NEW YORK STATE DEPARTMENT OF HEALTH OFFICE OF PUBLIC HEALTH CENTER FOR ENVIRONMENTAL HEALTH TECHNICAL REFERENCE	**ITEM NO:** WSP 42 TR **DATE:** 08/06/07 **SUBJECT:** Identification of Ground Water Sources Under the Direct Influence of Surface Water Page 1 of 18

REGULATORY BACKGROUND

The Surface Water Treatment Rule (SWTR), requirements in Subpart 5-1, Section 5-1.30, of the Sanitary Code also apply to public water systems that use a ground water source determined to be under the direct influence of surface water. Section 5-1.1 (a.a.) of Subpart 5-1 states the definition of ground water directly under the influence of surface water (GWUDI) as: “any water beneath the surface of the ground which exhibits significant and rapid shifts in water characteristics such as turbidity, temperature, conductivity or pH which closely correlates to climatological or surface water conditions and/or which contains macroorganisms, algae, large diameter (three microns or greater) pathogens or insect parts of a surface water origin.”

The purpose of regulating ground water sources under the direct influence of surface water in the SWTR is to protect against contamination from large-diameter pathogens associated with surface waters. Ground water sources determined to be under the direct influence of surface water must be filtered or meet filtration avoidance criteria as contained in Section 5-1.30 of the State Sanitary Code. In some cases, it will be easier to replace the source with a properly designed and constructed well or spring, or possibly to modify the source to eliminate the direct influence of surface water. Public water systems with ground water sources under the direct influence of surface water are also subject to more stringent monitoring requirements for total coliform, turbidity, and entry point disinfection residual. The types of ground water sources potentially regulated under the SWTR include: dug wells, springs, infiltration galleries, shallow or improperly constructed wells, or other collectors in subsurface aquifers near surface waters.

The local health department (LHD) is responsible for identifying which public water sources are subject to the SWTR. However, it is the responsibility of the water supplier to provide the LHD the information needed to make this determination. The LHD is also responsible for recording and reporting the criteria used and the results of determinations. Ultimately, this information will be recorded in a SDWIS add-on, or very similar format.

All ground water sources used to supply public water systems must be evaluated for evidence of ground water under the direct influence of surface water GWUDI. This evaluation will focus on the likelihood that the ground water source could be contaminated with large-diameter pathogens, such as Giardia lamblia and Cryptosporidium, through a hydraulic connection with surface water. If a drinking water source has been identified as GWUDI, the source must meet the criteria established under the SWTR, as dictated in Section 5-1.30 of the State Sanitary Code.

OVERVIEW

Information gathered during Sanitary Surveys, as outlined in Technical Reference PWS 180, will be important in making GWUDI determinations. In addition, information such as compliance monitoring data, topographic maps, geological reports, well logs, and data on potential contaminant source(s) gathered during vulnerability determinations (Technical Reference PWS. 72), the development of source water assessments, and/or during the implementation of watershed rules and regulations will be useful.

A two phased methodology should be used to determine whether or not a ground water source is under the direct influence of surface water.

- The Source Screening Phase is first used to separate those sources that are clearly not subject to surface water influences from those sources in need of further evaluation.
- The Detailed Evaluation Phase applies to sources identified to be tested to evaluate their degree of hydraulic connection with surface water.

There are three components of the Detailed Evaluation Phase: Hydrogeologic Assessment, Water Quality Assessment, and Microscopic Particulate Analysis (MPA). It is the water suppliers' option whether to begin the hydrogeologic or the water quality assessment portion. Both of these assessments are capable of providing the information required to determine that no surface water influence is present. However, if the results of a hydrogeologic assessment are inconclusive, a water quality assessment should be performed to complete the Detailed Evaluation. MPAs should be conducted during times which represent worst-case GWUDI conditions, as indicated by the water quality assessment.

