What are the threats to water quality in agricultural areas? **Lesson: 4**

National Science Education Standards for Grades 9-12

Content Standard D: Earth and Space Science: Geochemical Cycles

- *Movement of matter between reservoirs is driven by the earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter.*

Content Standard E: Science and Technology: Abilities of Technological Design

- *Communicate the problem, process and solution.*

Content Standard F: Science in Personal and Social Perspectives: Environmental Quality

- *Many factors influence environmental quality. Factors that students might investigate include population growth; resource use; population distribution; overconsumption; the capacity of technology to solve problems; poverty; the role of economic, political and religious views' and different ways humans view the earth.*

Content Standard F: Science in Personal and Social Perspectives: Natural and Human-Induced Hazards

- *Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by human beings bring benefits to society, as well as cause risks.*

Student Learning Objectives

4.1 Define different sources of water pollution, both human and natural: Point vs. Nonpoint Source Pollution (broadly)

4.2 Define the most common threats to local sources of drinking water

4.3 Communicate to others about drinking water contamination

Teacher Info Table Time

Instruction time for this lesson: 90 minutes

Resources, Tools, Equipment and Supplies

4.1. Define different sources of water pollution, both human and natural: Point vs. Nonpoint Source Pollution (broadly)

Resources

- Copies of SW.4.1.AS – Source Water Contamination worksheet
- *Sources of Groundwater Contamination*, The Groundwater Foundation, http://groundwater.org//gi/sourcesofgwcontam.html
- *Groundwater Information,* USGS, http://water.usgs.gov/owq/
- *Polluted Runoff (Nonpoint Source Pollution),* Environmental Protection Agency, http://www.epa.gov/owow_keep/NPS/index.html
- *Polluted Runoff: Nonpoint Source Fact Sheets*, Environmental Protection Agency, http://www.epa.gov/owow_keep/NPS/facts/index.html

4.2. Define the most common threats to local sources of drinking water

Resources

- Powerpoint slide SW.4.2.TM – Point vs. nonpoint source pollution
- Access to Internet for accessing natural resources agencies, organizations and/or professionals
- *Drinking Water Contaminants*, U.S. EPA, http://water.epa.gov/drink/contaminants/index.cfm
- *Basic Information about Pathogens and Indicators in Drinking Water,* U.S. EPA, http://water.epa.gov/drink/contaminants/basicinformation/pathogens.cfm
- *Water Where You Live*, U.S. EPA, http://water.epa.gov/type/location/states/. Maximum *Water Quality Assessment and Total Maximum Daily Loads Information*, U.S. EPA, http://www.epa.gov/waters/ir/

Resources, Tools, Equipment and Supplies

4.2. Equipment

Computer
LCD projector
Screen

4.3. Communicate to others about drinking water contamination

Resources

- Access Public Service Announcements in the EPA's Nonpoint Source Outreach Toolbox at http://cfpub.epa.gov/npstbx/index.cfm
- *Getting in Step: A Guide for Conducting Watershed Outreach Campaigns*, U.S. EPA, http://cfpub.epa.gov/npstbx/files/getnstepguide.pdf
- *Source Water Stewardship: A Guide to Protecting and Restoring Your Drinking Water*, http://.cleanwateraction.org/publication/source-water-stewardship-guide-protection-and-restoring-your-drink-water

Key Terms

Disinfectant
Disinfection byproduct
Insecticides
Microbes
Nonpoint source pollution
Nutrients
Pathogen
Point source pollution
Public service announcement
Runoff
Toxin
Water contamination

SUMMARY OF CONTENT AND TEACHING STRATEGIES:

Sources of Drinking Water Contaminants

Point source pollution comes from one or a series of known discharge points from a commercial or public facility. Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS is caused by rainfall or snowmelt moving over and through the ground. As runoff moves, it picks up and carries away natural and manmade pollutants, depositing them into lakes, rivers, wetlands, coastal waters and groundwaters. This contamination is often referred to as polluted or stormwater runoff.

