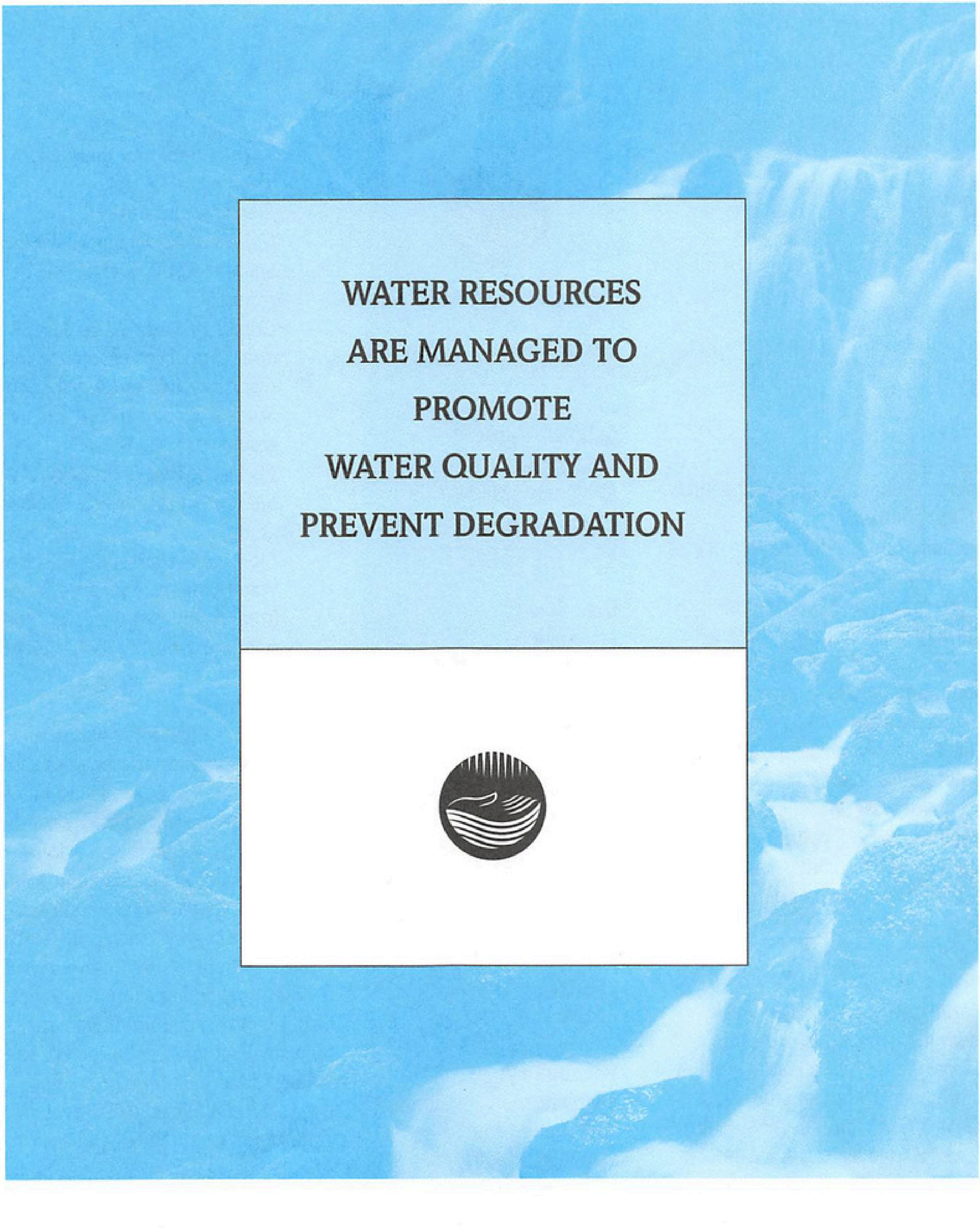


WATER RESOURCES ARE MANAGED TO PROMOTE WATER QUALITY AND PREVENT DEGRADATION

There Is No Point To This Pollution!

Summary

Students analyze data to solve a mystery, interpret a topographic map, and analyze and compare water quality data to learn about the cumulative impacts of nonpoint source pollution.

Objectives

Students will:

- identify point and nonpoint source (NPS) pollutants.
- demonstrate the cumulative effects of NPS pollution.
- learn to read and interpret a contour map while identifying important map clues about watersheds and water quality.
- graph, analyze, and interpret data sets to draw conclusions about a pollution source.
- compare local household and community NPS pollution to surface water quality standards.
- list ways to reduce or eliminate NPS pollution.

