Drinking Water Operator Certification Training Instructor Guide

Module #2: Groundwater Sources of Supply and Protection

This course includes content developed by the Pennsylvania Department of Environmental Protection (Pa. DEP) in cooperation with the following contractors, subcontractors, or grantees:

The Pennsylvania State Association of Township Supervisors (PSATS)
Gannett Fleming, Inc.
Dering Consulting Group
Penn State Capitol Campus

A Note to the Instructor

Dear Instructor:

The primary purpose of this course, *Groundwater Sources of Supply and Protection*, is to acquaint the participants with the hydrologic cycle, groundwater aquifers, well development and use of groundwater as a potable water supply. This module has been designed to be completed in approximately 3 hours, but the actual course length will depend upon content and/or delivery modifications and results of course dry runs performed by the DEP-approved sponsor. The number of contact hours of credit assigned to this course is based upon the contact hours approved under the DEP course approval process. To help you prepare a personal lesson plan, timeframes have been included in the instructor guide at the Unit level and at the Roman numeral level of the topical outline. You may need to adjust these timeframes as necessary to match course content and delivery modifications made by the sponsor. Please make sure that all teaching points are covered and that the course is delivered as approved by DEP.

Web site URLs and other references are subject to change, and it is the training sponsor's responsibility to keep such references up to date.

Delivery methods to be used for this course include:

- Lecture
- Exercises/Activities
- Discussion Questions
- Exercise

To present this module, you will need the following materials:

- One workbook per participant
- Extra pencils
- Laptop (loaded with PowerPoint) and an LCD projector **or** overheads of presentation and an overhead projector
- Screen
- Flip Chart
- Markers

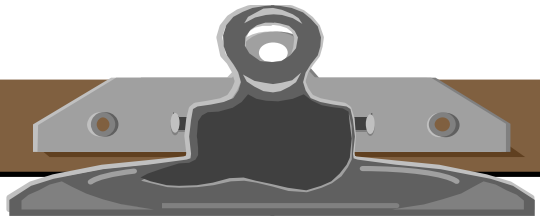
Icons to become familiar with include:

Participant Workbook	Instructor Guide
 Exercise/Activity	Same icons for Participant Workbook apply to the Instructor Guide.
 Case Study	**Ans:** Answer to exercise, case study, discussion, question, etc.
 Discussion Question	 PowerPoint Slide
 Calculation(s)	 Overhead
 Exercise	 Flip Chart
 Key Definition(s)	 Suggested "Script"
 Key Point(s)	

Instructor text that is meant to be general instructions for the instructor are designated by being written in script font and enclosed in brackets. For example:

[Ask participants if they have nay questions on how to read the table. Answer any questions participants may have about how to read the table.]

If your module includes the use of a PowerPoint presentation, below are some helpful controls that you may use within the Slide Show.



PowerPoint Slide Show Controls

You can use the following shortcuts while running your slide show in full-screen mode.

To	**Press**
Advance to the next slide	N, ENTER, or the SPACEBAR (or click the mouse)
Return to the previous slide	P or BACKSPACE
Go to slide <number>	<number>+ENTER
Display a black screen, or return to the slide show from a black screen	B
Display a white screen, or return to the slide show from a white screen	W
Stop or restart an automatic slide show	S
End a slide show	ESC
Return to the first slide	Both mouse buttons for 2 seconds
Change the pointer to a pen	CTRL+P
Change the pen to a pointer	CTRL+A
Hide the pointer and button temporarily	CTRL+H
Hide the pointer and button always	CTRL+L
Display the shortcut menu	SHIFT+F10 (or right-click)
Erase on-screen annotations	E
Go to next hidden slide	H
Set new timings while rehearsing	T
Use original timings while rehearsing	O
Use mouse-click to advance while rehearsing	M

INTRODUCTION OF MODULE: 5 minutes

[Display Slide 1—Module 2: Groundwater Sources of Supply and Protection.]

[Welcome participants to "Module 2 – Groundwater Sources of Supply and Protection." Indicate the primary purpose of this course is to acquaint the participants with the hydrologic cycle, groundwater aquifers, well development and use of groundwater as a potable water supply.]

[Introduce yourself.]

[Provide a brief overview of the module.]

The module contains 4 units. On page I, you will see the topical outline for **Unit 1—Introduction to Groundwater,** and **Unit 2—Aquifers**. **Unit 3—Source Development and Construction**, and **Unit 4—Source Water Protection** are on the next page.

[Briefly review outline on this page.]

*[Continue to briefly review the topical outline for **Unit 2—Aquifers**, **Unit 3—Source Development and Construction**, and **Unit 4—Source Water Protection**.]*

UNIT 1 INTRODUCTION TO GROUNDWATER: 45 minutes

[Display Slide 2—Unit 1: Introduction to Groundwater].

At the end of this unit, you should be able to:

- Define evaporation, transpiration, evapotranspiration, groundwater, and, water table.
- List three types of water and explain each.
- Explain the steps in the Hydrologic Cycle.

Our introduction to groundwater has five components.

What do you think of when someone says "Hydrologic cycle"?

[This question is intended to generate some discussion. You can choose to write their responses on a flipchart].

Now that I have an idea of your knowledge of the hydrologic cycle, let's dive into the cycle itself.