NPS can include:

- Excess fertilizers, herbicides and insecticides from agricultural lands and residential areas
- Oil, grease and toxic chemicals from urban runoff and energy production
- Sediment from improperly managed construction sites, crop and forest lands and eroding stream banks
- Salt from irrigation practices, road de-icing and acid drainage from abandoned mines
- Bacteria and nutrients (nitrogen and phosphorous) from livestock, wildlife and pet wastes and bacteria, nutrients and viruses from improperly designed, located, constructed, or maintained septic systems
- Atmospheric deposition: Pollution from coal-fired power plants and automobiles is deposited either directly into water or is deposited onto land and then carried to water bodies by runoff
- Hydromodification: Building dams, modifying channels, erosion of stream banks and shorelines are examples of hydro-modification

Source Water Contamination

A. Residents who live in suburban and urban areas often drink treated surface water. Residents who live in rural areas often drink untreated groundwater.

   1. Surface water: Water that comes from lakes, rivers and reservoirs. The watershed is the area of land where water flows into such bodies of water.
      a. Drinking water problems in *treated* surface water could include contaminants not affected by treatment, such as manufactured chemicals or contaminants created during treatment such as disinfection byproducts

b. Contaminants found in *untreated* surface water sources of drinking water could include residues from pharmaceuticals, including antibiotics; antidepressants; hormones from birth control pills; painkillers; microbial pathogens, such as *Giardia*; enteroviruses; antibiotic-resistant bacteria; nitrate from nitrogen fertilizer; and other contaminants from commercial and industrial, agricultural, and wastewater sources

2. Groundwater: Water that was pumped from a well. Wells tap into aquifers, which are the natural reservoirs under the earth's surface.

3. Drinking water risks in groundwater include microbial pathogens, nitrate from nitrogen fertilizer, arsenic, radium or radon contamination, which stems from the soil and rock that comes in contact with the drinking water source.

B. All people whether they live in suburban, urban or rural areas may face specific drinking water risks relative to location or how the water is supplied.

1. Drinking water contamination caused by human activity, animal activity and naturally occurring substances are a potential risk in suburban, urban and rural drinking water supplies
   a. A home in a rural, suburban or urban neighborhood could have corroded household plumbing, which may cause a drinking water risk from lead or copper contamination
   b. Someone living in a rural, suburban or urban community downstream from or drawing groundwater near a farm with row crops may be faced with drinking water contamination caused by *E. coli 0157:H7*, a bacterial pathogen typically found in cattle, that produces toxins that cause kidney failure in children and the elderly; alachlor, an organic chemical from herbicide runoff; or nitrate, resulting from application of nitrogen fertilizer to row crops
   c. People living in suburban, urban and rural communities may all be faced with a drinking water risk caused by contamination from microbes and insecticides

2. Suburban, urban and rural drinking water problems can cause mild health risks – upset stomach or other gastrointestinal illnesses – to severe health risks – Blue Baby Syndrome, liver or kidney problems or cancer

3. Minor health risks like gastrointestinal illnesses can occur from short-term exposure to the drinking water contaminant. However, these illnesses may be a more severe threat to children, the elderly and people with compromised immune systems

4. Severe health risks such as cancer are typically the result of long-term exposure to drinking water contaminants. Other severe health risks can be illnesses associated with microbes, such as *Salmonella* or *E. coli 0157:H7*. Many originate from domestic animals, including cows, hogs and hens

5. The health effects associated with agricultural production of crops and livestock include cancer or birth defects produced by pesticides and herbicides, Blue Baby Syndrome produced by excess nitrogen and kidney failure associated with toxin producing bacteria such as *E. coli 0157:H7* or *Shigella*

C. Drinking water problems are caused by three sources: Human activity, animal activity or naturally occurring substances.

1. Drinking water contamination caused by human activity:
    a. Chemicals that are used excessively or improperly disposed of (discharged onto land so that they percolate into aquifers), such as fertilizers, pesticides, disinfections byproducts

        - A disinfectant is a chemical, like chlorine, that kills microorganisms such as viruses, bacteria and protozoa

        - Disinfection byproducts are formed when disinfectants (such as chlorine) used to treat drinking water react with natural organic matter (e.g. algal blooms from excess nutrients in source waters). Some disinfection byproducts have been linked to cancer; reproductive health risks; and nervous system problems.