Materials

- *Large clear bowl, 2-liter bottle with top cut off, jar, or baking dish*
- *Water* (enough to fill large bowl or bottle plus 25 ml per student)
- *Clear plastic cups* (1 per student; fewer if used as instructor demonstration)
- *Assorted food coloring* (dilute 1 drop in 250 ml of water for each color)
- *Powdered cocoa or hot chocolate mix* (14.8 ml or 1 tablespoon)
- *Cooking oil* (5 drops)
- *Eyedropper* (optional)
- *Copies of* ***Loop Lake Worksheet*** *Student Copy Page* (8–one per group)
- *Copies of* ***Loop Lake Map*** *Student Copy Page* (8–one per group)
- *Copies of* ***Water Quality Data*** *Student Copy Page* (8–one per group)
- *Copies of* ***Water Quality Graphs*** *Student Copy Page* (8–one per group)
- *Optional:* Local (state) Surface Water Quality Standards, available from: http://www.epa.gov/ost/standards/wqslibrary/index.html

Grade Level:
6-12

Subject Areas:
Environmental Science, Geography, Mathematics, Ethics, Social Studies, Language Arts

Duration:
Preparation:
20 minutes

Activity:
two-three 50–minute periods

Setting:
Classroom

Skills:
Graph, Interpret, Debate, Quantify, Compare, Analyze

Vocabulary:
nonpoint source pollution (NPS), point source pollution, runoff, sediments, nutrients, cumulative, turbidity, dissolved oxygen, watershed

Background

Oil spills, leaking toxic waste, and industrial smokestack emissions make headlines in the news. These kinds of environmental tragedies, where the source of pollution is an obvious known point, are called point source pollution. Though these pollution events are highly visible, the truth is that the "nation's leading source of water quality degradation is nonpoint source (NPS) pollution, where there is no single point of pollution" (United States Environmental Protection Agency). NPS reaches our waterways via runoff from rainfall and snowmelt.

As runoff travels over land, it picks up soil particles as well as natural and human-made pollutants that eventually end up in rivers, lakes, and oceans. While some of these contaminants are benign as they reside in the soil, they can become problematic when carried into waterways via runoff. Common types of NPS pollution include sediments, nutrients, and contaminants such as pesticides and petroleum products.

Sediments can come from construction sites, poorly managed farmlands, logging sites, and eroding stream banks. Although sediments do not seem like a pollutant, they can cause damage to aquatic organisms by clogging the gills of fish, filling in pore spaces between rocks where macroinvertebrates live and fish lay their eggs, and harboring nutrients such as phosphates and nitrates that can cause algae blooms.

Sediments also increase turbidity, allowing less sunlight to penetrate the water, which harms plant and animal life. This increased sediment influences turbidity, which is "an optical property of water based on the amount of light reflected by suspended particles" (USEPA, 1999). Thus, very turbid water appears murky or cloudy. To measure the turbidity, samples are collected and measured using a nephelometer, or turbidimeter, which uses a light beam and a photoelectric cell to electronically measure the amount of light scattered by suspended particles. The units of measurement are called Nephelometric Turbidity Units or NTUs. The higher the NTU (turbidity) value, the more light is scattered and, generally, the more solids it contains.

To decrease the amount of sediment reaching our waterways and prevent unnecessary erosion, farmers use techniques such as contour tilling, loggers leave buffer zones of trees along rivers, lakes and oceans, and builders and homeowners plant vegetation along stream banks. All natural waters are somewhat turbid, even if only at microscopic levels.

Excessive nutrients can be a result of improper disposal of human and animal/pet waste, as well as runoff from farmlands or lawns and gardens. Human and animal/pet wastes contain nitrates and phosphates. When these wastes are improperly managed, they can wash into storm drains and surface water during rainstorms.

A common but sometimes overlooked source of nutrients in surface water comes from fertilizers applied by homeowners to their lawns and gardens. Many homeowners often over-fertilize to keep their lawns and gardens fertile and green. When it rains, excess fertilizers can run into streams and storm drains (which often drain directly to a stream or river). Runoff from farmlands can carry nitrate-rich fertilizers into surface water, especially if fertilizers have been over-applied or haven't fully infiltrated the soil before a heavy rain comes. Applying fertilizers in the minimum amount necessary, or fertilizing with compost made from recycled animal waste help control nutrient loads.