DEFINITIONS: 30 seconds

We have several definitions in regard to the hydrologic cycle on page 1-2 in your workbook. I'm not going to go through each definition now since we'll cover each during this unit. However, we wanted you to be able to easily refer to all the definitions in one place.

Understanding the types of water and how water moves in, on and around the earth will help us understand the sources of groundwater supply. Let's turn the page as we focus on Types of Water.

TYPES OF WATER: 5 minutes

Atmospheric Water

[Briefly review the information on Atmospheric Water.]

Surface Water

[Review the information presented on Surface Water. Fresh water is abundant in Pennsylvania. In fact, just for surface water, Pennsylvania has more miles of streams per square mile of area than most other states.]

Groundwater

While we covered atmospheric and surface water, the focus of this module will be groundwater.

Groundwater is water that is found ***below*** the earth's surface. It includes both fresh water and salt water. Groundwater is found in saturated soil, as shown below, or in fractures in the bedrock.

[Point out the figure in the workbook (1.1) that displays saturated soil.]

[You can review the following information on Groundwater as you see fit:]

- Readily available global groundwater = 1100 quadrillion (10^{15}) gallons.
- Next to glaciers and icecaps, which do not have readily available water, groundwater reservoirs are the largest holding basins for fresh water in the world hydrologic cycle.
- Estimated total usable groundwater in storage is about equal to total precipitation for 10 years, or total surface runoff to streams and lakes for 35 years.

Sources of Groundwater for Drinking Include:

► Water obtained from dug, drilled, bored, jetted or driven wells.

A dug well is a hand dug, shallow well. Drilled, bored, jetted, and driven wells are deeper wells developed using mechanical well drilling equipment.

► Water obtained from Infiltration Galleries and Radial Collectors.

An Infiltration Gallery is one or more horizontal screens placed adjacent to (on-shore), or directly underneath (bed-mounted), a surface water source. A radial collector is an infiltration gallery with horizontal screens projecting outward from a central collection basin like the spokes of a wheel.

We have reviewed three types of water. Let's take a look at how water moves among these three and how our water resources are renewed. Turn to the next page.

HYDROLOGIC CYCLE: 15 minutes

Overview

[Review the Overview.]

[Display Slide 3—Hydrologic Cycle (Figure 1.2 of participant workbook)]

Don't get overwhelmed by this picture of the entire cycle. We are going to cover each of the components. Because we are talking about a cycle that has no beginning or end, we could start at any point in the process. Let's start with the precipitation from the clouds.

Process

*[As you review the Process, indicate where **Precipitation** and **Evaporation** are represented in the slide. As you indicate where Infiltration and Percolation occur, say:]*

The remaining water infiltrates into the ground. Let's take a closer look at infiltration.

[Continue reviewing infiltration on the next page.]

[Continue displaying Slide 3—Hydrologic Cycle (Figure 1.2 of participant workbook).]

[Review Infiltration. Indicate on the slide where transpiration and evaporation from crops, trees and other plants is listed. After covering transpiration, reiterate that ***evapotranspiration*** *is the combination of transpiration and evaporation.]*

[*Display Slide 4—Groundwater Infiltration (Figure 1.2 of participant workbook).]*

[Indicate that Figure 1.2 illustrates groundwater infiltration. As you review water filtering through an unsaturated zone, point out the zone of saturation, the water table, and groundwater storage on the slide.]

As water moves through the ground, it eventually returns to the surface. We see these surface waters as lakes, wetlands, streams and springs. This part of the Hydrologic Cycle where water returns to the earth's surface is called Discharge. Let's turn the page to learn more about this phase of the cycle.

Discharge

[Display Slide 5—Groundwater Movement (Figure 1.4 of participant workbook).]

[Review the material on Discharge. Indicate that figure 1.4 illustrates groundwater movement. Use slide 5 to illustrate the movement of groundwater. Point out the areas of discharge in this illustration (spring and wetland). As you indicate the discharge points on the slide, point out the Recharge point and say:]

Since all groundwater eventually surfaces, eventually it needs to be recharged. Depending on the area in which one lives this can take place any time of year and depending on the types of ground cover, soil, and temperature the time it takes to recharge can vary.

Exercise: Take a minute and fill in the blanks in the hydrologic cycle graphic. There are three blanks.

[From the left side, the answers are: water vapor, groundwater, and transpiration. Ask participants for their answers before you tell them the correct ones.]

Now that we have an understanding of how the hydrologic cycle works, let's take a closer look at information specific to Pennsylvania's hydrologic cycle.

Hydrologic Cycle in Pennsylvania

[Review the information presented on Precipitation.]

Before turning the page:

[Ask participants the following questions and write their responses on the flip chart.]

- When (what season) do you think our groundwater recharge occurs and why?
- What type of area (i.e. forested or urban) do you think have the highest recharge rate?
- What type of areas (i.e. forested or urban) do you think have the lowest recharge rate?

Let's turn the page and check our responses.

[Review Groundwater Recharge and Recharge Rates and compare to participant responses.]