    b. Leaking or improperly designed, located, constructed, or maintained septic systems allow viruses, bacteria and other microorganisms to seep into water sources. Microorganism means small living organism, such as bacteria – some can cause acute health problems when consumed. Disease-causing organisms are called pathogens
    c. Industrial products and wastes, such as leaking or improperly maintained landfills, open waste dumps or local factories
    d. Inadequately treated sewage
    e. Improperly treated or disinfected drinking water
    f. Household plumbing materials, such as lead or copper

2. Drinking water contamination caused by animal activity
    a. Animal waste from farms, which may contain contaminants such as nitrate bacteria, antibiotics or arsenic (from poultry waste) that can runoff into drinking water sources
    b. Viruses from animal waste
    c. Microorganisms from wildlife

3. Drinking water contamination caused by naturally occurring substances
    a. Microorganisms found in soil or rock
    b. Metals found in underground rocks can contain arsenic, lead, radium or radon
    c. Nitrate or nitrite: Nitrogen compounds found in soil

D. Sources of potential contamination (from state source water assessments of drinking water):

1. Agriculture: Concentrated animal feeding operations, grazing, crop production, fertilizer/pesticide application, agricultural irrigation, tile or ditch drains/agricultural drainage wells
2. Commercial/Industrial: Gas stations, chemical/petroleum storage, dry cleaners, storage tanks, mining and industrial discharge and disposal
3. Wastewater systems: Municipal sanitary waste treatment and disposal, (improperly functioning wastewater utilities), large capacity septics, on-site sewage disposal systems
4. Transportation: Airports, railroads/subways, freeways/highways, roads/streets
5. Residential: Leaking or improperly maintained septic systems, lawn/garden care, underground and above ground storage tanks
6. Contaminated sites: known contaminated sites, plumes, spills; leaking, underground storage tanks
7. Other contaminants include pharmaceuticals and personal care products and other emerging contaminants of potential concerns

E. Types of Contaminants

1. Inorganic contaminants/chemicals: Mineral-based compounds, such as metals, nitrates and asbestos, that are naturally occurring in some water but can also enter water through human activities
    a. Discharge from petroleum refineries
    b. Discharge of drilling waste
    c. Discharge from metal refineries
    d. Discharge from coal-burning factories
    e. Discharge from steel and pulp mills
    f. Erosion of natural deposits
    g. Discharge from factories
    h. Discharge from electronics, glass and drug factories
    i. Runoff of chemical fertilizers

2. Organic contaminants/chemicals: Carbon-based chemicals, such as solvents, pesticides and herbicides, that enter water through cropland runoff or discharge from factories
    a. Runoff from pesticides and herbicide used on crops
    b. Discharge from drug and chemical factories
    c. Discharge from petroleum refineries
    d. Industrial discharge

F. Sources of Pollution

1. *Natural disaster:* An episode in which the processes of nature cause human or animal suffering. These episodes can transport contaminants so that they enter drinking water or they can disable water treatment systems
    a. Hurricanes
    b. Earthquakes
    c. Floods
    d. Seismatic waves (tidal waves, tsunamis)
    e. Tornados
    f. Droughts
    g. Avalanches
    h. Forest fires
    i. Volcanoes
    j. Landslides
    k. Sink holes

2. *Point source:* Pollution comes from a direct, identified source
    a. Sewage treatment plants
    b. Sewer systems
    c. Storm drains
    d. Industries discharging contaminated water back into the environment
    e. Accidental spill, such as an oil rig explosion or ship crash
    f. Concentrated animal feeding operations (CAFOs)
    g. Storm water from municipalities, construction, and industry

3. *Non-point source:* Pollution that comes from many diffuse sources
    a. Fertilizer, herbicide and insecticide from agricultural lands
    b. Oil, grease and toxic chemicals from urban runoff and energy production
    c. Sediment from improperly managed construction sites, crop and forest lands and eroding stream banks
    d. Acid drainage from abandoned mines
    e. Bacteria and nutrients from livestock, pet wastes and septic systems, including antibiotic-resistant bacteria
    f. Agricultural storm water and irrigation return flows

INTEREST APPROACH:

Students will be engaged by the opportunity to develop a public service announcement that relates to a pollutant that is of concern to them individually.