Source Screening Phase

The Source Screening Phase should be used to separate those sources that are clearly not subject to surface water influences from those sources in need of further evaluation. A schematic of the screening procedure is presented on Figure 1, and the overall Detailed Evaluation Phase Methodology is presented on Figure 2. Box 1 (on Figure 1) includes criteria that will immediately select a ground water source for further review. These source water criteria include historical indication of GWUDI such as: a waterborne disease outbreak, chemical contamination that is thought to have originated from surface water (e.g., pesticides), and rapid fluctuations in source output, well water level, water quality (e.g., turbidity or color), and/or chlorine demand, particularly when associated with runoff events. These criteria also include the following collection device types and characteristics: springs, dug wells, infiltration galleries, cribs, shallow horizontal underground collectors, drilled wells in carbonate aquifers, and wells within 200 feet of surface water in fractured bedrock with 100 feet or less of casing. If none of these criteria are met, then the screening process continues in Box 2.

The criteria in Box 2 asks if the source is located within 200 feet of a surface water, and/or if the well has 50 feet or less of casing. When both criteria are met, the source is selected for further review. If neither of these conditions is met, the source is designated as not being under the direct influence of surface water.

When only one of the criteria in Box 2 is met, the next step in the GWUDI determination is dependent on whether or not the water source is currently disinfected. Undisinfected wells that have met the criteria for a disinfection waiver and have an adequate coliform monitoring history (typically five years of quarterly monitoring) are to be designated as not being under the direct influence of surface water. Disinfected wells have the option of either performing one year of monthly raw water coliform monitoring or moving directly into the Detailed Evaluation Phase. Any raw water sample that is E. coli positive would require the system to perform a Detailed Evaluation. Conversely, once one year of satisfactory monthly raw water samples are obtained, the source can be designated as not being under the direct influence of surface water.

