Drinking Water Treatment **Lesson: 7**

National Science Education Standards for Grades 9-12

Content Standard A: Abilities Necessary to Do Scientific Inquiry

- *Design and conduct scientific investigations.*

Content Standard F: Science in Personal and Social Perspectives: Personal and Community Health

- *Hazards and the potential for accidents exist. Humans have a variety of mechanisms—sensory, motor, emotional, social and technological—that can reduce and modify hazards.*

Student Learning Objectives

7.1 Explain how to interpret a local Consumer Confidence Report (CCR).

7.2 Describe options for private well drinking water treatment for common, local contaminants.

Teacher Info Table Time

Instruction time for this lesson: 65 minutes

Resources, Tools, Equipment and Supplies

7.1.a. Illustrate the basic structure and function of a public water distribution system.

Resource

- SW.7.1.A.TM – *Public Water Distribution System* slide.

Equipment

Computer
LCD projector
Screen

Resources, Tools, Equipment and Supplies

7.1.b. Describe the important components of a CCR.

Resources

- SW.7.1.B.TM – *Requirements for CCR* slide
- SW.7.1.B.AS – CCR Worksheet; one copy for each student or group as needed
- *Consumer Confidence Reports,* EPA, http://water.epa.gov/lawsregs/rulesregs/ sdwa/ccr/index.cfm
- *Drinking Water Consumer Information*, EPA, http://water.epa.gov/drink/info/ index.cfm
- *Public Drinking Water Systems Programs,* EPA, http://water.epa.gov/ infrastructure/drinkingwater/pws/index.cfm

Equipment

Computer
LCD projector
Screen

7.1.C. Describe the work of a water treatment plant or system operator.

Resource

- SW.7.1.C.AS – *Water Treatment Plant and System Operators* handout; one for each student

7.2. Describe options for private well drinking water treatment for common, local contaminants.

Resources

- SW.7.2.TM – *Steps for Identifying Potential DW Problems and for Selecting a DW System Drinking Water and Human Health*: http://www.extension.org/pages/ Home_Water_Treatment_Devices
- *Private Drinking Water Wells*, EPA, http://water.epa.gov/drink/info/ well/index.cfm

Equipment

Computer
LCD projector
Screen

Key Terms

Cryptosporidium

Consumer Confidence Report

Contaminant levels

Microorganisms

Regulatory procedures

Water treatment plant

SUMMARY OF CONTENT AND TEACHING STRATEGIES:

CAREER EMPHASIS

DRINKING WATER SYSTEM OPERATORS

Water treatment plant and system operators treat water so that it is safe to drink. Pumped from aquifers, rivers, streams and reservoirs to water treatment plants, most water then undergoes a series of processes, as needed, to remove or destroy harmful materials and microorganisms. System operators ensure that the purification process goes smoothly and efficiently.

To do this, water treatment plant and system operators control high-tech equipment, such as control pumps, valves, and computers, which move the water through the numerous treatment processes. Operators are responsible for testing the water at various stages of treatment; interpreting and adjusting meters and gauges; performing chemical and biological laboratory analyses; and developing the Consumer Confidence Report. Advanced computer technology has provided operators with a valuable tool for monitoring equipment, testing the water for harmful materials, and troubleshooting problems in the treatment process. The complexity of this work depends on system size, contaminants present and contaminant sources.

Drinking water system operators must follow the drinking water standards set, and other requirements under the authority of the Safe Drinking Water Act. The Safe Drinking Water Act sets standards for drinking water. Because new contaminants are added to the prohibitions on a regular basis, operators must be familiar with all federal and local regulations, laws, and standards regarding the quality of drinking water.

In large water treatment plants, operators work with chemists, engineers, laboratory technicians, mechanics, and supervisors. They often specialize in one aspect of the water treatment process and have a lot of support staff to ensure the process goes smoothly. They may also have additional staff specializing in source water protection to identify potential sources of contamination, identify possible solutions, talk with local land use decision makers, develop and implement a source water protection plan to reduce threatened or actual contamination. In smaller plants there are fewer employees; therefore, an operator may be responsible for many tasks, such as operating machinery, keeping records and performing repairs and maintenance.