Working in groups, students will develop public service announcements that relate to a pollutant that is of concern to them individually. Additions to the map or model they developed in Lesson 1 will help students apply broad concepts to their local concerns, giving meaning to the activities.

Record, cue up on websites or snap photos of public service announcements about drinking and driving from TV, billboards or other media outlets. An Internet search will provide many options; two good sources are http://www.adcouncil.org or http://www.madd.org/.

Take a look: Display public service announcements related to drinking and driving.

What is the purpose of ads like this? *Elicit responses about public education.*

Today, we'll look at some public service announcements related to water pollution and have a chance to create our own PSAs.

OBJECTIVE BY OBJECTIVE:

Activity Outline and Teacher Support Information:

Lesson 4 "*What are the threats to water quality in agricultural areas?"* focuses on point and nonpoint water pollution. Students will determine potential sources of contamination in their own watersheds and create a public service announcement about a local drinking water threat.

4.1. Define different sources of water pollution, both human and natural: Point vs. Nonpoint Source Pollution (broadly)

In this small group activity, students will focus on identifying potential water contaminants. Divide the class into seven groups. Assign each group one of the sections (A-G) from SW.4.1.SA. Ask each group to read the content and develop a creative strategy for conveying that content to the class. Ask students to present the information from their section verbally and also highlight one or two important points from their section, using a more creative means of communicating, such as music, mime or art work. The purpose of this activity is to introduce them to the contaminant lesson materials and have them think about how they might communicate to others about drinking water issues. What would be an effective way to engage their classmates and community in thinking about these issues?

4.2. Define the most common threats to local sources of drinking water.

States report that nonpoint source pollution is the leading remaining cause of water quality problems. The effects of nonpoint source pollutants on specific waters vary and may not always be fully assessed. However, we know that these pollutants have harmful effects on drinking water supplies, recreation, fisheries and wildlife.

Present content from slide SW.4.2.TM to the class. Content focuses on the differences between point and nonpoint source pollution and important considerations for assessing source water issues. Ask students to think about nonpoint source pollution in their community. Have them decide as a group what they think might be the most common NPS contaminants locally. Then to check their thinking, have them find state, county and local agencies or organizations, such as drinking water utilities or watershed groups, to help verify which water contaminants are most common in local agricultural areas and which bodies of water are affected according to their search. They should report back to the class about their findings.

Suggested resources for students:

- Local newspaper articles that discuss local water pollution issues
- State and county natural resources web resources

- State departments of environmental protection/quality and departments of health. Students may use this EPA website to locate their own state's resources: http://water.epa.gov/type/location/states/
- State department of natural resources professionals or other local water resource experts
- Local Drinking Water Information: http://water.epa.gov/drink/local/"

Students should mark the affected waters on their watershed maps or models from Lesson 1.

4.3. Communicate to others about drinking water contamination[1]

A Public service announcement (PSA) is a brief presentation of a message by a non-profit organization via broadcast media. The term "public service" should be understood to mean that it is in the interest of and for the benefit of the public and the time allocation for which is provided free of charge by the broadcaster. (Subset of public service advertising which can include print media.)

Students will choose four PSAs to watch that describe various NPS issues. The videos are available for viewing from this EPA site: http://www.epa.gov/owow_keep/NPS/toolbox/TVcatalog.htm

What pollutants are mentioned in the PSAs they choose? Write the list on the board. Who is the audience for each PSA? Are these audiences mostly urban, suburban or rural communities? What discrete action is the PSA encouraging the audience to take to conserve or protect water?

Ask students, individually or in a small group, to write the script for their own PSA announcement designed to draw attention to nonpoint source pollution issues in a rural community. Ask the students to answer the following questions:

- What one source water issue would you focus on and why?
- What needs to be done to improve the water issue? (This might take some Internet research or a discussion with a local natural resource professional).
- Who is the audience for the PSA and why? Be as specific as possible in choosing the audience (for example, a suburban homeowner, lakeshore property owner, car owner, pet owner, livestock or crop producer).
- What specifically do you think the audience needs to do to protect drinking water? (for example, avoid raking leaves into the street, maintain natural shoreline vegetation, wash car on the lawn or at car wash and pick up pet waste)
- What type of PSA would you create – a video for TV or a radio announcement? Why?