Figure 1: Source Screening Phase Methodology

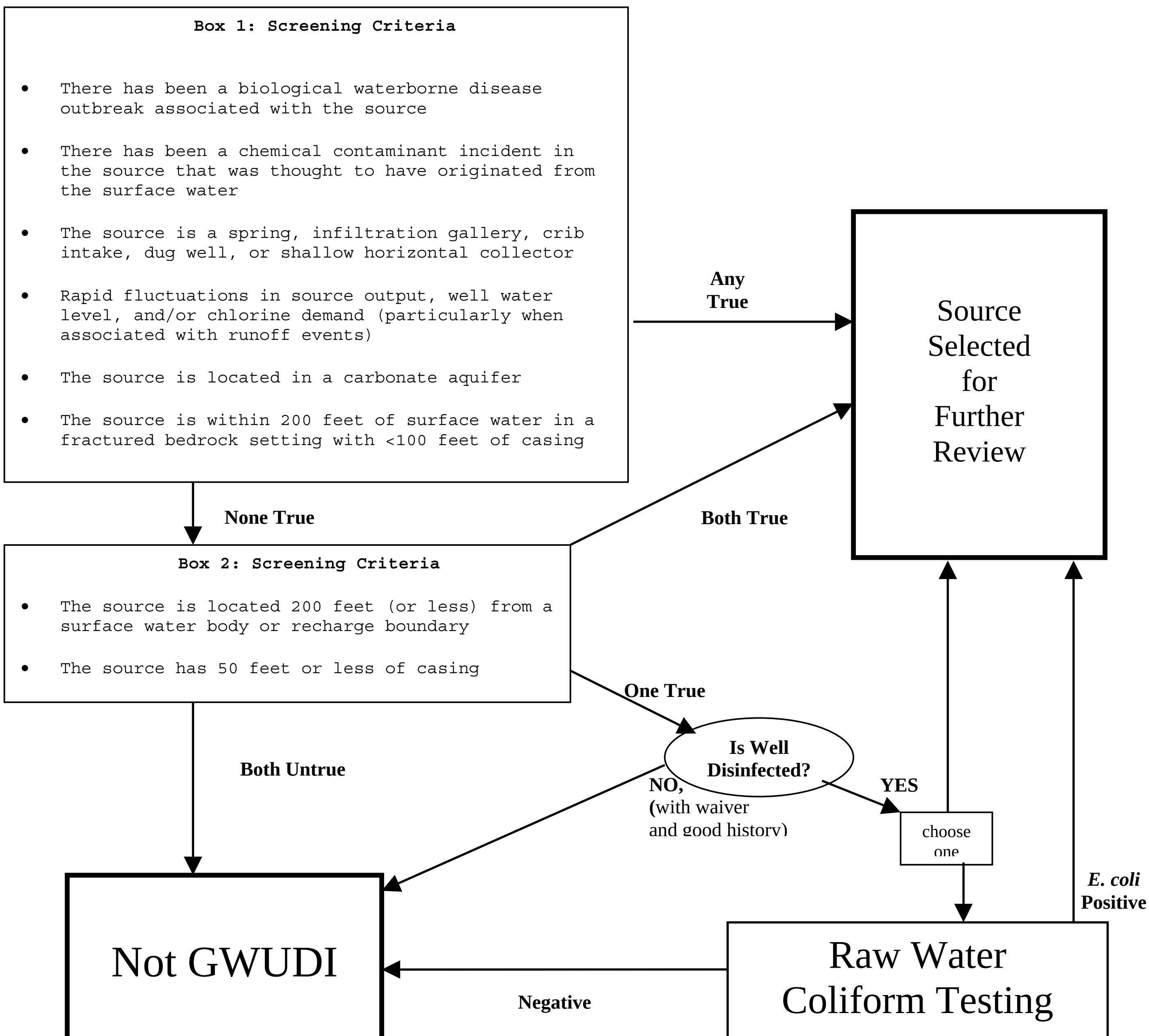

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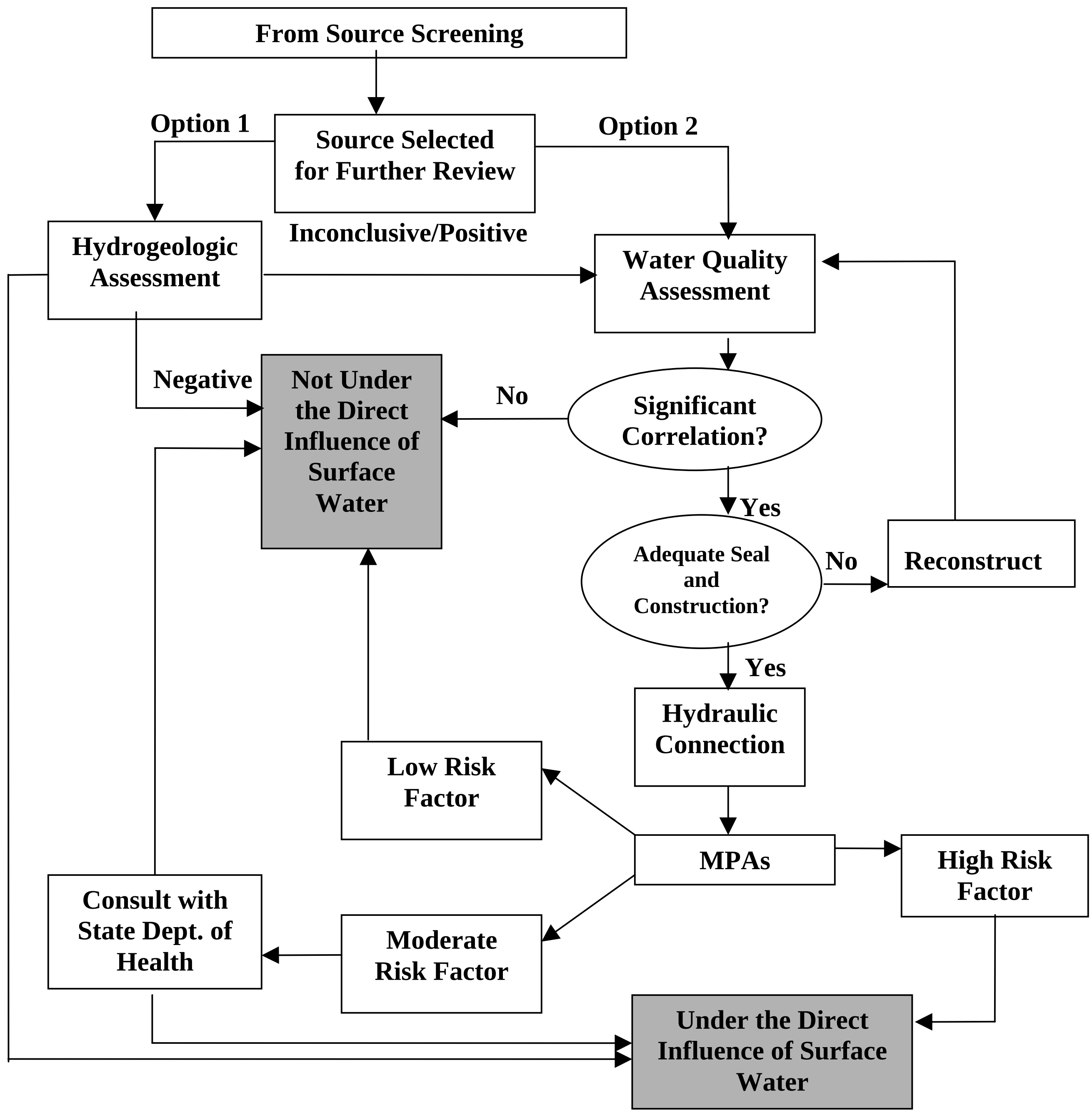
Figure 2: Detailed Evaluation Phase Methodology