Consumer Confidence Reports

A. Purpose for Consumer Confidence Reports (*CCR)*

1. Examine local Consumer Confidence Reports for information on your local public drinking water supply
2. Available at www.epa.gov/safewater/dwinfo.htm

B. Parts of a ***CCR***

1. Water source
2. Summary
3. How to obtain the report
4. Levels of contaminants
5. Sources of contaminants
6. Regulations and rules
7. *Cryptosporidium*
8. Educational information
9. Contact information

C. EPA's Drinking Water Hotline

D. Methods to determine if drinking water is impaired

1. Find out where your drinking water comes from (private well, public surface or groundwater source).
2. For public drinking water sources, see your local water system Consumer Confidence Report.
3. Six basic steps to help protect your private drinking water supply
   a. Identify potential problem sources
   b. Talk with local experts
   c. Have your water tested periodically
   d. Have the test results interpreted and explained clearly
   e. If you have a well, set and follow a regular maintenance schedule for your well, and keep up-to-date records
   f. Immediately remedy any problems

E. Actions to use if your drinking water is impaired

1. Point-of-use (POU) systems – treat water at a single tap
    a. Installed at various places in the home (counter top, faucet, under the sink)
    b. May not address some contaminants
2. Point-of-entry (POE) systems – treat water used throughout the house
    a. Installed where the water line enters the house
    b. May not address some contaminants
3. Examples of POU and POE systems
    a. Activated carbon filter – adsorb organic contaminants that cause taste and odor problems
    b. Distillation unit – boil water and condense the resulting steam to create distilled water
    c. Ion exchange unit – used to remove minerals (calcium and magnesium) from water; sold for water softening
    d. Reverse osmosis unit – generally remove a more diverse list of contaminants than other systems

F. Agencies that can provide resources and information

1. Contact your local water utility and public health department first to get the most specific information.
2. In most states, State Departments of Environmental Protection, Environmental Quality, or Public Health have responsibility for state drinking water protection programs (http://water.epa.gov/drink/local/).
3. Environmental Protection Agency (EPA) – EPA leads the nation's environmental science, research, education and assessment efforts. The mission of the EPA is to protect human health and the environment.

INTEREST APPROACH:

Examining a CCR for a local or regional area has significance to students now that they have learned about some common contaminants and their impacts. Understanding how and why local drinking water is treated is the logical result of the exploration of local water quality reports. Students explore the roles of the professionals who collect the testing data and treat the drinking water problems.

A suggestion for starting Lesson 7:

I'd like to tell you about the results of another contaminant in drinking water. In 1993 more than 400,000 people in Milwaukee, Wis., became ill when one of the two drinking water treatment plants failed to filter out the single-celled microbe, C*ryptosporidium*. More than 50 people, who had other compromising medical conditions, died as a result of complications of the outbreak. It has been estimated that the cost in loss of productivity and medical costs was more than $96 million.

Safety of drinking water became a topic of greater concern after this. In 1996, the Safe Water Drinking Act was amended to require community water systems to supply annual drinking water quality reports to consumers. These reports are called Consumer Confidence Reports (CCRs); they help us determine the safety of our public drinking water. We will look at CCRs today to find out what they report and what they can tell us about our local drinking water.

OBJECTIVE BY OBJECTIVE:

Activity Outline and Teacher Support Information:

In Lesson 7, *Drinking Water Treatment*, students will explore the workings of a public water treatment and distribution system, the roles of those responsible for providing safe drinking water, and the tool public water suppliers use to communicate to the public about the quality of their water.

7.1. Interpret consumer report(s) from a local drinking water utility.

Debrief on the homework assignment from Lesson 6 (SW.6.AS.HW). Ask students to brainstorm a list of skills someone on a professional water assessment team needs to measure and evaluate the results of drinking water tests. (mathematics, chemistry, others?)

7.1.a. Illustrate the basic structure and function of a public water distribution system.

Display slide SW.7.1.A.TM – Public Water Distribution System. Cities and townships often have a common water supply that is monitored and treated. The system might draw surface water, ground water, or a combination of the two, to distribute to homes, businesses, schools and other users in the community. Ask students to identify the source of the water in the diagram. After the water is retrieved from the water source it has to go through a water treatment plant to make sure it is safe to drink (blue line in the diagram). Drawing on their work in Lesson 3 and Lesson 6, ask students to predict what types of testing might occur at the water treatment plant.

Consumers of treated water receive a report on their drinking water quality generally every six to twelve months. This report is called a ***Consumer Confidence Report***. The EPA regulates what must be included in these reports. Let's take a look at the reporting requirements.

7.1.b. Describe the important components of a CCR.

Display SW.7.1.B.TM – Requirements for a **CCR** and introduce students to basic components of a CCR.