SW.4.3.ASSESS provides a rubric for evaluating the presentations.

1 From EPA Communications: Stylebook Appendix B – Glossary http://www.epa.gov/productreview/stylebook/appb.html

REVIEW / SUMMARY:

To make their points to the intended audience, public service announcements rely on dramatic elements to capture attention and elicit emotion. How did the PSAs about drinking and driving make their points effectively? How did your PSA about pollution issues drive its point home to viewers? Write answers down in journals.

APPLICATION:

Pollution and Pollywogs may interest students who built a watershed model in activity 1.3. and will extend their comprehension of nonpoint source pollution.

Activity: Pollution and Pollywogs
This activity is best to split it up into two programs. The first one that would focus on introducing run-off pollution into our waterways and the second addressing how scientists study effects of water pollution on organisms that live in those waterways.

Week I: Pollution

Materials needed:

- 9 x 13 aluminum foil pans (or plastic)
- Material for making the landscape in the pan (e.g., scrap paper, bubble wrap, styrofoam)
- Aluminum foil (as "ground")
- Different colors of Kool-Aid to represent different types of pollution
- Spray water bottles (1 per every 2-3 students)
- Worksheet (Part 1)
- Plastic tablecloth and garbage bags

Creating a watershed

- Students are asked to create a watershed in a shallow pan using crumpled paper, styrofoam, etc., so that they have "high" and "low" places in their pan
- Cover the paper and styrofoam with a large piece of aluminum foil to make the ground. Students use different colored markers to draw different characteristics of their watershed (e.g., parks, river, roads, farms, houses, industrial buildings)
- As a group we determine which color of Kool-Aid should represent the different types of pollution that are wrote up on the board (e.g., green for fertilizer, purple for car oil/gas)
- The students sprinkle a little bit of Kool-Aid crystals in the appropriate places (pollution sources) on the watershed
- A big storm blows through town and waters everyone's watershed (use the spray bottle to rain over watershed); the Kool-Aid crystals dissolve and the colored-water starts to run down their watersheds into their rivers and lakes

Goals/Desired Results: Skill or concepts

- Creating hypotheses
- Learning new vocabulary
- Observing

APPLICATION: *(continued)*

Evidence of Learning (acceptable evidence)

What evidence could be used to determine that the kids actually learned these concepts/skills?

1) Introduce concept with initial discussion
   - I first ask the students if they have heard the word "pollution" before and what that means to them. Then we talk about where pollution comes from- what are some sources of pollution? I write them on the board so that all of the students can read them.
2) Introduce vocabulary and ask the students to apply the vocabulary
   - Introduce the idea of point versus non-point source pollution and ask them to identify which types we have talked about and write match them up on the worksheet I provided for them (see next page).
3) Practice making predictions
   - I would like them to think about how weather could influence pollution, and make predictions about how pollution moves between environments. Each student (or pairs of students) would then write down a prediction on their worksheet. After students have written down their predictions, we would then discuss as a group.
4) Trial 1
   - Allow students to create a landscape and then follow it through to the rain storm. Following the first trial, ask the students to write down on their worksheet what happened in their watershed. Did their predictions hold?
5) Evaluation and creation of a test-able hypothesis
   - Ask whether a variable could be manipulated to change the level of run-off pollution in their watersheds and with this information create a hypothesis for their second trial. This would be recorded on their worksheet.
6) Trial 2
   - Run experiment again and change one variable (e.g., location of pollutant sources in watershed, types of land usage – parks vs. industry vs. farms – location of physical barriers between pollution sources and waterways).
7) Evaluation
   - Record what happened the second time and if they notice anything different.

APPLICATION: *(continued)*

Discussion following the rain event in each watershed would get them actively sharing their new information with each other which is vital to their learning process and allow for students to teach other students.

Pollution and Pollywogs

Part I) Pollution: Creating a watershed

Types of Pollution	Point source (P) or Non-point source (NP)?

Predict how you think pollution will move in your watershed:

APPLICATION: *(continued)*

TRIAL 1: Observations

What variable will you change?

What is your hypothesis?

