Watersheds and Nonpoint Source Pollution

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Lower Grand River Watershed Lessons

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Unit Four: Managing Excess Nutrients

Groundswell

Communities for Clean Water

Groundswell

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To learn more about Groundswell, environmental stewardship education, and to view the companion videos, please visit **groundswellmi.org**.

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OVERVIEW & LESSON
STUDENT ACTIVITY
ANSWER KEY
TEACHER RESOURCE
STUDENT READING

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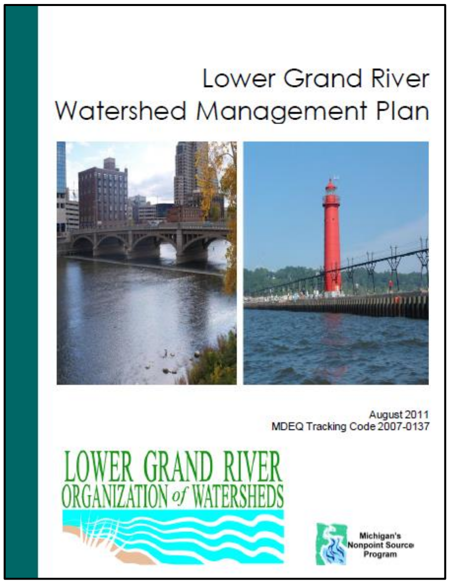
About the Lessons

The Michigan Department of Environmental Quality's Nonpoint Source Program assists numerous non-profit entities and other local, state, and federal partners to reduce nonpoint source (NPS) pollution statewide. NPS pollution comes from all over the watershed – anywhere rain falls. There is no specific source like a pipe or smoke stack. As such, the basis for this program is watershed management.



The *Lower Grand River Watershed Management Plan* (LGRWMP) is a document developed to provide a description of the watershed, identification of impairments, and goals and objectives for management and improvement of the watershed. The LGRWMP's *Information and Education* (I&E) *Strategy* calls for educating stakeholders about the watershed and the impacts that stakeholders have on the watershed. The strategy has three steps: (1) awareness, (2) education, and (3) action.

With funding from the Michigan Department of Environmental Quality (MDEQ) Nonpoint Source Program, four lessons that draw upon information from the Lower Grand River Watershed Management Plan (WMP) have been developed for teachers. The purpose of these lessons is to further the I&E objectives that reach students as outlined in the WMP.

The three main nonpoint source pollutants of concern in the *Lower Grand River Watershed Management Plan* include sediment, pathogens, and nutrients. The lesson titles, which reflect this, are:

- Watersheds and Nonpoint Source Pollution
- Nonpoint Source Pollution: Managing Excess Sediment
- Nonpoint Source Pollution: Managing Pathogens
- Nonpoint Source Pollution: Managing Excess Nutrients

Videos have been developed to accompany each of the lessons. Lessons and videos are posted at http://groundswellmi.org/resources/educator-resources/. Educators can select the activities about the Lower Grand River Watershed that best fit their classrooms.

About the Lower Grand River Watershed Management Plan

The current Lower Grand River Watershed Management Plan (LGRWMP) was approved by the Michigan Department of Environmental Quality in 2011. The LGRWMP provides a detailed implementation plan and assigns responsibility to stakeholders to ensure the plan's actions are put into practice. The Lower Grand River Organization of Watersheds (LGROW) was formed in 2009 to provide basin-wide oversight, implement watershed-wide initiatives, and prioritize water quality concerns.

For more information: lgrow.org

The nine key elements of the Lower Grand River Watershed Management Plan include:

1. Understanding watershed characteristics
2. Identifying and involving local agencies and citizens in the watershed planning process
3. Identifying designated and desired uses
4. Defining critical areas which are contributing a majority of the pollutants
5. Identifying and prioritizing pollutants, sources, and causes
6. Determining objectives and tasks for meeting watershed goals
7. Identifying and analyzing existing local projects, programs, and ordinances that impact water quality within the watershed
8. Informing and involving the public
9. Developing an evaluation process

The chapters in the LGRWMP reflect the nine elements.