Requirements for a ***CCR (Consumer Confidence Report)***

1. The source of the water
2. A summary of the contaminants
3. How to obtain a copy of the full report
4. The level of the contaminants found in the water and the basic comparisons
5. The possible source of the contaminants
6. How the water quality is compliant with other water related rules
7. An explanation of how to avoid ***Cryptosporidium***

8. Educational information on nitrate, arsenic or lead in the areas where this may be a concern
9. Other contact information and additional information on water safety
10. EPA's Drinking Water Hotline
11. May include other information

For the following part of this activity, the instructor may choose a local CCR from the EPA site http://www.epa.gov/safewater/ccr/whereyoulive.html and make copies for students as needed. If Internet access is available to students, have students visit this website and choose a CCR to interpret.

Pass out copies of a CCR from a local water utility along with the CCR worksheet SW.7.1.B.AS. Ask students to complete the worksheet using information found in the CCR. This can be done as an individual or group activity.

7.1.c. Describe the work of a water treatment plant or system operator.

[CAREER EMPHASIS]

Who are the people who collect the data found in the CCR? – Water Treatment Plant and System Operators. Pass out copies of 7.1.C.AS the description of this particular career. Ask students to read the description. Have them reflect on the qualifications a person in this position might need to do the job effectively. Have them circle key words in the description that will help them decide, such as "control high tech equipment", "chemical and biological laboratory analyses." Emphasize that communicating with the public through tools like the CCR is an important role for system operators. If time allows, have students check the Internet for job opportunities in this field and note the qualifications listed to check their thinking. Any surprises?

7.2. Describe options for private well drinking water treatment for common, local contaminants.

Students have learned about potential drinking water contaminants and about what is included on a public water system drinking water report. People who use private drinking water systems are responsible for testing their own wells, and must interpret test results and take action to treat any problems themselves; the EPA does not require the testing of private wells. What steps should private well owners take to keep their drinking water safe?

Display slide SW.7.2.TM – *Steps for identifying potential drinking water problems and selecting a drinking water system*.[1] Review the steps –

1. Have water tested at a state certified or licensed lab.
2. Review lab results to determine if a water quality problem exists.

1 From eXtension Drinking Water and Human Health: http://www.extension.org/pages/31580/selecting-a-home-water-treatment-system

3. Contact your local health department or Cooperative Extension office for help understanding test results.
4. If test results show a problem, you may need a water treatment system to fix it.

When shopping for in-home water treatment systems you will likely find systems categorized as point-of-entry (POE) or point-of-use (POU) treatment systems. POE water treatment systems treat all of the water entering and being used in the home. POU water treatment systems, on the other hand, treats part of the water in the home water distribution system, usually at one faucet. The treated water is typically only used for drinking and cooking. Note that some drinking water contaminants can release contaminants into the air (increasing risk of exposure while showering, for example), and any treatment would need to take that into account. Choosing an in-home water treatment device can be confusing and complicated if more than one water quality problem exists. Sometimes, several problems can be eliminated with one treatment. In other treatment cases, two or more systems may be needed to satisfactorily treat the water.

Depending on your source of water, you may have to correct minor problems before you can address your major concern. The following guidelines for water treatment are based on the belief that it is practical and efficient to treat some water quality problems before others. For instance, only after turbidity, acidity, hardness and iron have been controlled will activated carbon filters, reverse osmosis units, or distillers operate efficiently. Turbidity, acidity, hardness and iron are included in the National Secondary Drinking Water Regulations (NSDWRs or secondary standards), which are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards. Students can read more about these contaminants at http://water.epa.gov/drink/contaminants/index.cfm#SecondaryList.

Remember, these steps are a simplification of water treatment. When considering home water treatment, well owners should consult with reputable water treatment professionals to determine the best treatment approach for the problem.

Students break into four groups. Each group should choose one well contaminant from the CCR report, collect information regarding the contaminant and treatment options for that contaminant, and makes a report to the class. Teachers may encourage students to use the eXtension Drinking Water site as a resource: http://www.extension.org/pages/ Home_Water_Treatment_Devices or can pass out copies of SW.7.2.AS – *Private Drinking Water Systems*.