APPLICATION: *(continued)*

TRIAL 2: Observations: Did anything change from TRIAL 1?

Activity: 'Pollution and Pollywogs'.

Week II: Pollywogs

Materials needed:

- Paper strips (will serve as game pieces)
- Pens
- Four plastic containers (old cottage cheese/yogurt containers). These will be used to hold paper strips.
- Dry beans
- Worksheet (Part 2)

1) Create game pieces that reflect how pollution may impact growth of tadpoles; write these down on worksheet.

2) Students are split up into groups that represent four different ponds with different levels of pollution (none to high):
   - Control group (no pollution)
   - Low pollution level
   - Medium pollution level
   - High pollution level

3) Tell students a story about a group of scientists that want to find out about how each pollution level affects tadpole growth. Each group begins with five beans and is comprised of happy little tadpoles. They need to acquire 15 beans to begin metamorphosis and 20 beans to become frogs.

4) During each round of the game or week of the scientists' experiment, a student from each group picks a piece of paper from their group's cup to tell them how they will grow (or perhaps not grow). For example, a control group may pick a paper that says, "Found Algae to Eat: 5 beans," while a medium group may be one that say, "Slow hind limb development: Lose 2 beans." In addition, jumping jack penalties are introduced to demonstrate how energy requirements might be different in stressful living conditions.

5) Create dose response curve on worksheet.

This game teaches the students that the tadpoles become metamorphs first and then frogs and that if they are developing in waters that are polluted it may take the tadpoles longer to become frogs (or they may never develop into frogs).

APPLICATION: *(continued)*

'Pollution and Pollywogs'

Part II) Pollywog Growth and Development Game

How might pollution affect tadpole growth?

_____

_____

What was the result of increased pollution in this study?

_____

_____

Draw a graph to represent the findings:

EVALUATION AND ANSWERS:

SW.4.3.ASSESS

Public Service Announcement Rubric Check List

Group members _____

_____The PSA was informative (3 points).

_____ The presentation was developed to reach a particular audience (3 points).

_____ The PSA identified a specific action the audience might take to protect drinking water (3 points).

_____ The PSA was engaging (3 points).

_____ Group members followed directions and participated (3 points).

Total Score _____

ACTIVITY WORKSHEET(S) – AS NEEDED:

SW.4.1.AS

Source Water Contamination

A. Residents who live in suburban and urban areas often drink treated surface water. Residents who live in rural areas often drink untreated groundwater.

1. Surface water: Water that comes from lakes, rivers and reservoirs. The watershed is the area of land where water flows into such bodies of water.
    a. Drinking water problems common in *treated* surface water include contaminants not affected by treatment such as manufactured chemicals, or contaminants created during treatment, such as disinfection byproducts
    b. Contaminants found in *untreated* surface water sources of drinking water could include residues from pharmaceuticals, including antibiotics, antidepressants, birth control pills, painkillers; microbial pathogens, such as *Giardia*, enteroviruses, antibiotic-resistant bacteria, nitrate from nitrogen fertilizer/manure, and other contaminants from commercial/industrial, agricultural and wastewater sources
2. Groundwater: Water that was pumped from a well. Wells tap into aquifers, which are the natural reservoirs under the earth's surface
3. Drinking water risks more common in groundwater include microbial pathogens, nitrate from nitrogen fertilizer/manure, arsenic or radium contamination, which stems from the soil and rock that comes in contact with the drinking water

B. While people who live in suburban, urban or rural locations may face specific drinking water risks relative to location or how the water is supplied, most of the drinking water issues can occur in all types of drinking water

1. Drinking water contamination caused by human activity, animal activity and naturally occurring substances are a potential risk in suburban, urban and rural drinking water supplies
    a. A home in a rural, suburban or urban neighborhood could have corroded household plumbing, which may be a drinking water risk because of lead or copper contamination

SW.4.1.AS *(continued)*

b. Someone living in a rural, suburban or urban community downstream from or drawing groundwater near a farm with row crops may be faced with drinking water contamination caused by *E. coli 0157:H7*, a bacterial pathogen typically found in cattle, that produces toxins that cause kidney failure in children and the elderly; alachlor, an organic chemical from herbicide runoff; or nitrate, resulting from application of nitrogen fertilizer/manure to row crops
c. People living in suburban, urban and rural communities may all be faced with a drinking water risk caused by contamination from microbes and insecticides and herbicides