[Here are the questions again, with the answers:]

- *When (what season) do you think our groundwater recharge occurs and why?*
  - *Spring*
- *What type of area (i.e. forested or urban) do you think have the highest recharge rate?*
  - *Forested areas*
- *What type of areas (i.e. forested or urban) do you think have the lowest recharge rate?*
  - *Urban areas*

We now have an overview of nature's process with the Hydrologic Cycle—types of water and ground water movement, discharge and recharge. Let's move forward to learn more about the demands we make on groundwater both nationally and within Pennsylvania.

GROUNDWATER USAGE: 10 minutes.

*[As you review the information on Fresh Water and Groundwater Statistics in the United States and Pennsylvania, be sure that students understand that when we are talking about groundwater for **drinking** that we are only referring to **fresh** water groundwater.]*

Groundwater in United States

[Review the information on the percentages of water usage provided by groundwater.]

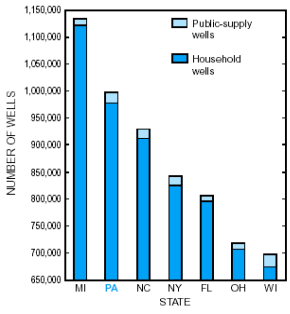
Groundwater in Pennsylvania

[As you review the information provided in the text, share the following illustration:]

Pumping all of Pennsylvania's fresh groundwater onto the surface would cover the entire state with more than 8 feet of water.

Pennsylvania Groundwater Statistics

[*Display Slide 6—Top 7 States in Terms of Water-Supply Wells.]*



Top seven states in terms of water-supply wells.

[Review the information presented on the slide. Point out that Pennsylvania ranks 2nd (after Michigan) for total number of wells, 2nd (after Michigan) for number of household wells, and 3rd (after Wisconsin and New York) for number of public water supply wells.]

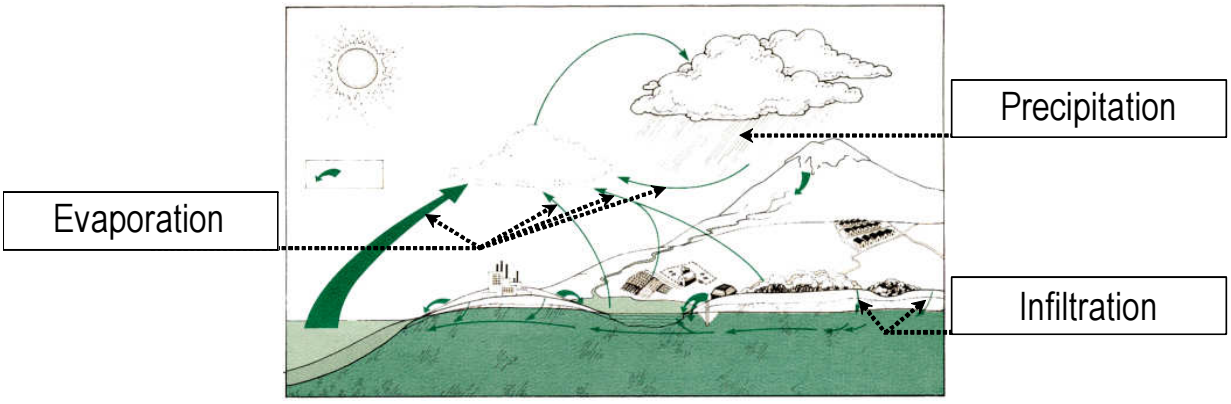
[You can review some of the Pennsylvania Groundwater Statistics, but do not spend too much time on it].

[At this point, ask participants if they have any questions on anything covered in Unit 1. Respond to appropriate questions. Then proceed with Unit 1 Exercise.]

UNIT 1 EXERCISE: 10 minutes

1. On the diagram below, label the following parts of the Hydrologic Cycle: Precipitation, Evaporation and Infiltration.

Ans:



2. In addition to surface water, name two other types of water below and briefly describe each.

A. Groundwater – found beneath earth's surface

B. Atmospheric water – found in air surrounding the earth – clouds, fog, and precipitation

3. Match the word with its definition:

Word Pool		
Evapotranspiration	**Transpiration**	**Groundwater**
Evaporation	**Water Table**	

Evaporation	1. When water turns into a vapor and returns to the atmosphere
Transpiration	2. When water travels through a plant and some evaporates directly from plant to air
Evapotranspiration	3. Loss of water by evaporation from the soil and transpiration from plants
Groundwater	4. Water found beneath earth's surface (can be fresh or salt water). This is our largest source of fresh water
Water Table	5. The boundary below which all of the spaces and cracks in the soil and rock are filled with water

[Have the participants review the Key Points for Unit 1 as listed on this page.]

[Point out the references for Unit 1.]

[Ask participants if they have any questions regarding Unit 1. Respond accordingly.]

[This page was intentionally left blank.]

UNIT 2 - AQUIFERS: 40 minutes

We've discussed the Hydrologic Cycle and its relation to groundwater. In this unit, we will look at aquifers, both in general and specific to Pennsylvania.

[Display Slide 7—Unit 2: Aquifers]

At the end of this unit, you should be able to:

- List four types of groundwater aquifers found in Pennsylvania.
- Identify on a map, the location of Pennsylvania's principal groundwater aquifers.
- Describe the geology of each of the four aquifers.
- List three common types of groundwater sources found in Pennsylvania.