REVIEW / SUMMARY:

Respond to these questions in your journal:

- Is the water in your home obtained from a private well or a community drinking water system?
- If you were planning to purchase a home, what questions would you ask about the drinking water system?
- What measures can you take, as an individual, to be certain that the water you drink is safe?
    - If you get water from a public water system
    - If you get water from a private well system

EVALUATION AND ANSWERS:

SW.7.1.ASSESS

Name _____

1. What is the purpose of a Consumer Confidence Report?

_____

2. How often is a Consumer Confidence Report required to be released from the water utility?

_____

3. Using the information provided in the chart below answer the questions A-C:

SW.7.1.ASSESS *(continued)*

Water Testing Results for Citytown, USA

Detected Substance	Units of Measure	MCL	MCLG	Violation	Range Detections	*Typical Source in Drinking Water*
Fluoride (ppm)	0.9	4	4	No		*Added for dental health*
Copper (ppm)	0.067	1.2	0	No	No results exceeded action level	*Common household plumbing*
Nitrate (ppm)	*0.1*	*10*	*N/A*	*No*		*Fertilizer runoff; septic tank leakage; sewage; runoff*

A. What was the level of fluoride in the city water supply this year?

_____

B. Did the city/town water supply meet all the required level of contaminants? If not, list the affected areas.

_____

_____

C. Where might the copper contaminants come from?

_____

_____

Answers to Evaluation

1. To inform the customer of the quality of drinking water, to educate the consumer on drinking water

2. At least once a year

3. A. 0.9

   B. Yes

   C. Common household plumbing

ACTIVITY WORKSHEET(S) – AS NEEDED:

SW.7.1.B.AS

Consumer Confidence Report Worksheet

Name _____

As you read over the report look for the following information:

1. What is the source of the water? _____

2. How safe is the water based on the testing that was completed?

_____

_____

3. Did any of the contaminant levels not meet the EPA requirements? If yes, which contaminant?

_____

_____

4. What are some if any potential health effects in the water?

_____

_____

5. Does it include information about *Cryptosporidium*? If yes, what information?

_____

_____

_____

SW.7.1.B.AS *(continued)*

6. Does it include any educational information about water?

_____

_____

7. Does it include contact information about the water system or supplier?

_____

_____

8. Is it easy to understand? Why or why not?

_____

_____

9. What questions do you have about this report?

_____

_____

SW.7.1.C.AS

CAREER EMPHASIS

Water Treatment Plant and System Operators[2]

Water treatment plant and system operators treat contaminated water so that it is safe to drink. Pumped from aquifers, rivers, streams and reservoirs to water treatment plants, water then undergoes a series of processes that remove or destroy harmful materials and microorganisms. System operators ensure that the purification process goes smoothly and efficiently.

To do this, water treatment plant and system operators control high-tech equipment, such as control pumps, valves, and computers, which moves the water through the numerous treatment processes. Operators are responsible for testing the water at various stages of treatment; interpreting and adjusting meters and gauges; and performing chemical and biological laboratory analyses. Advanced computer technology has provided operators with a valuable tool for monitoring equipment, testing the water for harmful materials and troubleshooting problems in the treatment process.

Water treatment plant and system operators must follow the water pollution standards set by the Clean Water Act and the Safe Drinking Water Act. In the Clean Water Act, the federal government strictly controls the discharge of pollutants in the water supply. The Safe Drinking Water Act sets standards for drinking water. Because new contaminants are added to the prohibitions on a regular basis, operators must be familiar with all federal and local regulations, laws and standards regarding the quality of drinking water.

In large water treatment plants, operators work with chemists, engineers, laboratory technicians, mechanics and supervisors. They often specialize in one aspect of the water treatment process and have a lot of support staff to ensure the process goes smoothly. They may also have additional staff specializing in source water protection to identify potential sources of contamination, identify possible solutions, talk with local land use decision makers, develop and implement a source water protection plan to reduce threatened or actual contamination. In smaller plants there is fewer staff; therefore, an operator may be responsible for many tasks, such as operating machinery, keeping records and performing repairs and maintenance.

2 StateUniversity.com, http://careers.stateuniversity.com/pages/43/Water-Treatment-Plant-System-Operator.html

SW.7.2.AS

Private Drinking Water Systems[3]

The table below outlines information on specific home water treatment approaches. Keep in mind that some water treatment can be for aesthetic as well as health factors. For instance, the amount of iron in your water might not a pose a health risk, but may stain sinks or tubs. If drinking water poses a health risk, the well owner may also consider the cost of purchasing bottled water or tying into a public water system if available as an alternative to treatment. Private well owners should always contact a water treatment professional to install or repair a home treatment system or to assess a problem.