Storms can erode soil directly into storm drains, which often flow directly into nearby streams. Courtesy: United States Environmental Protection Agency

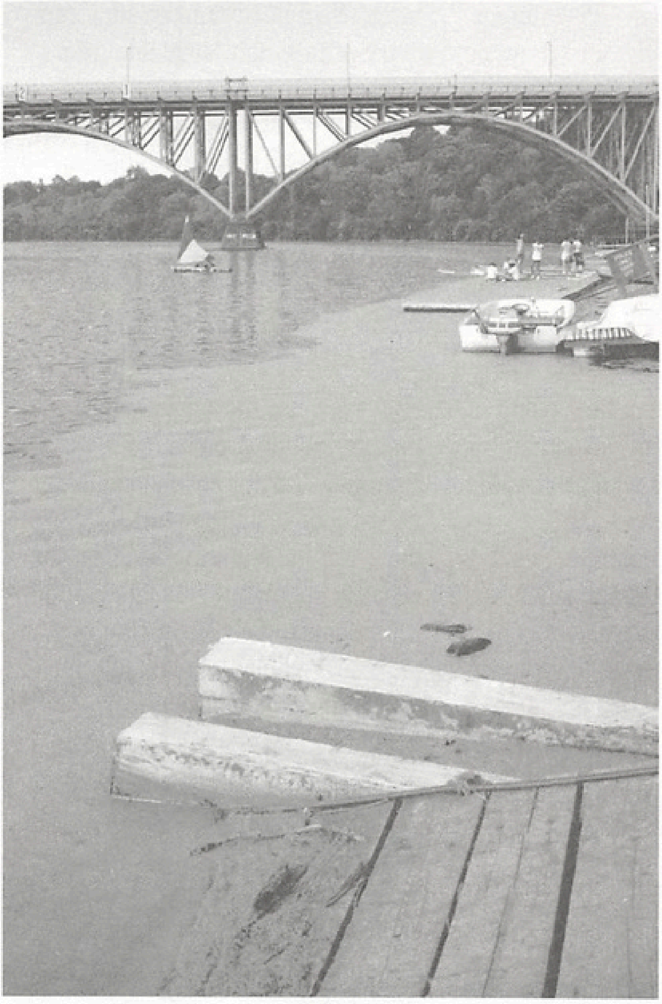
However common it may be, nonpoint source pollution is not front-page news. Rarely does a newspaper headline read, "Neighbor cited for dumping used motor oil down the drain! Read all about it!" Because we all contribute to the problem, we can all contribute to the solution as well. By taking simple actions like using caution when changing motor oil or filling the lawnmower with gas, planting buffer strips along waterways and drainage areas, and applying fertilizers as instructed, we can minimize the amount of NPS pollution in our waterways.

Procedure

Warm Up

Part I

1. Lead a discussion on pollution. Ask students to brainstorm a list of pollutants while you write them on the board.
2. Explain the difference between point source pollution (pollution source is a known point–e.g. an effluent pipe from a factory), and nonpoint source pollution (pollution source is not defined by a point, also called runoff–e.g., oil and gas from city streets).



Algal bloom on a lake caused by phosphates. American Water Works Association

3. Go through the list and have students identify whether each pollutant is classified as a point source or nonpoint source pollutant.

Part II

Note: Also works well as an instructor demonstration.

1. Provide each student with approximately 50 ml of clear water in a small cup.

2. Each student represents one household and the water in their cup represents the water that flows across their property. Students should choose one pollutant for their household from the list in *Part I.*

3. Show students the pollution indicators that will represent the pollution flowing across their property. The diluted food coloring will represent fertilizers; powdered cocoa will represent sediment; cooking oil will represent used motor oil, etc.

4. Have each student place a small amount (e.g., 1 drop of diluted food coloring; pinch of cocoa; drop of cooking oil; etc.) of pollution into his or her cup according to the pollution indicators provided.

5. Fill the large clear bowl (or clear 2-liter bottle) half-full with clear water and place it in a central location. The bowl represents a lake that is surrounded by the students' homes. One at a time, have students pour their water into the bowl, announcing which pollutants are present in their cup of water.

6. Notice that though each individual household contributes only slightly polluted water, once the whole neighborhood has added their water, the lake becomes very polluted. Students should be able to see through each of their samples, but the watershed water should be very dark. This illustrates the cumulative effect of NPS pollution and how we all contribute to it.