Detailed Evaluation Phase

Once a ground water source has been selected for further review, as a result of the Source Screening Methodology, the procedure described below should be closely followed. The protocol’s steps are presented in the flowchart in Figure 2. The water supplier is responsible for carrying out the studies required by the protocol. The water system has two evaluation options. The first option requires a detailed hydrogeologic assessment that addresses the potential of surface water to move quickly to the subsurface collection device. The second option entails an evaluation of water quality parameters daily over a 12-month period. However, at any time during an evaluation the water system’s operator can halt an ongoing evaluation by accepting a GWUDI designation and making the appropriate modifications to bring the system into compliance with the SWTR.

Hydrogeologic Assessment

If the first option, the Hydrogeologic Assessment, is selected, and results of the assessment indicate that the aquifer supplying the source is not in hydraulic connection with surface water, no further analysis will be required. However, if the LHD determines that the Hydrogeologic Assessment does not contain enough information to establish whether there is a hydraulic connection between surface water and the source water collection device, the water supplier should collect additional hydrogeologic information or proceed with a water quality assessment.

The Hydrogeologic Assessment option will be more effective when much of the data already exists, and the water suppler has access to a hydrogeologist to perform the work. The Hydrogeologic Assessment option is preferred when evaluating a new source. Data that should be available include: complete and accurate well logs, pump test data, existing monitoring wells or piezometers, and the availability of other related local hydrogeologic studies. It is recommended that the water supplier have their hydrogeologist meet with LHD officials before beginning work. The Hydrogeologic Assessment should be designed to provide the following information:

<u>Well Construction Details</u>

Provide a well log and construction diagram

Does the well and installation methods meet current standards?

<u>Aquifer Characteristics</u>

Aquifer geometry and texture, including the unsaturated zone
Saturated thickness
Hydraulic Conductivity
Transmissivity

<u>Ground Water Flow Characteristics, Pre-Pumping and Pumping</u>

Water table/potentiometric surface elevations
Ground water flow directions
Ground water flow velocity
Zone of contribution/influence of the well

<u>Degree of Hydraulic Connection between Surface Water Source and Aquifer</u>

Geology underlying surface water body
Characterization of bottom sediments in surface water body
Determination of vertical hydraulic gradient in surface water body
Hydraulic relationship between the surface water body and the well
Calculations of travel times between the surface water body and the well

<u>Seasonal Variations in Hydrogeologic Characteristics</u>

What are the likely changes in flow patterns during seasonal fluctuations or periods of drought?

The Hydrogeologic Assessment should include, as a minimum, geologic logs and construction details for the pumping well and any observation wells or piezometers; aquifer pumping test(s); a survey of the elevations of water level monitoring measuring points; water level monitoring of ground water and surface sources; and preparation of detailed maps of water table/potentiometric surface and geologic cross-sections. It may be necessary to install observation/monitoring wells or piezometers if these do not already exist.

In addition to requiring an assessment of hydrogeologic factors, the Hydrogeologic Assessment should include a description and review of the collection device (i.e., type, age) and a summary of any current or historical sanitary conditions. Any information available from previous sanitary surveys or field investigations should be included in the assessment, as appropriate. Attachment 1 gives an example of a sanitary and field survey report form that can be used for information gathering.