The LGRWMP also outlines a strategy to identify and restore the state's designated uses of the surface waters in the Watershed, which are:

- Agricultural use
- Industrial water supply at the point of intake
- Public water supply at the point of intake
- Navigation
- Warmwater and/or coldwater fishery
- Other indigenous aquatic life and wildlife
- Partial body contact recreation
- Total body contact recreation between May 1 and October 31

Sediment, nutrients, pathogens, temperature, unstable hydrology, chemicals, and habitat fragmentation have an impact on the designated uses of the Watershed. Designated uses are considered impaired if the water does not meet Michigan's water quality standards. Total Maximum Daily Loads (TMDLs), which are calculations of the maximum amount of a pollutant that a water body can receive and still meet applicable water quality standards, have been developed for parts of the watershed.

Subjects/Target Grades
Subjects: Science and Social Studies
Grades: 7-12

Duration
Five 50-minute class periods
Classroom and outdoor setting

Materials
Per class
- Videos: Communities for Clean Water: Managing Excess Nutrients
- Teacher resource masters
- Answer keys
- Bottle with an algal bloom
- Pond water with duckweed

Per small group
- Option 1: Algal bloom experiment (pond water, plastic bottles, house plant fertilizer)
- Option 2: Duckweed experiment (duckweed, clear egg carton, forceps, graduated cylinder, house plant fertilizer)
- Phosphorus and nitrate monitoring kits

Per student
- Student activity sheets
- Student reading

MI Science Standards:
- Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. MS-LS2-4
- Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-3

Lesson Four: Nonpoint Source Pollution: Managing Excess Nutrients

Lesson Overview
This lesson explores nutrients - a major type of nonpoint source pollution affecting the Lower Grand River Watershed. In this lesson you will explore the types and sources of nutrients, visualize the effects of nutrients on plant growth, and simulate a task force to address nutrient issues.

Focus Questions
Students answer these essential questions in the context of the Lower Grand River Watershed: What are nutrients? What are the sources and effects of nutrients? How can we reduce the amount of nutrients in a stream or river?

Objectives
Students will be able to identify nutrients as a major nonpoint source pollutant, determine how nutrients get into a river or stream system and potential effects of nutrients in the waterways, indicate the relative impact of nutrients in various parts of the Lower Grand River Watershed, and explore ways to reduce nutrient inputs to local waterbodies.

Advanced Preparation
- Assemble materials for creating an algal bloom or growing duckweed
- Preview Communities for Clean Water: Managing Excess Nutrients video before showing it to the class
- Make copies of student activity sheets you are using
- Check the Extensions and Additional Resources sections for other activities on the lesson topics

Background Information

Nutrient pollution is one of the top causes of water quality impairment in our nation's surface waters. In a March 16, 2011 memo, the United States Environmental Protection Agency (EPA) stated its commitment to working with states and other stakeholders to accelerate the reduction of nutrient inputs to our nation's waters. Working in partnership with the EPA, the Michigan Department of Environmental Quality (MDEQ) prepared steps for Michigan to protect its surface waters from excessive nutrient pollution – specifically **nitrogen** and **phosphorus** (See Link 4R in the Additional Resources section for more information). The MDEQ works to reduce nutrient loads and achieve water quality restoration and protection goals through a combination of point-source and nonpoint source pollution reduction activities.[1]

Nitrogen and phosphorus are natural and necessary components of aquatic ecosystems. (Nitrogen is also the most abundant element in the air we breathe.) These nutrients support the growth of algae and aquatic plants, which provide food and habitat for fish, shellfish, and smaller organisms that live in water. But when too much nitrogen and phosphorus enter the environment – usually from a wide range of human activities – the natural ecosystem is disrupted and the water quality can become impaired.[2]

The primary sources of excess nutrients from human activities are:

- **Agriculture**: Animal manure, fertilizer applied to crops and fields, and soil erosion make agriculture one of the largest sources of nitrogen and phosphorus pollution in the country.
- **Urban Stormwater**: When precipitation falls on our cities and towns, it runs across hard, impervious surfaces – like rooftops, sidewalks and roads – where it picks up any chemicals and other substances. This runoff can contain nitrogen and phosphorus from fertilizers, pet waste, and yard waste. The precipitation then carries these pollutants, down storm drains and into local waterways.
- **Wastewater**: Resource reclamation plants (wastewater treatment plants) are responsible for treating large quantities of sewage and water. These systems do not always operate properly or remove enough nitrogen and phosphorus from items such as human waste, food waste (garbage disposals), and some soaps and detergents before discharging into waterways.
- **In and Around the Home**: Fertilizers, yard and pet waste, ammonia-based cleaning products, and certain soaps and detergents contain nitrogen and/or phosphorus. These can contribute to nutrient pollution if not properly used or disposed of.[3]

A number of environmental factors influence the amount of nutrients entering the waterways. For example, **geology** and **topography** of a watershed impact the quantity of nutrients that enters lakes and streams via surface runoff.