The Activity

Part I

1. Divide students into eight groups and distribute the Loop Lake Map and the *Loop Lake Worksheet* to each group.

2. Instruct groups to complete Part I: Map Reading of the *Loop Lake Worksheet.* Have them share their answers after completion. *(Option: Skip Part I if your students are experienced in reading and interpreting a contour map.)*

3. Encourage students to find the various locations named as you present the following scenario:

Loop Lake Village, the community surrounding Loop Lake, is small but prosperous. Residents of Loop Lake Village include Jack Pine, the local nursery grower who has just expanded his operation and Mr. and Mrs. Holstein who own and operate a dairy farm with cows and sheep. Around the lake are several small neighborhoods. There is a well-maintained trailer park that has been a stable part of the *community for many years. There is an older housing development with meticulously maintained lawns stretching down to the lake. Idle farmland was recently sold and a new subdivision is under construction in its place.*

There is a bustling town center with a strip mall and large parking lot. The town's park has a public swimming pool and a popular pet play area. On the other side of the hill, across Watershed Divide Road, there is a new factory that provides several jobs for local community members.

This summer, for the first time ever, a large algal bloom (when algae grows at a rapid rate) developed in the lake, and several dead fish washed up on the shore. Some speculate that wastes are being dumped from the factory, which are then draining into the lake. The locals feel it couldn't be just coincidence that there is a new factory and now, for the first time, the lake has an algal bloom and dead fish. The town residents agree that in the last ten years the clarity of the lake has decreased, while the temperature and algal growth have increased.

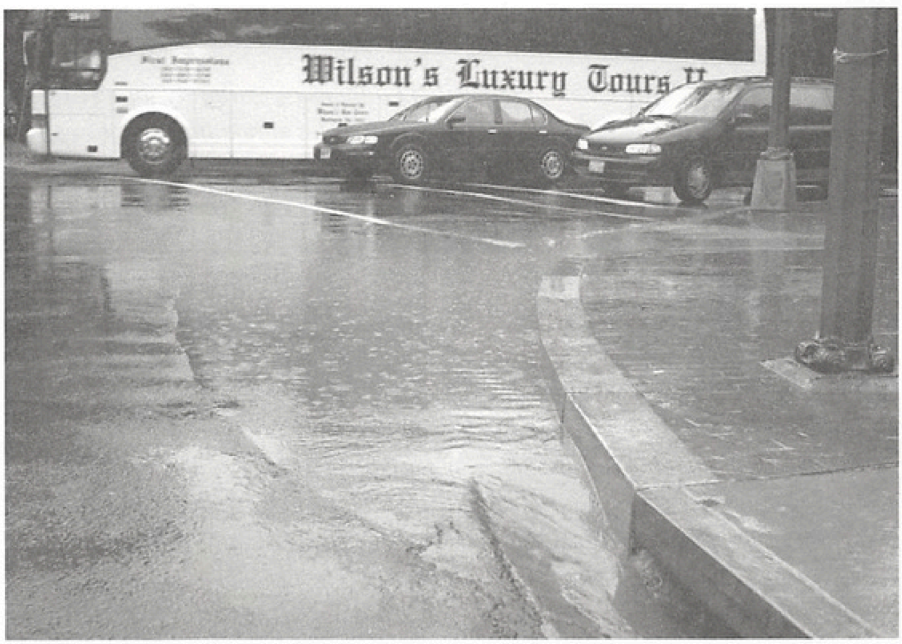
Part II

4. Have students complete Part II of the *Loop Lake Worksheet* and share their answers.
(They should determine that the factory resides in a separate watershed from Loop Lake, and therefore their wastes can not enter Loop Lake via runoff.)

5. Ask students to listen carefully as you continue reading the scenario.
The factory owners assure the community that they are careful with their wastes and they meet the environmental regulations for hazardous waste disposal. They feel certain they are not harming Loop Lake or the surrounding environment. Understanding that factories can easily be used as scapegoats, factory owners sponsor a surface water quality sampling project to determine who is really polluting Loop Lake. The owners also subsidize purchasing of the monitoring equipment for the sampling.

On the volunteer water sampling day, community members arrive eager to participate. Three parameters will be tested: fertilizers/nutrients, dissolved oxygen, and turbidity, a measure of water clarity. Samples are collected from streams that flow through various properties surrounding the lake, all of which eventually flow into the lake.

6. Explain to student groups that they will now represent volunteer water quality monitors, each stationed at a particular sampling site. Their challenge is to investigate and determine the cause of the algae bloom and fish kill in Loop Lake by "collecting" and analyzing the water quality data (found on their *Water Quality Data* card). Distribute a copy of their ***Water Quality Data*** card and inform groups that the data reflects samples taken from the stream running through their site. Discuss Nephelometric Turbidity Units (NTUs) a



Runoff from streets is another source of nutrients entering a stream or lake. Courtesy: US Environmental Protection Agency common unit of measure for the turbidity of water. Remind them that the lower the number of NTUs, the clearer the water and the higher the number, the cloudier the water.