TYPES OF AQUIFERS: 5 minutes

Definition of Aquifer

Can anyone define the word "Aquifer"?

[Based on the participants' response, review the definition of Aquifer as presented in the student workbook.]

[Display Slide 8—Types of Aquifers (Figure 2.1 of participant workbook).]

[Review the three types of aquifers as presented in student workbook. Use the slide to point out each type of aquifer as well as the surface area (area exposed to air), flow of water (indicated by arrows) and water table (indicated by dotted lines) for each.]

Unconfined Aquifer

The first one we will look at is the Unconfined Aquifer**.** As you can see, the Unconfined or Water Table Aquifer is exposed to air; in other words, it is not surrounded (confined) on all sides by soil or rock. You can see that this one feeds springs, a stream, and a wetland area. Because of that, it is said to be under atmosphere pressure.

Confined Aquifer

Looking at the second type of aquifer, the Confined Aquifer**,** you can see that this water is between two layers of impermeable rock or Aquitards. An aquitard is a low permeability layer. The area exposed to the atmosphere is minimal. As you can see, most of the water is underground and therefore under pressure greater than atmospheric.

Perched Aquifer or Perched Water Table

The third type of aquifer is called the Perched Aquifer or Perched Water Table. Notice how the layers appear. There is an aquitard above the water table dotted line and below the perched water table dotted line. The water that collects ABOVE the aquitard but underground is the Perched Water Table. This usually doesn't hold much water.

In Pennsylvania, aquifers can also be grouped based on the geological formations in which they are found. The next section, Pennsylvania's Aquifers will present the four groups.

PENNSYLVANIA'S AQUIFERS: 20 minutes

[Display Slide 9—Pennsylvania's Aquifer Distribution (Figure 2.2 of participant workbook).]

This slide illustrates the types and locations of the aquifers found in Pennsylvania. It's important to understand that these are the four principal types found in Pennsylvania. They are grouped based on their geology. The dark green areas (point out) represent the sand and gravel aquifers. The pink represents sandstone and shale aquifers. The lightest green is where one can find the carbonate rock aquifers. The crystalline rock aquifers are represented by the medium shade of green.

[Ask participants to locate the county they are from on the map in their workbooks. Select volunteers to tell what county they are from and the type of aquifers found in their area based upon the map. Thank them for their help.]

Each principal type of aquifer has distinctive characteristics. The next 4 pages show characteristics of each of the aquifers. Characteristics include location, geology, yields, and quality. Find the type of aquifers in your county and read over the information.

After you have read it over, answer the questions on Page 2-9. If your county has more than one aquifer, try to pinpoint the aquifer in which your water system is located using the map on page 2-4.

[Allow the participants about 5 minutes to complete this exercise.]

Sand and Gravel Aquifers

[Continue displaying Slide 9—Pennsylvania's Aquifer Distribution.]

[Go to page 2-9 of this instructor guide.]

Sandstone and Shale Aquifers

[Continue displaying Slide 9—Pennsylvania's Aquifer Distribution.]

[Go to page 2-9 of this instructor guide.]

Carbonate Rock Aquifers

[Continue displaying Slide 9—Pennsylvania's Aquifer Distribution].

[Go to page 2-9 of this instructor guide.]

Crystalline Rock Aquifers

 *[Continue displaying Slide 9—Pennsylvania's Aquifer Distribution.]*

[Go to page 2-9 of this instructor guide.]

QUESTIONS BASED ON AQUIFER TYPES:

[The participants answer these questions in the workbook based on their reading of the aquifer description.]

1. What is the typical yield in gpm?
2. What is the typical pH
3. What is the quality considered?
4. At your system, have you found similar water quality characteristics?
5. Write down one thing you learned about your aquifer (something you didn't know before):

[After they are done with the questions, say:]

 We had you do this exercise so that you could learn more about your aquifer. There is a lot of information available for each aquifer. This may help you make future decisions about treatment, or drilling other wells.

 Now that we know the types of water, its movement and the kinds of aquifers found in Pennsylvania, let's move on to learn about Groundwater Sources.

Groundwater Sources: 5 minutes

Types of Groundwater Sources

[Review the three types of groundwater sources.]

[Display Slide 10—Water Source Placement (Figure 2.3 of participant workbook).]

[Review the three types of groundwater sources and refer to the slide for placement of wells and springs.]

This slide is similar to the one we viewed on aquifers; however, our focus now will be on water source placement. Let's start with wells.

Wells

[Review the material on Wells. As you review, point to the appropriate example on the slide for Perched Aquifer Well, Unconfined Aquifer Well, and Confined Aquifer Well.]

[With the slide still displayed, turn page to continue review.]

Springs

We briefly discussed springs in Unit 1. But let's look at them again.

[Point out the springs on the slide and review material on springs as presented in participant workbook]

Infiltration Galleries, Radial Collectors

[Review the information on infiltration galleries and radial collectors.]

As we learned in Unit 1 when we were talking about sources of groundwater, an infiltration gallery is one or more horizontal screens placed adjacent to (on-shore), or directly underneath (bed-mounted) a surface water source. Figure 2.4 is an illustration of an infiltration gallery. We also learned that a radial collector is an infiltration gallery with horizontal screens projecting outward from a central collection basin like the spokes of a wheel. Figure 2.5 is an illustration of a radial collector.

