991. Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources. U.S. Environmental Protection Agency, Office of Drinking Water. March 1991.

EPA 1992. Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA). U.S. Environmental Protection Agency. EPA 910/9-92-029. October 1992

Rapacz, 1991. Rapacz, M.V., and Stevens, H.C. Groundwater To filter or Not to Filter: That is the Question. Massachusetts Department of Environmental Protection. November 1991.

ACKNOWLEDGEMENT: The organization of much of this document was adapted from a February, 1993 draft document prepared by the Idaho Department of Environmental Quality. The screening criteria form was adapted from a procedure developed by USEPA region VIII.