7. Explain to students that one way to analyze data is to graph it and compare it with graphs of data for the same parameters. In this activity they will compare their new data with that of Loop Lake today, Loop Lake of ten years ago, state water quality standards, and the data from other groups.

8. Distribute the *Water Quality Graph* to each group and explain that the data for Loop Lake and the state standards are already graphed. Instruct students to graph the data from their sampling site. Tell them to compare their stream data to the other graphs. *(Option: Substitute your state's actual surface water quality standards, if available, for those in the activity. These state-specific standards, if available, can be downloaded from:* http://www.epa.gov/ost/standards/wqslibrary/index.html.)

9. Make an overhead of the *Water Quality Criteria Graphs* or draw the graphs on the board. Have each group plot their data on one main graph to allow all groups to compare their data.

Part III

10. Have students complete Part III of their *Loop Lake Worksheets.*

11. After students share their predictions, ask them what further information may be needed to make a prediction about the cause of the algae bloom and fish kill. After hearing their ideas, share this article printed in the local paper on the day following the volunteer water quality sampling:

After sampling Loop Lake, the Water Quality District has determined that the fish died due to a lack of dissolved oxygen, which they need to live. Dissolved oxygen is forced out of water when algal blooms occur and also when water warms. While algae are typically a source of dissolved oxygen, an algal bloom causes a rapid growth in algae which results in increased die-offs, the end result being a decrease in dissolved oxygen as the bacteria that decompose the dead plants rapidly consume the dissolved oxygen. Nutrients and fertilizers reaching the lake via runoff often cause algal blooms. The blooms then increase turbidity, preventing sunlight from reaching the deeper aquatic plants and killing them. As these plants die, the bacteria that decompose them will consume even more dissolved oxygen as they multiply. Higher turbidity also increases water temperature because the suspended particles absorb heat from the sun, further depleting the dissolved oxygen. We need your help to find out where these fertilizers and nutrients are coming from.

12. Have students analyze the data again, focusing on identifying the cause of the algal bloom and fish kill in Loop Lake based on this recent report. Ask them to complete Part IV of the ***Loop Lake Worksheet.***

Wrap Up

Have groups share their answers to the questions in Part IV of the ***Loop Lake Worksheet.*** The students should conclude that no single source of fertilizers/nutrients exceeds the state standards, but the combined impact of all the sources accumulating in Loop Lake is causing the algal bloom and fish kill.

Lead a discussion using the following questions: Why does the older housing development with big lawns contribute so much fertilizer and nutrients to the lake? (Over-fertilization of lakeside lawns allows fertilizers to run directly into the lake.) Why is the park a heavy contributor of fertilizers/nutrients? (Fertilizers and pet waste contains high levels of nutrients.) How does the new subdivision contribute to the turbidity of the lake? (Construction excavation increases erosion that, in turn, increases turbidity. Phosphates, a limiting nutrient in freshwater systems, can be carried with sediments and released into the water, there by increasing the nutrient load even further.)

Review the causes of the algae bloom and subsequent fish kill. (Accumulated fertilizer/nutrient loading from numerous sources around the lake, increased turbidity and sedimentation, decreased sunlight penetration into the water, accelerated death of deeper water plants, decreased dissolved oxygen levels as bacteria decompose dead plants.)

Divide class into small groups and have each write a short paragraph outlining possible ways each contributor on the list could reduce fertilizers and nutrients deposited into the lake. Discuss their solutions. Ask students to brainstorm ways to reduce household nonpoint source pollutants. Examples: use designated hazardous waste disposal facilities for used motor oil, either reduce the amount of chemical fertilizers used or replace them with natural fertilizers, plant vegetative buffer strips around waterways, clean up pet wastes, and others.

Assessment

Have students:

- identify point and nonpoint source (NPS) pollutants (***Warm Up***).
- demonstrate the cumulative effects of NPS pollution (***Warm Up***).
- read and interpret a contour map while identifying important clues about watersheds and water quality (***Part I***).
- graph, analyze, and interpret data sets to form conclusions about pollution sources (***Parts I II, III***).
- compare community pollution to surface water quality standards (***Part III***).
- list ways to reduce or eliminate NPS pollution from your yard or community (***Wrap Up***).

Extensions

Invite your local water quality district specialist or other water quality expert to discuss which water pollutants are most problematic in your community. What are the sources of these pollutants? Are they nonpoint source or point source pollutants? What is being done in your community to minimize water pollution?

Testing Kit Extensions

Organize a water quality monitoring project for a local watershed. Refer to the study design overview in the activity *Water Quality Monitoring, From Design to Data* on page 70 in this guide.