Watershed managers use a **trophic state index** as a system for classifying lakes based on their biological activity, which is heavily influenced by the quantity of nutrients present in the system. A lake with relatively low biological productivity (indicating low levels of nutrients) is called **oligotrophic**. A lake with moderate biological productivity is called **mesotrophic**. And a lake with high productivity (indicating high levels of nutrients) is called **eutrophic**. This can be a natural progression whereby lakes gradually become filled in by abundant plant life, sediment, and organic material from dead plants and animals. However, human activities can accelerate the process by increasing sediment and nutrients that enter the waterways in stormwater runoff.[4] This is a condition referred to as **cultural eutrophication**.

Phosphorus typically functions as the "**growth-limiting**" factor in lakes, meaning the addition or reduction of phosphorus will directly impact the amount of algae and plant growth that occurs. Under natural conditions, the amount of phosphorus available for plants to use is typically very low. Most phosphorus in a lake system will be bound to organic matter and soil particles. Any unattached or "free" phosphorus is quickly removed from the aquatic system by algae and larger aquatic plants.[5] Nitrogen, on the other hand, is present in abundance because it is the largest component of the air we breathe. The nitrogen from the air dissolves into the water and nitrogen-fixing organisms and plants convert it into a form useable for plant growth. This constant source of additional nitrogen means plant growth in lakes typically isn't limited by the amount of nitrogen present. Therefore, phosphorus is the nutrient of greatest concern for most lake ecosystems.

Phosphorus can accumulate in the sediment at the bottom of a lake, in deposited clays, silts, and organic matter. Under certain conditions, this accumulated phosphorus can be released from the sediment and become available for plants. This is called **internal phosphorus loading** when the phosphorus comes from internal sources instead of entering the lake from external sources like waterbodies that flow into the lake or runoff from land. For internal phosphorus loading to occur, the lake must experience anoxic conditions. The phosphorus released under these conditions then can become available for plant growth and often leads to increased algae. Managing phosphorus inputs (and the resulting algae growth) can be more difficult in lake systems with internal phosphorus loading. Typical management approaches focus on reducing external sources of phosphorus. However, the benefits of these efforts might not appear for several years if internal loading is occurring.[5]

Excessive concentrations of phosphorus can quickly cause extensive growth of aquatic plants and **algal blooms**, which can lead to detrimental consequences. Excessive algae and plant growth can deplete the oxygen that is dissolved in the water. Water can hold only a limited supply of dissolved oxygen (DO) and it comes from only two sources – 1) diffusion from the atmosphere and 2) a byproduct of photosynthesis. Dissolved oxygen levels are temperature and pressure dependent. Cold water holds more oxygen than warm water. Most aquatic organisms are highly dependent upon dissolved oxygen and will experience stress, or perhaps even be eliminated from a system, when dissolved oxygen levels fall too low.[6] Excessive plant growth leads to depletion of DO because of nighttime respiration by living algae and plants and because the bacteria decomposing dead algae/plant material use oxygen.[5] Extremely low DO can cause large fish kills and so-called "**dead zones**."

Severe nuisance **algal blooms** also can cause unpleasant odors and an appearance that reduces the aesthetic appeal of water bodies. In addition to algae, microorganisms like **cyanobacteria**, historically known as blue-green algae, can produce **cyanotoxins** that are released into the water when the algae die and begin to decompose. One example is the cyanobacteria called **Microcystis**, which produces **microcystin** toxins. These toxic algae blooms are known as **cyanobacterial harmful algal blooms** (cyanoHABs or HABS) and are of special concern because of their potential impacts on human and animal health through drinking water, irrigation, and recreational contact.[7]

Factors that can contribute to HABs include:

- Excess nutrients
- Sunlight
- Low water levels or low flow conditions
- Calm water (low wind conditions)
- Warmer temperatures