Following is a short exercise. We're going to use the next 5 minutes to complete the exercise. We will then review the answers so that you will have an idea of what you learned and what you need to review. Turn the page and you may begin.

UNIT 2 EXERCISE: 10 minutes

1. List the three types of groundwater sources.

Ans: Wells, springs, infiltration galleries and radial collectors

2. On the map below, label the map's key to indicate the geological types of groundwater aquifers found in Pennsylvania.

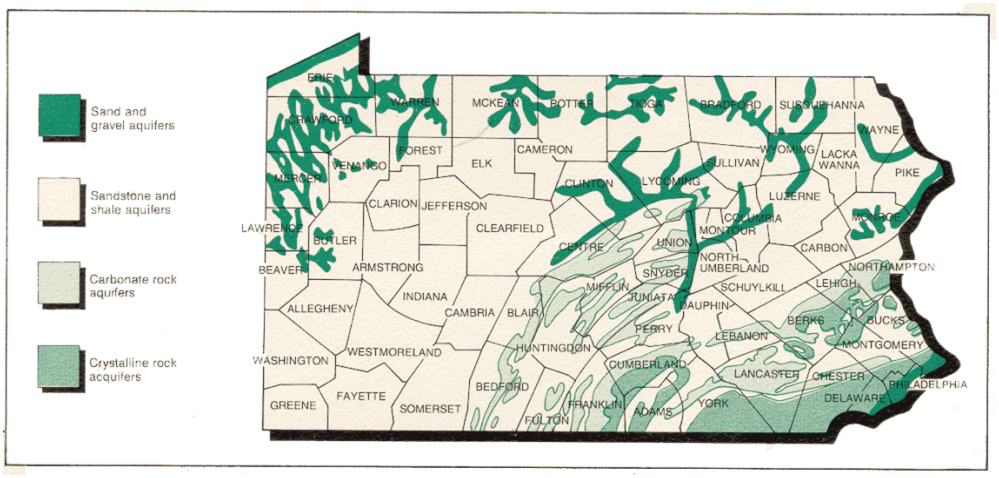
Ans: Student responses should be as listed in the legend: Sand and Gravel, Sandstone and Shale, Carbonate Rock, and Crystalline Rock Aquifers.

3. **True or False:** A stratum is a layer of earth
Ans: True

4. Which one of the following best defines the term ***aquifer***?

a. A low lying area where water pools
b. Water-bearing stratum of rock, sand, or gravel
c. Impervious stratum near the ground surface
d. Treated water leaving the water system

Ans: B



5. List the three types of aquifers.

Ans: Unconfined Aquifer, Confined Aquifer, Perched Aquifer or Perched Water Table

6. Based ***solely*** on **quality** of water and **yield**, which of the four aquifer formations would provide the largest amount of fresh water? Why?

Ans: Sand and Gravel Aquifers

Yield: Contain large quantities of water, easily withdrawn, Well yields of 100 – 800 gallons per minute (gpm), Yield in excess of 1000gpm are common.

Quality: is variable, but generally good to excellent

[Note to the Instructor: This brings you to about the half-way point for Module 2—Groundwater Sources of Supply and Protection, and may be an appropriate place for a short break.]

[Have the class review the Key Points for Unit 2 as listed on this page in their workbook.]

This brings us to the end of Unit 2—Aquifers. Are there any questions about any of the material we've covered?

[Answer questions that arise.]

[It is not necessary to discuss the references for Unit 2.]

[This page was intentionally left blank.]

UNIT 3 –SOURCE DEVELOPMENT AND CONSTRUCTION: 55 minutes

We talked about water source placement in Unit 2. In Unit 3, we will learn about the development and construction of a source.

Purpose: For a lot of you, your engineer (or consulting firm) will do a lot of the legwork in constructing a new source. Regardless, it is important for you to know about what goes into the development of a new well.

[Display Slide 11—Unit 3: Source Development and Construction]

At the end of this unit, you should be able to:

- Identify the considerations in new source development
- Define Safe Yield and explain why it is important to groundwater supply sources.
- Explain the basic components of well construction and the importance of proper installation of the well casing.
- Define and explain wellhead protection

SOURCE DEVELOPMENT: 5 minutes

Water Supply Alternatives

[Review the material on water supply alternatives.]

We will focus on developing a groundwater source in this unit. If you are interested in surface water, there is a separate course (Module #3) that covers surface water sources.

Facility Location

[Review the material on considerations for facility locations.]

In this unit we will go into more detail about the first 3 of these, which deal with the quantity and quality of a prospective source. The last 2 items deal with costs.

Now we're going to focus on those items that are specific to Groundwater Source Development. Let's turn the page to learn more.

GROUNDWATER SOURCE DEVELOPMENT: 20 minutes

Sanitary Survey

A Sanitary Survey is a systematic evaluation of the area in which the prospective groundwater source will be located. Its main purpose is to identify any potential sources of contamination that might impact the water quality of the prospective source. A person trained in public health engineering should complete a sanitary survey. It is a very large and detailed process.

[Review the considerations list.]