Using the water quality sampling data, have students calculate the percent saturation of dissolved oxygen in the water. Refer to dissolved oxygen percent saturation charts in the *Healthy Water, Healthy People Instructors Manual* for calculations.

Resources

Goo, R. n.d. *Do's and Don'ts Around the Home.* Retrieved on July 27, 2001, from the Environmental Protection Agency Web site: http://www.epa.gov/owow/nps/dosdont.html

Horton, G. 2001. *Dictionary of Water Words.* Reno, NV: Great Basin Research.

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United States Environmental Protection Agency. n.d. *What is Nonpoint Source (NPS) Pollution?* Retrieved on July 27, 2001, from the Web site: http://www.epa.gov/owow/nps/qa.html

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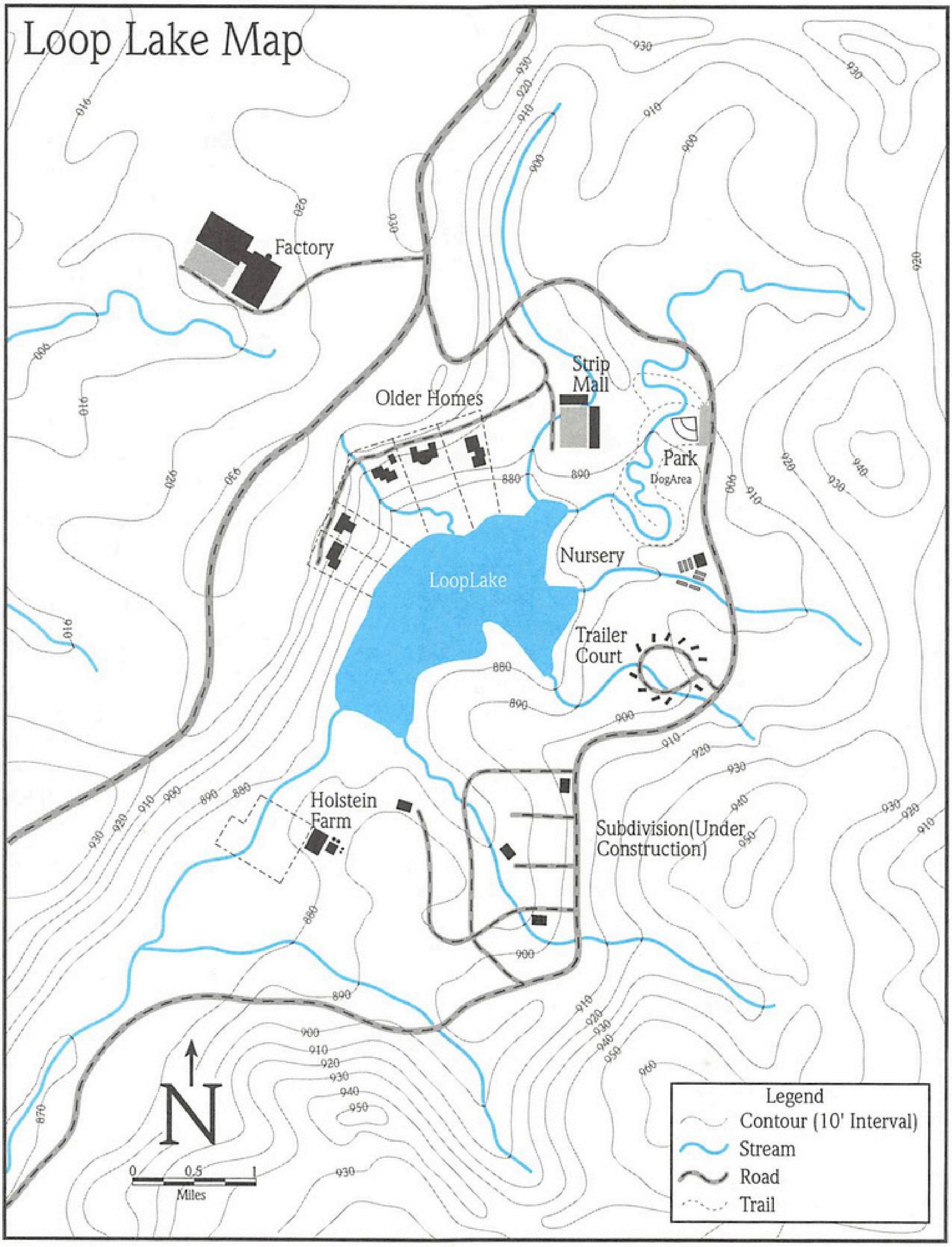