Device	Primary Use	Limitations
Activated Carbon Filter	Removes chlorine, volatile organic compounds (VOCs), radon, some synthetic organic compounds (SOCs), and general taste and odor problems.	• Does not remove nitrate, bacteria or inorganic compounds. • Periodic replacement of activated charcoal required. • Would not address radon in indoor air from soil under the home
Reverse Osmosis	Removes more contaminants than any other treatment system except distillation, some organic chemicals (not volatile or semi volatile), pesticides, bacteria and viruses.	• Does not remove all organic chemicals, such as chloroform. • Does not remove 100 percent of most chemicals. • Uses large amounts of water. • Not recommended for bacteria and dissolved gases.
Ion Exchange	Cation Exchange Units - Removes positively charged ions, inorganic compounds, such as iron and manganese ions, arsenic, chromium, and hard water minerals - calcium and magnesium. Anion Exchange Units - Removes negatively charged ions such as nitrates, bicarbonate, selenium and sulfate.	• Removal of one type of ion replaced with another, for example iron removed may be replaced with sodium. • Periodic backwashing and regeneration required.

3 From eXtension Drinking Water and Human Health: http://www.extension.org/pages/31581/home-water-treatment-devices

SW.7.2.AS *(continued)*

Device	Primary Use	Limitations
Filtration	Removes small particles and suspended solids such as ferric iron, clay, silt and sand, and some pathogens such as bacteria and viruses and colloids (suspended matter).	Filter replacement based on concentration of contaminant, pressure head loss and water usage in the home.
Distillation	Removes dissolved minerals, trace amounts of metals and some toxic organic chemicals.	• Might produce bland-tasting water. • Small capacity units produce limited quantity for drinking, cooking. • Large units require kitchen or adjoining space or small diameter plastic plumbing can be run to the faucet location from a basement unit. • Not effective against most volatile and semi-volatile chemicals and some bacteria.
Aeration	Dissolved gases like radon, carbon dioxide, methane and hydrogen sulfide, as well as volatile organic compounds, like MTBE or industrial solvents. Aeration can be used for the precipitation and removal of dissolved iron and manganese.	• If iron and manganese are present in solid form, pre-treatment of the water to remove these particles before entering the aeration treatment and post-treatment may be necessary. • Waste air must be vented from house in such a way as to prevent contamination of indoor air quality.
Ultraviolet Radiation	Efficient at inactivating vegetative and sporous forms of bacteria, viruses, and other pathogenic microorganisms.	Not recommended if the untreated water contains high levels of total coliform bacteria, substantial color or turbidity. Does not improve the taste, odor, or clarity of water.