To be definitive, a Hydrogeologic Assessment needs to include an interpretation of the information collected with respect to the potential for a hydraulic connection between a surface water body and the aquifer. The LHD has the discretion to decide whether the Hydrogeologic Assessment is sufficiently complete to warrant the conclusions. If the Hydrogeologic Assessment indicates a potential hydraulic connection, the water system should be required to initiate a water quality assessment.

Water Quality Assessment

In the Water Quality Assessment portion of the Detailed Evaluation Phase, the collection of daily conductivity and temperature data will be an important step in evaluating the extent of hydraulic connection and communication and estimating time of travel between the surface water and the subsurface collection device. This water quality information will be collected to establish whether there is hydraulic communication between the ground water source and the nearby surface water body. Furthermore, these data will also help determine if the time of travel from the surface water body to the ground water source is short enough to allow for the transport of Giardia lamblia cysts or Cryptosporidium oocysts to the ground water source.

A water supplier may choose to proceed directly to this step in the determination process, rather than carry out a hydrogeological assessment. In addition, those ground water sources for which Hydrogeologic Assessments have been completed, and the sources have been determined to have the potential for hydraulic connection, should next be evaluated with a water quality assessment.

The rationale for performing a water quality assessment is, with some exceptions, ground water that is not under the direct influence of surface water generally exhibits only minor variations in physical and chemical parameters. Conversely, surface waters, undergo more substantial variations as a result of the season, or rainfall or snowmelt events. If the

ground water is hydraulically connected to the surface water, changes in the ground water's physical and chemical qualities should reflect surface water characteristics. For example, even a single ground water temperature reading which is outside the range typical for ground water provides a strong indication that GWUDI conditions may exist.
The extent of hydraulic connection and time of travel from surface water to the underground collection device should be evaluated under the guidance of the LHD using one year of daily temperature and conductivity data collected by the water supplier. GWUDI determinations will be made by the LHD based on the presence/absence of similar seasonal fluctuations between the surface and ground waters. Where location and other logistical factors make daily measurements difficult, weekly measurements will usually suffice to detect large peaks and lag times. However, since high surface water levels during storms and floods can enhance or create GWUDI conditions (particularly when preceded by a drought), special efforts should be taken to collect daily source water measurements around periods of heavy precipitation and snow melt. It is very important to stress that all sampling plans stress the safety of sampling personnel, and no samples should ever be taken under unsafe conditions.

Temperature and conductivity measurements should be made at the ground water source and in the nearby surface water body. The sampling location for sampling for a ground water source should only characterize one underground collector and should not be influenced by air temperatures. In addition to safety concerns, surface water sampling locations should be selected that adequately characterize the water where the influence is suspected of occurring. For example, using a bridge to collect data from middle of a stream upstream of a well would be adequate for most cases, but collecting data from the surface of a shallow bay of deep lake would not likely be very useful. Precipitation should also be recorded, preferably using a gauge set up at the ground water source location. The biggest concerns for temperature data are the measuring device's precision and accuracy, and that temperature readings adequately reflect groundwater conditions. These concerns are best addressed by using high quality equipment, running the water long enough for the temperature to stabilize, collecting data at individual wells or spring collectors to minimize the influence of air temperature or source water blending, and the proper placement of remote sensors. Knowing the depth of the ground water collection point to assure that the depth is below the neutral zone for temperature variations is also important. The neutral zone is the depth below which there is no significant seasonal variation in ground water temperature due to the influence of air temperature. The neutral zone concept is not a concern when comparing conductivity data.

Temperature fluctuations in spring water may not necessarily indicate a surface water influence. This is because springs are the result of ground water discharge at the land surface. Therefore, spring water is above the neutral zone, and its temperature can be influenced by air temperature and heat from the sun. If spring water is moving slowly out of rock (e.g., one to five gallons per minute or less per square foot of production area), the water temperature may be influenced by variations in ground surface temperatures. When a determination is being made for a spring with wide temperature fluctuations, the LHD should weigh more heavily the conductivity and hydrogeologic information collected. In addition, spring collectors are often not located near a surface water. Regardless, rapid fluctuations in water quality can indicate a surface water influence associated with direct runoff and/or a construction flaw.