Loop Lake Map
Factory
Older Homes
Strip Mall
Park
DogArea
Nursery
LoopLake
Trailer Court
Holstein Farm
Subdivision(Under Construction)
N
0 0.5 1
Miles
Legend
Contour (10' Interval)
Stream
Road
Trail

Loop Lake Worksheet

Part I

Map Reading

1. Locate the contour lines on the map. These lines indicate the elevation of the land at a location on the map. Since there are ten feet between each contour line, comparisons with other elevations can be made. Place an X on the highest and lowest points on the map.
2. Locate the streams on the map. Streams always flow from the highest to the lowest elevations. How many streams are there? ________ Locate the stream that flows through the subdivision and mark its highest and lowest elevations with an X. What is the elevation of the highest point on this stream? How many feet in elevation does this stream drop between its highest and lowest points?
3. Place a Y on the highest points of the streams that flow into Loop Lake.
   a. Place a Z on the highest points *above the streams* that flow into Loop Lake
   b. Following the highest elevations between these points, connect these Zs with lines.
   c. This outline encompasses all of the land area that drains into Loop Lake. What is the name for an area that is drained by streams and flows to a central location? ____________
4. One stream serves as the outlet stream for Loop Lake. Locate it and name the business that the stream flows through. How did you know that this was the outlet stream for the lake?

____

Part II

1. After hearing the story of the fish kill in Loop Lake, write whether you think the factory is to blame. Why or why not?

Part III

1. After analyzing the water quality data, write your predictions of the causes of the algal bloom and fish kill. Be sure to write your reasons or evidence for your prediction.

Part IV

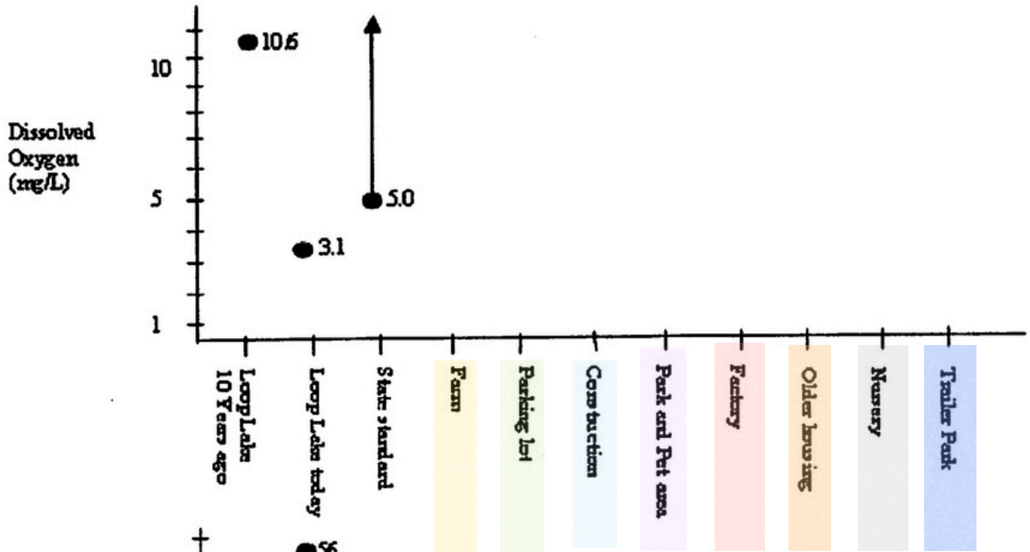
1. How many of the land uses around Loop Lake have fertilizer/nutrient levels that exceed the state standards? ______________ For turbidity? ____________
2. Write an explanation for how the algal blooms and fish kill occurred in Loop Lake:

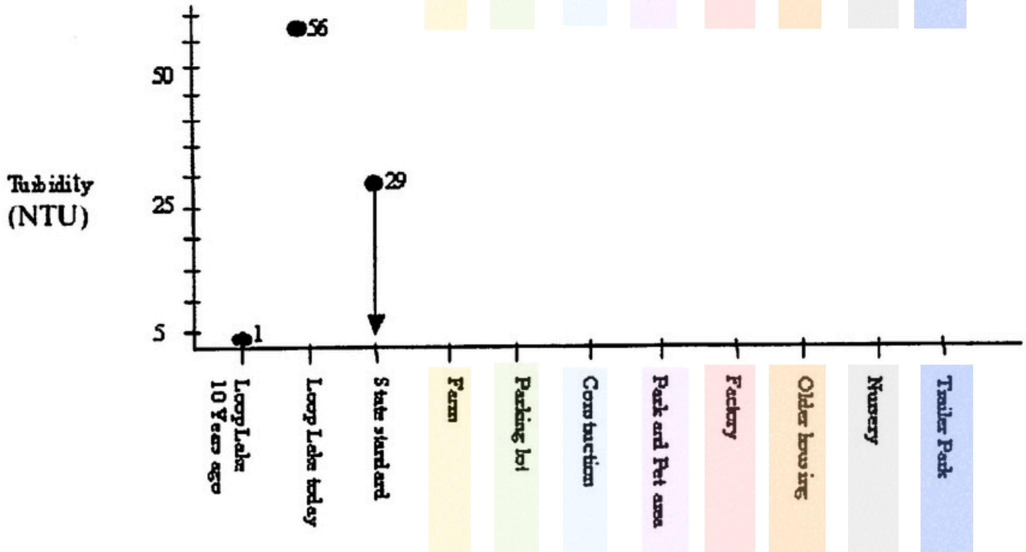
3. Is the pollution that caused the fish kill in Loop Lake from point sources or nonpoint sources?