2. Most suburban, urban and rural drinking water problems can cause mild health risks, like upset stomach or other gastrointestinal illnesses, to severe health risks, such as Blue Baby Syndrome, liver or kidney problems or cancer

3. Minor health risks, like gastrointestinal illnesses, typically occur from short-term exposure to the drinking water contaminant, such as illness caused by eating improperly cooked food. These illnesses may be a more severe threat to children, the elderly and people with compromised immune systems

4. Severe health risks, such as cancer, are typically the result of long-term exposure to the drinking water issue or illness associated with microbes, such as *Salmonella* or *E. coli 0157:H7*. Many originate from domestic animals like cows, hogs and hens

5. The health effects associated with agricultural production of crops and livestock include cancer or birth defects caused by pesticides and herbicides; Blue Baby Syndrome produced by excess nitrogen; and kidney failure associated with toxin producing bacteria such as *E. coli 0157:H7*, or *Shigella*

SW.4.1.AS *(continued)*

C. Drinking water problems are caused by three sources: human activity, animal activity or naturally occurring substances

1. Drinking water contamination caused by human activity
    a. Chemicals that are used excessively or improperly disposed (discharged onto land, so that they percolate into aquifers or runoff to surface waters), such as fertilizers, pesticides, disinfectants and disinfectant byproducts
        - A disinfectant is a chemical like chlorine or physical process like ultraviolet light that kills microorganisms such as viruses, bacteria and protozoa
        - A disinfection byproduct is a chemical or compound like bromate or chlorite that results from the process that kills microorganisms in drinking water
    b. Leaking or improperly maintained septic systems allow viruses, bacteria and other microorganisms to seep into water sources Microorganism means small living organism, such as bacteria; some can cause acute health problems when consumed. Disease-causing organisms are called pathogens
    c. Industrial products and wastes, such as leaking or improperly maintained landfills, open waste dumps or local factories
    d. Improperly treated or disinfected drinking water
    e. Household plumbing materials such as lead or copper
2. Drinking water contamination caused by animal activity
    a. Animal waste from farms that may contain contaminants, such as bacteria, antibiotics, arsenic (poultry waste) and nutrients (nitrogen and phosphorus) that can runoff into drinking water sources
    b. Viruses from animal waste
    c. Microorganisms from wildlife
3. Drinking water contamination caused by naturally occurring substances
    a. Microorganisms found in soil or rock
    b. Metals found in underground rocks can contain arsenic, lead or radium
    c. Nitrate or nitrite: Nitrogen compounds found in soil

SW.4.1.AS *(continued)*

D. Sources of potential contamination (from state source water assessments of drinking water):

1. Agriculture: Concentrated animal feeding operations, grazing, crop production, fertilizer/pesticide application, irrigation, tile or ditch drains/ agricultural drainage wells
2. Commercial/Industrial: Gas stations, chemical petroleum storage, dry cleaners, leaking storage tanks, mining and industrial discharge and disposal
3. Wastewater systems: Municipal sanitary waste treatment and disposal, improperly functioning wastewater utilities, septic system
4. Transportation: Airports, railroads/subways, freeways/highways, roads/ streets
5. Residential: Septic systems, lawn/garden care, underground and above ground storage tanks
6. Other: Pharmaceuticals and personal care products and other emerging contaminants (such as endocrine disrupters)

E. Types of Contaminants

1. Inorganic contaminants/chemicals: Mineral-based compounds, such as metals, nitrate and asbestos; naturally occurring in some water but can also enter water through human activities:
    a. Discharge from petroleum refineries
    b. Discharge of drilling waste
    c. Discharge from metal refineries
    d. Discharge from coal-burning factories
    e. Discharge from steel and pulp mills
    f. Erosion of natural deposits
    g. Discharge from factories
    h. Discharge from electronics, glass and drug factories
    i. Runoff of chemical fertilizers