Conductivity, or specific conductance, is the measure of water's ability to carry an electric current. This ability depends on the presence of ions in the water and the water's temperature. Ground water is generally higher in conductivity than surface water, because ground water dissolves minerals from substrates through which it moves. Generally, the longer the contact time between ground water and its aquifer, the higher the conductivity. However, there are exceptions to this generalization (e.g., surface water bodies receiving large amounts of ground water recharge, surface water bodies contaminated with salts, clays, metals, or polar organics).
Conductivity data are especially important in making determinations for springs (and other situations where large seasonal fluctuations in temperature are expected). Overall, conductivity tends to be a more sensitive parameter than temperature and more difficult to interpret.

Water quality assessment data should also be analyzed to estimate the time of travel from the surface water body to the ground water source. Time lags between peaks, inflection points, and other features of the surface water and ground water temperature and conductivity graphs should be measured to derive an estimate of average time of travel. It should be noted that the accuracy of this method is best for short times of travel. Also, all else being equal, cold water moves through the ground more slowly than warmer water.

Once water quality assessment data are collected and analyzed, a determination must be made whether there is a significant hydraulic connection between the surface water body and the ground water source. A significant hydraulic connection exists when water movement from the surface water body to the ground water source allows for the transport of Giardia lamblia cysts and Cryptosporidium oocysts. Dilution and time of travel estimates should be considered when determining the significance of the hydraulic connection. If the time of travel estimate for the source is less than 100 days, a significant hydraulic connection should be assumed and the supplier should proceed to the next step, MPA.

If a source appears to be in significant hydraulic connection based on water quality data, a detailed evaluation of well construction (or source development) should follow. It is possible that measured variability in source water quality could be the result of surface water intrusion due to a construction flaw, rather than a hydrogeologic connection. Rainfall data collected as part of the water quality assessment will be useful for this evaluation. If construction flaws are found, the supplier must decide whether to repair or reconstruct the well prior to restarting the GWUDI determination process.

Unfortunately, temperature and conductivity data may not be very useful in making GWUDI determinations for seasonally operated drinking water sources located near lakes and reservoirs that thermally stratify. This is because water in the lower strata of the surface water does not show wide seasonal temperature changes, particularly during the summer months. Conductivity data can be of limited value when there are small differences in conductivity level between surface and ground waters, such as near seepage lakes with no inflow tributaries. In these cases, monthly raw water coliform monitoring should be performed during the operating season. If E. coli is found, MPA should be performed during the next July or August after the positive sample date. It is important to note that temperature and conductivity data are still useful in these settings to detect the influence of direct runoff entering the subsurface collector due to damage and/or construction flaws.

Microscopic Particulate Analysis (MPA)

When the hydrogeological conditions and/or water quality assessment results suggest that the ground water source is probably under the direct influence of surface water, then MPA shall be conducted. Information collected as part of the characterization of hydraulic communication and time of travel will be very important in determining the correct timing of MPA sample collection. MPA samples shall be collected at least twice, and the dates of sampling should represent worst case conditions, when maximum potential recharge from the nearby surface water is taking place (usually during extremely wet or dry periods).

It is important that geologic conditions, hydraulic communication, and MPA results be used together to make the final determination whether a ground water source is under the direct influence of surface water. MPA alone is not a reliable approach to making GWUDI determination, because improperly timed samples can yield meaningless results, and there are numerous difficulties associated with MPA methodologies.

Basically, the use of MPA in a GWUDI determination involves the careful enumeration of microscopic organisms (and other particulates) in the raw drinking water. These data are then systematically evaluated to determine if the particles found are more indicative of surface or ground water. Some of the organisms which are considered to be characteristic of surface water include: Giardia, Cryptosporidium, algae, diatoms, and rotifers.

All MPA methodologies used in GWUDI determinations must be approved by the Health Department. Overall, MPA analyses are difficult to perform, and their results are highly dependent on the skill of the microscopist performing the work. In addition, organisms are often difficult to identify due to damage suffered during the concentration process, thereby reducing accuracy. Consequently it is advisable that representative surface water grab samples also be collected, because they can help in making difficult identifications. It is for these reasons, along with the difficulty in identifying suitable sampling times, that MPA results should not be used alone to make GWUDI determinations.