The first bullet deals with elements that can affect the quantity of water. Local sources of pollution, the second bullet, deal with elements that can affect the quality of water. The last three bullets address elements that can affect both the quantity and quality of water.

All of these considerations help you to

1. Identify potential hazards
2. Determine factors affecting water quality
3. Select the type of treatment you need

You may also hear the term Sanitary Survey used for an existing water source. It is recommended that water systems complete a sanitary survey every year that analyzes the potential sources of contamination and the physical components of the system for any "weak links."

Based on results of the Sanitary Survey and developed well capacity, a wellhead protection **area** is identified.

Wellhead Protection Area

[Review the information presented on Wellhead Protection Area. You may want to expand on the three-tiered approach.]

Once the well is drilled, the available water is tested.

Testing

Overview:
[Review the information presented in the Overview.]

Performing various tests on the well is a regulatory requirement. Testing is done to determine two factors. The first factor is the quantity of water or capacity of the well and the second factor is the quality of the water. Safe Yield is the main reason for capacity testing (review definition). But before we talk about the specific tests that help determine capacity, let's quickly review the general hydraulics of wells and the testing protocol. Please turn to page 3-4 in your workbook.

[Display Slide 12—Well Drawdown (Figure 3.1 of participant workbook).]

General Well Hydraulics:
[Review the material on General Well Hydraulics. Use Figure 3.1 to illustrate the flow of water during the pumping process, creating the cone of depression, and the induced recharge from the stream.]

This figure also appears in your book. When water is pumped from a well, the water table in the vicinity of the well is lowered, creating a Cone of Depression (Point to the cone of depression on the slide.) If the Cone of Depression extends to a surface water body, *(point to the stream on the slide)* water will flow from the surface water body to the groundwater. This is known as surface water infiltration. The extent of cone of depression is called the Radius of Influence and is dependent upon the extent of recharge area, the aquifer capacity, and the pumping rate. The Cone of Depression expands both laterally and in depth until the flow into the well equals the pumping rate. When the flow into the well equals the pumping rate, the well is in equilibrium.

Since most pumps do not run continually, the cone of depression does not stay constant.

Testing Protocol:
[Review the information presented on Testing Protocol.]

DEP drilling reports must be completed by the well drilling contractor and filed with the state. A very important physical test of the well is the Plumbness and Alignment Test. A rigid dummy is lowered into the well. The dummy must pass freely throughout the entire length. This indicates that the well is aligned and plumb, and that the well pump will not get stuck during installation or removal. If a pump gets stuck in the well, the source may need to be abandoned.

As we learned on the previous page, testing is done to determine two factors, the quantity and quality of the water. Let's move on to review the specific testing used for quantity or capacity of water.

Capacity Testing

Since the capacity of springs is highly dependant upon weather, Capacity Testing is only done on wells.

There are two tests that are conducted to determine the Safe Yield of a groundwater source. These two tests are the Step Drawdown Test and the Sustained Yield Test**.**

[Review the information presented on Step Drawdown and Sustained Yield Tests.]

[At this point, ask participants if they have any questions on either test.]

We've just covered the water testing for capacity or quantity. Let's move on to Water Quality Testing.

Water Quality testing is done on wells, springs, and surface water. The requirements vary, as we will see, but the goal is always to ensure safe water. We will begin with wells.

[Review the information presented on Water Quality testing in wells.]

[Review the information presented on Water Quality testing in springs.]

To determine if groundwater sources are susceptible to the direct influence from surface water, there is a special protocol that must be followed. This testing is known as Surface Water Identification Protocol or "SWIP." Turn to page 3-7.

[Review the material on the Surface Water Identification Protocol (SWIP) Testing.]

There is a six-month monitoring program required prior to submittal for a construction permit for the prospective source. And, if the monitoring indicates the groundwater is under the influence of surface water, they then must comply with the Surface Water Treatment Rule within 48 hours.

[Show figure 3.1 again as you discuss "surface water influence possibilities."]

WELL CONSTRUCTION: 15 minutes

Now that we have found the location for our facility and the tests have all been conducted satisfactorily we move to the construction phase.

As we review the material in this section, keep in mind that the components we are addressing are common to all wells. It is only when we review the Special Construction Requirements that we talk about construction requirements unique to a particular kind of well.

First, we will look at casings. A casing is a form of liner which is installed in the top portion of the well to prevent surface water and shallow groundwater from entering the well.

Casings

[Review the information on Material and the associated graphic].

[Display Slide 13 – Well Components. Point out the casing].

The components of a well are also shown in Figure 3.2 on page 3-8 in your workbook. You can see how the casing surrounds the well. This figure shows the other well components that we will discuss soon.

Casings Cont'd: Grouting

[Review the information on grouting.]

[Display Slide 14 - Grouting.]

This slide is also shown in Figure 3.3 in your workbook (page 3-9).

[As a quick exercise to get participants thinking, ask:]

DEP has set up standards for Protective Casing Depths. Why do you think this is important?

Ans: Casings installed to the minimum specified protective depth would help to insure that surface water is prevented from contaminating the source.

DEP has set up standards for protective casing depths. Table 3.1 – Protective Casing Depths can be found on the next page.