SW.7.2.AS *(continued)*

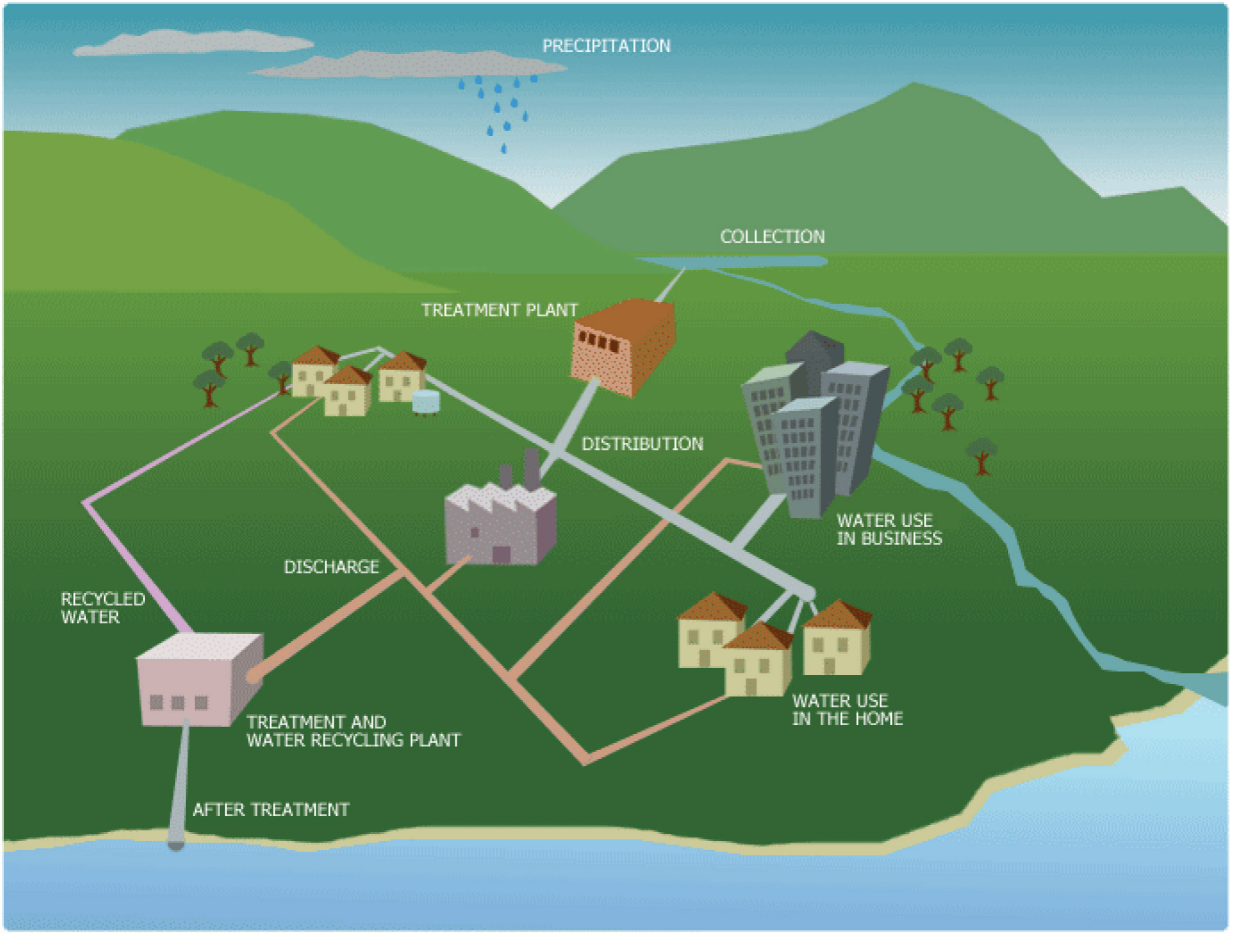
Device	Primary Use	Limitations
Ozone	Pathogenic (disease-causing) organisms including bacteria and viruses, phenols (aromatic organic compounds), some color, taste and odor problems, iron and manganese and turbidity.	Not effective for large cysts and some other large organisms, inorganic chemicals, heavy metals.
Activated Alumina	Used primarily for removing fluoride and arsenic.	May require a post-treatment system for bacteria removal.
Chlorination	Used to treat viruses and bacteria; dissolved iron, manganese and hydrogen sulfide; iron, manganese and sulfur bacteria.	May require a post-treatment system for taste and odor removal.
Oxidation • Potassium	Used to treat viruses and bacteria; dissolved iron, manganese and hydrogen sulfide; iron, manganese and sulfur bacteria.	• Requires careful calibration and monitoring. • Potassium permanganate is a skin irritant.
pH Adjustment	Neutralizing filters and soda ash/ sodium hydroxide injection raise the pH of drinking water to near neutral 7. Acid injection lowers pH to near neutral 7.	pH adjustment does not treat any type of contaminants in water; it serves to lower or raise pH until a neutral level is reached. Neutralizing filters can cause hardness in treated water. Sodium hydroxide and strong acids such as sulfuric acid and hydrochloric acid can be hazardous to handle and store.

Adapted from Household Water Treatment by Annette Bach and Darnell Lundstrom. 25 HF & E-2. NDSU Extension Service, North Dakota State University, Fargo, ND 58105. June 1988.

POWERPOINT SLIDES – AS NEEDED:

SW.7.1.A.TM

Public Water Distribution System Diagram



SW.7.1.B.TM

Requirements for a (Consumer Confidence Report) CCR

1. The source of the water
2. A summary of the contaminations
3. How to obtain a copy of the full report
4. The level of the contaminants found in the water and the basic comparisons
5. The possible source of the contaminants
6. How the water is compliant with other water related rules
7. An explanation of how to avoid *Cryptosporidium*
8. Educational information on nitrate, arsenic or lead in the areas where this may be a concern
9. Other contact information and additional information on water safety
10. EPA's Drinking Water Hotline
11. May include other information

SW.7.2.TM

Steps for identifying potential drinking water treatment problems and for selecting a drinking water system:

1. Have water tested at a state certified or licensed lab
2. Review lab results to determine if a water quality problem exists
3. Contact your local health department or Cooperative Extension office for help understanding test results
4. If test results show a problem, you may need a water treatment system to fix it
5. Contact a drinking water professional for assistance in identifying and installing the proper treatment system