One acceptable method for collecting, analyzing, and interpreting MPA data was developed by Vasconcelos and Harris (1992). In this methodology (usually referred to as the EPA Consensus Method), samples are collected by concentrating large volumes (typically 500-1000 gallons) of raw drinking water using a fiber filter. Tables are then used to assign a relative risk rating based on types and numbers of organisms present. It is important to note that these tables were developed using a relatively small number of ground water samples that were analyzed by a number of different laboratories.

An alternative MPA method employed by the New York State Department of Health's Wadsworth Laboratory does not involve the filtration of large volumes of drinking water. Instead, 10 Liters of raw drinking water are collected, and organisms and particles are then concentrated for enumeration using a combination of bench-top filtration and sedimentation. In addition, the viability of algal chloroplasts (viable chloroplasts are an indication of a short travel time) are verified using UV-fluorescence. The risk rating system used with this methodology is conceptually similar to that used in the EPA Consensus Method, but it has been modified to account for the improved enumeration accuracy.

As mentioned previously, it is very important that hydrogeologic information and the results of the water quality assessment be used in conjunction with MPA to make the GWUDI determinations. Most importantly, MPA samples should be collected when the water quality assessment and hydrogeologic data indicate the greatest probability that surface water is impacting the ground water source, as indicated by hydrogeological and water quality data. The difficulty associated with selecting an ideal sampling time requires that at least two MPA samples be collected at different times of the year. MPA samples should be collected on occasions when the time of travel is suspected of being the shortest, usually when surface water levels are elevated (i.e., spring runoff and following storm events) and when pumping rates are highest. Ideally samples should be collected to reflect both periods of high and low regional ground water levels.

Even with the difficulties and uncertainties associated with these analyses, the information gained by MPA can help in the GWUDI determination process. It is relatively safe to conclude from a “high” MPA rating that the ground water source is under the direct influence of surface water, particularly when considered along with corroborating information collected in the earlier phases of a GWUDI evaluation. However, it is more difficult to conclude from a “low” MPA rating that the ground water source is not under the direct influence of surface water, because surface water influences often only occur intermittently under particular hydrologic conditions (usually during very wet or dry periods). Samples given a “moderate” MPA rating should be evaluated on a case-by-case basis, with assistance from New York State Department of Health scientists and engineers.

<u>REFERENCES</u>

1. Technical Reference PWS 180 - Sanitary Surveys of Public Water Supplies

2. Technical Reference PWS 72 - Determining Vulnerability To Contamination By Volatile Organic Chemicals

3. Vasconcelos, J., and S. Harris. 1992. Consensus method for determining groundwater under the direct influence of surface water using microscopic particulate analysis. Port Orchard, WA: U.S. Environmental Protection Agency.

Attachment 1. Example of sanitary and field survey report form that could be used to collect information for the hydrogeological assessment

Well Location and Characteristics

Water System Name/Address/Fed ID#______________________________
____
____

Name of Site ____

Description of Device

____

Name and Description of Nearby Surface Source(s)

____
____
____

Describe Datum for Elevations

____

Is there a USGS gauging station nearby, or other flow records available?