Minimum Protected Depth

[Display Slide 15—Protective Casing Depths]

On page 3-10, let's look at Table 3.1.

Two factors affect the protective casing depths: the water bearing formation, as seen in the far left column, and the overlying materials found in the middle column. In some cases, you will also see that the pumping level affects the depth of casing. Pumping level is defined as the water level when pumping is in progress.

Let's try our hand at using this table. On the next page, there are three scenarios in question form.

[Continue displaying Slide 15—Protective Casing Depths (Table 3.1 in participant workbook)].

[Review the material on Minimum Protected Depth by taking participants through the following exercise. As you review the answers, use the slide to show how the answer was determined.]

10 minutes -- Application of Protective Casing Depths.

[After asking each question, ask volunteers for the correct protective casing depth.]

1. What is the recommended protective casing depth when the water bearing formation is gravel, overlying material is a mixture of sand and gravel, and the pumping level is 28 feet?

Ans: 38 feet. (The depth of casing will be governed by the pumping level. For pumping levels 30 feet or less, the casing shall extend 10 feet below pumping level. For pumping levels greater than 30 feet the casing shall extend five feet below pumping level.)

2. What is the recommended protective casing depth when the water bearing formation is limestone and the overlying material is mantle to a depth of 52 feet for a radius greater than a mile?

Ans: The casing shall be firmly seated in the rock formation. (See Section 3.3.6.3)

3. What is the recommended protective casing depth when the water bearing formation is sandstone and the overlying material is limestone at variable depths?

Ans: The casing pipe shall be extended 15 feet into firm sandstone.

You now have an idea of how to use this table. As you can tell just by the examples we did, the variables are many, that's why we have the table to refer to.

Once the well is drilled, screens may be needed.

Screens

[Review the material as presented on screens].

[You may want to display Slide 13 - Well construction again during the next two topics.]

Screens are not always used in wells. For example, dug wells do not include screens because of the size of the excavation necessary to permit construction access. Similarly, drilled rock wells do not require screens if the rock formation is sufficiently stable to prevent material from caving into the drill hole.

As we just discussed, development of a well takes special precautions to prevent the introduction of surface water or shallow groundwater into the well supply by the installation of a properly installed protective well casing. However, if the upper well terminus is not properly protected as well, surface water could easily enter the well through the top of the casing. Therefore, various requirements exist for the protection of the top of the well.

Upper Well Terminus

 Display Slide 16 – Upper Well Terminus.

Figure 3.4 in your workbook also shows this slide.

[Review the material presented in the participant workbook on the requirements of an Upper Well Terminus.]

Capping and Abandonment

[Review material as presented on Capping and Abandonment as presented in the workbook.]

Once the decision not to abandon the source is made, well construction moves forward. It is then time to install some key components.

We are ready to install the pumps, discharge piping, pitless well units, and water level measurement equipment.

Well Components

[Continue to display Slide 13 - Well construction during the Well Components discussion.]

You have seen this slide before, but I wanted to show it again during this discussion.

[Review material as presented in participant workbook for pumps. Point out figures 3.5 and 3.6 in their workbook during the discussion.]

[Continue the review of well components with discharge piping, pitless well units, and water level measurement. Point out figure 3.7 in their workbook during the discussion.]

As I mentioned earlier, what we have covered with regard to well construction is true for all wells. We will now focus on special construction requirements of specific well types.

Special Construction Requirements

[Review the special construction requirements for each of the wells listed.]

 *[Display Slide 18 – Gravel Pack Wells during the discussion]*

 Figure 3.8 in your workbook also shows this slide.

[Continue the review of Special Construction Requirements.]

 *[Display Slide 19 during the discussion of limestone/sandstone wells. Point out that Figures 3.9a and b in the workbook is the same as slide 19.]*

 Unconsolidated material is essentially all the soil above bedrock. Unconsolidated means loose or unstratified soil.

[Complete the review of special considerations with Flowing Artesian Wells, Radial Water Collectors and Infiltration Lines.]

 *[Display Slide 20 during the discussion of Artesian wells. This is an animated slide.]*

Following is a short exercise. Take the next few minutes to write your responses. When you are done, I will ask for a volunteer or two to share answers. You may begin.

UNIT 3 EXERCISE: 5 minutes

1. In the space below, define Safe Yield and explain why it is important to groundwater supply sources.

Ans: Safe Yield is the amount of water that can be taken out of the ground in a year's time without having an adverse impact on the groundwater system.

This is important because with the time energy and money put into developing the water supply we want to make sure that the capacity of the source will remain constant indefinitely.

2. In the space below, explain the importance of proper installation of the well casing.

Ans: The proper installation of well casings helps to ensure that the water will be protected from possible contaminants which could be introduced by surface water entering the well.

3. What is the recommended protective casing depth when the water bearing formation is quartzite and the overlying material is 48 feet for a radius of one mile?

Ans: The casing shall extend 10 feet into uncreviced rock below 40 feet.

[Review the Key Points for Unit 3 with the participants.]

This brings us to the end of Unit 3. Does anyone have any questions regarding the material we've covered in this unit?

[There is no need to discuss the references listed on this page in the workbook.]

Once a well has been developed, the owner must take every measure available to protect the quality and quantity of the source water. Unit 4 is dedicated to protecting the source water.