SW.4.1.AS *(continued)*

2. Organic contaminants/chemicals: Carbon-based chemicals, such as solvents, pesticides and herbicides, that enter water through cropland runoff or discharge from factories.
    a. Runoff from pesticides and herbicide used on crops
    b. Discharge from drug and chemical factories
    c. Discharge from petroleum refineries
    d. Leaching from septic tanks
    e. Sewage

3. Radionuclides: Radioactive contaminants (atoms that spontaneously give off energy as particles or rays) the quality of sources of drinking water.
    a. Erosion of natural deposits and decay of natural and man-made deposits

F. *Sources of Pollution*

1. *Natural disaster*: An episode in which the processes of nature cause human or animal suffering. These episodes can transport contaminants so that they enter drinking water or they can disable water treatment systems
    a. Hurricanes
    b. Earthquakes
    c. Floods
    d. Seismatic waves (tidal waves, tsunamis)
    e. Tornados
    f. Droughts
    g. Avalanches
    h. Forest fires
    i. Volcanoes
    j. Landslides
    k. Sink holes

2. *Point source*: Pollution comes from a direct, identified source
    a. Sewage treatment plants
    b. Sewer systems
    c. Storm drains
    d. Industries discharging contaminated water back into the environment
    e. Accidental spill, such as an oil rig explosion or ship crash
    f. Concentrated animal feeding operations (CAFOs)
    f. Storm water from municipalities, construction, and industry

SW.4.1.AS *(continued)*

3. *Non-point source*: Pollution comes from many diffuse sources
    a. Excess fertilizers, herbicides and insecticides from agricultural lands and residential areas
    b. Oil, grease and toxic chemicals from urban runoff and energy production
    c. Sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks
    d. Acid drainage from abandoned mines
    e. Bacteria and nutrients from livestock, pet wastes and septic systems, including antibiotic-resistant bacteria
    f. Agricultural storm water and irrigation return flows

POWERPOINT SLIDES – AS NEEDED:

SW.4.2.TM

Point vs. nonpoint source pollution

Point source pollution comes from one or a series of known discharge points from a commercial, or sometimes public facility. Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall, snowmelt, irrigation runoff, or drainage systems moving over and through the ground. As runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and groundwaters. This contamination is often referred to as polluted or stormwater runoff.

NPS can include:

- Excess fertilizers, herbicides and insecticides from agricultural lands and residential areas
- Oil, grease and toxic chemicals from urban runoff and energy production
- Sediment from improperly managed construction sites, crop and forest lands and eroding stream banks
- Salt from irrigation practices, road de-icing and acid drainage from abandoned mines
- Bacteria and nutrients (nitrogen and phosphorous) from livestock, wildlife and pet wastes and bacteria, nutrients and viruses from leaking or improperly designed, located, constructed, or maintained septic systems. Properly maintained systems are designed to leach nutrients into groundwater

SW.4.2.TM *(continued)*

- Atmospheric deposition: Pollution from coal-fired power plants and automobiles is deposited either directly into water or is deposited onto land and then carried to water bodies by runoff
- Hydromodification: Building dams, modifying channels, erosion of stream banks and shorelines are examples of hydromodification

Source Water Assessments Steps

Step 1: Map or delineate the source water assessment area

a. Groundwater supplies
b. Simple map of area with radius circles around wells
c. Surface water
    - Topographic map
    - Using the watershed map and the surrounding areas
d. Sources where community members can seek assistance in delineating the source water area:
    - Local public water system
    - Environmental sciences department
    - Geology department
    - Engineering department
    - Environmental consulting firm
    - State drinking water or source water protection program: http://water.epa.gov/type/location/states/
    - Local watershed groups. Visit EPA's Adopt Your Watershed site, http://water.epa.gov/action/adopt/index.cfm, to find local groups in your community.

SW.4.2.TM *(continued)*

Step 2: Identify and list the potential sources of contamination (this is a partial list of possibilities)

a. Fuel Storage
   - above ground
   - underground

b. Septic systems
   - residential
   - commercial

c. Storm water runoff
   - streets
   - lawns
   - golf courses
   - parks

d. Pesticide and fertilizer use
   - farms
   - residential areas
   - golf courses
   - parks

e. Sludge disposal sites

f . Landfills

g. Animal agriculture

h. Nitrogen runoff from crop fields and drainage systems