____

Static Water Level

as a Depth______________ Date ______________

as an Elevation__________ Date ______________

Pumping Water Level

as a Depth______________ Date ______________

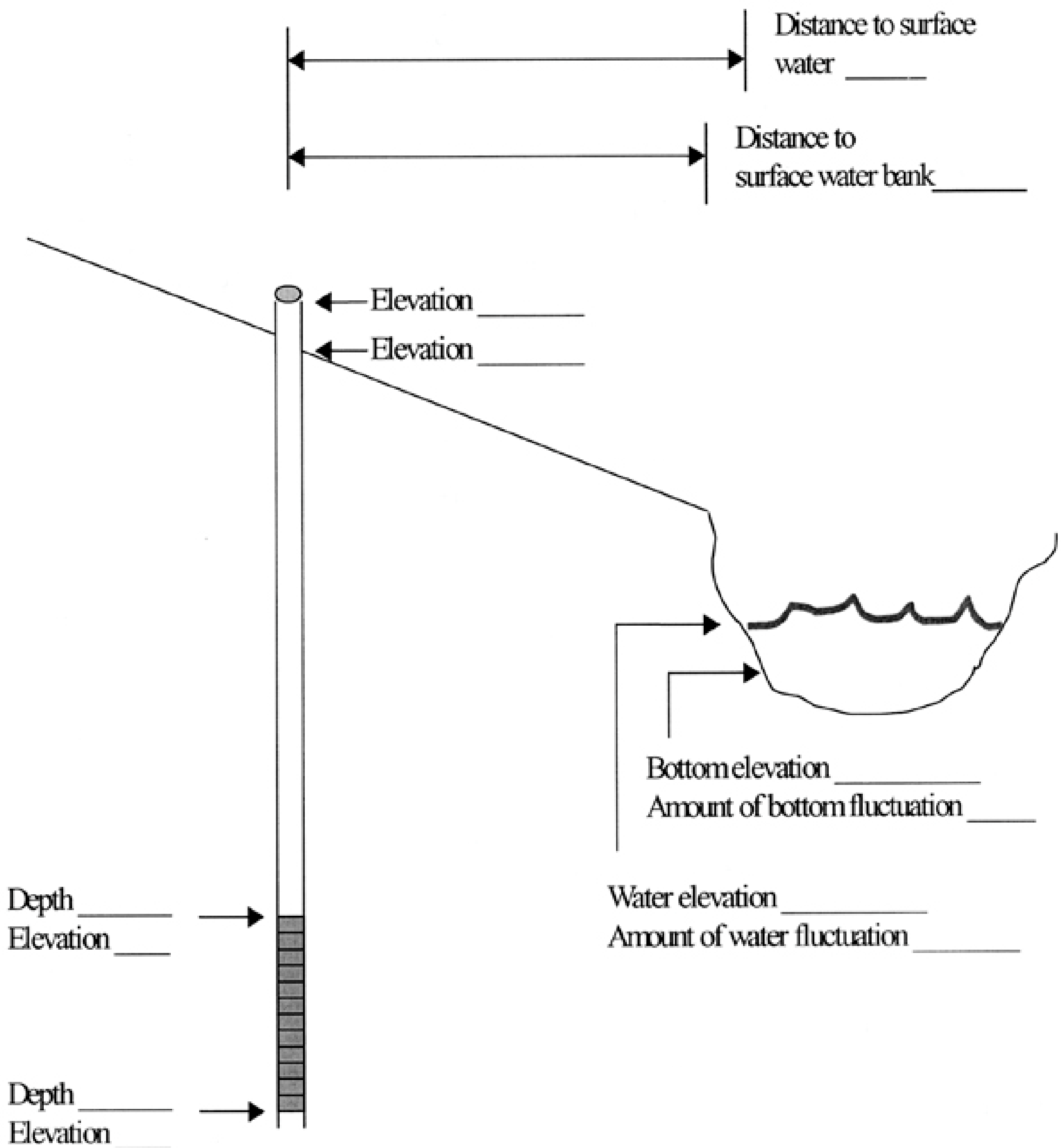
as an Elevation__________ Date ______________

Characterize pumping practices or spring flow (rates, seasonally, etc.)

____
____

Describe the vertical distance between the aquifer and the surface water under pumping conditions______________________________

Describe the horizontal distance between the aquifer and the surface water source under pumping conditions ____
____
____


Distance to surface water _____
Distance to surface water bank______
Elevation _______
Elevation _______
Bottom elevation __________
Amount of bottom fluctuation _____
Water elevation __________
Amount of water fluctuation _______
Depth ______
Elevation ____
Depth ______
Elevation ____

Well Construction

Construction date ____________________

Does construction conform to the current standards (i.e., Ten State)? ________________________

Construction methods/materials ____
____

Casing ____
Grouting ____
Screening ____
Well House ____
Other Information ____

Is a detailed plan/drawing available? ___________

Hydrogeology
Is a geologic log for this well available? ____

What is the thickness of the unsaturated zone? ____

What is the hydraulic conductivity's of the unsaturated zone and the aquifer? _____________

Is there a confining layer? At what elevation(s)? _______________________________________

Describe ____

Does the surface water body penetrate the aquifer? _____________________________________

Draw the aquifer(s), confining unit(s), and water table using one or more cross-sections with at least one cross-sections parallel to the flow direction. _________________________

Summary of Sanitary Conditions

Describe the results of past sanitary surveys and give the location of written reports
____
____
____