UNIT 4: 40 minutes

[Display Slide 21—Unit 4: Source Water Protection]

At the end of this unit, you should be able to:

- Describe a wellhead protection plan and discuss its importance.
- Define Drought Contingency Plan.

SOURCE WATER PROTECTION PLAN: 10 minutes

In order to protect the source water two plans are required to be in place: The Source Water Protection Plan and a Drought Contingency Plan. The Source Water Protection Plan is sometimes referred to as a Wellhead Protection Plan. Its purpose is to outline various protection measures which can be implemented in the area immediately adjacent to the wellhead to eliminate sources of pollution which could easily enter the well.

Minimum Requirements

[Review the material presented on who develops the plan and how the plan is developed.]

The public agency is responsible for pulling together a local steering committee and include public in the decision making process through public participation. Generally the steering committee would be made up of the local plant water operator, business owners, educators, consumers, and elected officials—anyone who would be impacted by the source water. This steering committee usually consists of about four to eight people. Once the steering committee had developed a preliminary plan, then, through public meetings, the general public is asked for input.

[Review the material on the components or the "what" of the plan:]

- The Source Water Protection Area Delineation is just that—a mapping of the area surrounding the source water that should be protected to prevent contamination of the water source or sources from sources of pollution.
- The Contaminant Source Inventory is a list of all of the contaminants and where they were found.
- The Protection Area Management Methods—would be a list of those methods which could be employed in the protection of the area, for example, zoning and land development ordinances, storage tank regulation, public education, and local waste contaminant collection.
- Contingency Planning is the development of a plan and course of action to be taken, in the event that an unexpected event occurs. The planning might include a notification list with telephone numbers, a listing of equipment available to mitigate the problem, or even an alternate source of water should the primary source become unusable.
- New Source Planning should take into consideration the potential of contaminants in the area of the new source. If possible, new sources should be located to minimize impacts from these potential problem sources.

Suggested Additional Components

Let's look at the **suggested** components. Can anyone tell me why these are thought to be good things to include in your plan?

[Review material on Program Promotion.]

For source water protection to work, it is important that the general public is aware of the potential problems associated with release of potential contaminants within the protection area. Therefore, promoting the program through public meetings and educational events is necessary. Once the general public becomes aware of how their actions might impact their drinking water, attitudes toward actions which might result in a "pollution" event change.

[Review material on Public Education.]

An example of public education might be the distribution of a flyer outlining that lawn chemical and pesticides should be applied according to the manufacturer's directions to prevent contamination of a water supply source. Or it could include education relative to the importance of safe and proper disposal of waste oil, tires, batteries, etc. rather than simply placing these materials on the ground at one's property. Others:

- Newspaper articles
- Float in a parade promoting the program
- Website

[Review material on Integration with Land Use.]

As we just indicated, zoning and land development are major components of a protection plan. Proper zoning and development on the source water protection area will help to prevent the development of uses, which might cause future problems.

[Ask if there are any questions on the Source Protection Plan. Respond as needed to questions.]

The second plan that is required of each facility is the Drought Contingency Plan. Let's turn the page to learn about its purpose and components.

DROUGHT CONTINGENCY PLAN: 10 minutes

Purpose

Each water facility should have a plan. If the governor proclaims a drought emergency, each PWS serving more than 50 connections in the drought area should develop, adopt, and submit a plan.

[Review the three purposes of the plan as presented in the workbook.]

Components

[Review the stages of a drought and the elements within each as presented in the workbook.]

 Think of these as trigger stages. Within your plan you should explain what you would do at each stage.

 If a drought occurs, water rationing is another consideration. Let's turn the page to see what that would entail.

[Review the elements under Local Water Rationing as presented in the workbook.]

Activity: 8 - 10 minutes – Draft Drought Contingency Plan

Divide the class into small groups or pair into partners. Have each group/pair Draft a Drought Contingency Plan. Allow participants to work for **5 minutes**. After 5 minutes, ask each group/pair to report out a basic overview of their plan. After each group/pair reports out, provide or ask other participants to provide positive feedback.

[Drought Contingency Plan is continued on this page.]

UNIT 4 EXERCISE: 10 minutes

1. Two plans that need to be in place to address Source Water Protection. Write the names of each plan below.

   Ans: Source Water Protection Plan or Wellhead Protection Plan, and Drought Contingency Plan.

2. **True or False:** A local steering committee is recommended, but not a required component of a source water protection program.

   Ans: False, it is actually required.

3. **Fill-in-the-blank:** The _____ _____ _____ is a list of all the contaminants and where they are found in a source water protection area.

   Ans: Contaminant Source Inventory

4. List three examples of source water protection public education methods.

   Possible Answers: Websites, floats, flyers, or newspaper articles

5. List the three drought stages:

   Ans: Watch, Warning, and Emergency

[Review the Key Points for Unit 4 that are listed on this page in the participant's workbook.]

This is the end of Unit 4 – Source Water Protection and the end of Module 2- Groundwater Sources of Supply and Protection.

[Ask participants if they have any questions. Thank them for their participation and wish them well as they prepare for the plant operators test. Remind participants that this workbook has been designed not only for instructional purposes but also as a reference resource.]