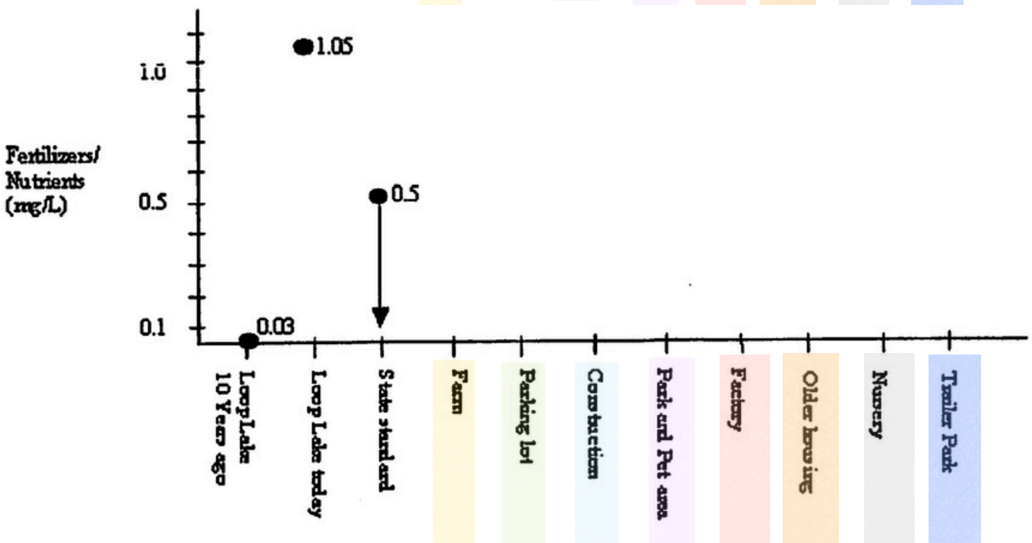
Water Quality Data

Mr. and Mrs. Holstein's Farm Dissolved Oxygen: 8.7 mg/L Turbidity: 12 NTU Fertilizers/Nutrients: 0.3 mg/L Temperature: 15° C (59 F)	**Parking Lot** Dissolved Oxygen: 5.6 mg/L Turbidity: 18 NTU Fertilizers/Nutrients: 0.1 mg/L Temperature: 15° C (59 F)
New Apartments –Construction (Subdivision) Dissolved Oxygen: 5.8 mg/L Turbidity: 33 NTU Fertilizers/Nutrients: 0.1 mg/L Temperature: 15° C (59 F)	**Loop Lake Park and Pet Play Area** Dissolved Oxygen: 5.1 mg/L Turbidity: 6 NTU Fertilizers/Nutrients: 0.5 mg/L Temperature: 15° C (59 F)
Factory Dissolved Oxygen: 8.9 mg/L Turbidity: 7 NTU Fertilizers/Nutrients: 0.3 mg/L Temperature: 15° C (59 F)	**Older Housing Development** Dissolved Oxygen: 5.2 mg/L Turbidity: 4 NTU Fertilizers/Nutrients: 0.48 mg/L Temperature: 15° C (59 F)
Jack Pine's Nursery Dissolved Oxygen: 5.7 mg/L Turbidity: 10 NTU Fertilizers/Nutrients: 0.3 mg/L Temperature: 15° C (59 F)	**Trailer Park** Dissolved Oxygen: 5.9 mg/L Turbidity: 9 NTU Fertilizers/Nutrients: 0.3 mg/L Temperature: 15° C (59 F)

Water Quality Graphs Student Copy Page







Note: The arrows represent the range of possible values. For example, "Dissolved oxygen shall not be less than 5.0 mg/L."