- Presence of zebra and quagga mussels (They filter feed on plankton increasing water clarity and allowing sunlight to reach deeper into the lake and creating ideal conditions for algae growth. Zebra and quagga mussels filter out the cyanobacteria, returning it back to the water intact.)[8]

Watershed managers are actively trying to reduce the amount of phosphorus entering water bodies in an effort to reduce excessive plant growth and algae blooms. Michigan passed legislation restricting the amount of phosphorus in household laundry and dishwashing detergents to no more than 0.5% by weight. In 2010, legislation was passed stating that no phosphorus fertilizer may be applied on domestic (residential) or commercial lawns, unless specific exemptions are met. [9,10]

[1] Michigan Department of Environmental Quality

[2] U.S. Environmental Protection Agency, Nutrient Pollution: The Problem, https://www.epa.gov/nutrientpollution/problem

[3] U.S. Environmental Protection Agency, Nutrient Pollution: Sources and Solutions, https://www.epa.gov/nutrientpollution/sources-and-solutions

[4] Minnesota Pollution Control Agency, Nutrients: Phosphorus, Nitrogen Sources, Impact on Water Quality - A General Overview Water Quality/Impaired Waters #3.22

[5] Michigan Department of Environmental Quality, Phosphorus, http://www.michigan.gov/documents/deq/wb-npdes-Phosphorus_247234_7.pdf

[6]Grand Valley State University. Instructor's Manual Dissolved Oxygen. https://www.gvsu.edu/wri/education/instructors-manual-dissolved-oxygen-30.htm

[7] U.S. Environmental Protection Agency, CyanoHABs: Cyanobacterial Harmful Algal Blooms, https://www.epa.gov/nutrient-policy-data/cyanohabs

[8]Michigan Sea Grant, Harmful Algal Blooms in the Great Lakes, http://www.miseagrant.umich.edu/explore/coastal-communities/harmful-algal-blooms-in-the-great-lakes/

[9] Michigan Department of Environmental Quality, Statewide Restrictions on Phosphorus in Cleaning Products and Fertilizers, http://www.michigan.gov/documents/deq/wrd-nutrient-framework-restrictions_429130_7.pdf

[10]Michigan Department of Agriculture and Rural Development, New Michigan Fertilizer Legislation Restricts Phosphorus Applications on Turf, https://www.michigan.gov/documents/mdard/Phosphorus_fertilizer_restriction_summary_for_MDARD_website_1_2012_372599_7.pdf

Lesson Procedure

1. What are nutrients and how can excess nutrients impact our waters?

Ask students if they have seen a lake or pond turn green. What time of year did this happen? Is the lake good for swimming then? What caused the green color? Show examples of algae, cyanobacteria, and duckweed if you are able to collect them or use the *Algal and Cyanobacterial Blooms, Harmful Algal Blooms and Muck*, and *Duckweed* teacher resources.

Website links can be found at: groundswellmi.org/lessonlinks

Explain that when a body of water turns green, it could be an **algal bloom**, **cyanobacterial bloom,** or heavy growth of plants like duckweed. **Duckweed** is an aquatic flowering plant that can rapidly reproduce. Explain that some algal blooms can be a nuisance or even toxic. When they are toxic, they are called **Harmful Algal Blooms** (**HABs)** or **CyanoHabs** (**Link 4A**). See the *Harmful Algal Blooms* teacher resource. An example would be the harmful algal blooms in Lake Erie that contaminated the water supply of Toledo, Ohio. See **Link 4B** for resources on Lake Erie algal blooms.

But what can cause an algal or cyanobacterial bloom and other excessive plant growth in water bodies?

Show and engage students in a discussion of the main points of the video, Communities for Clean Water: Managing Excess Nutrients. Tie in the idea that nutrients include nitrogen and phosphorus.

2. Explore sources of nutrients.

Engage students in determining how each of the numbered sources in the *Sources of Nitrogen and Phosphorus Pollution* diagram contributes to excess nutrients in a watershed. Using a pair-share format, have students discuss the sources of nutrients to water bodies and complete the *Sources of Nitrogen and Phosphorus Pollution* worksheet. Follow up this section with reflective discussion of the *Nutrients* student reading and have them add additional information to their worksheet.

3. Conduct an investigation to look at the effects of nutrients on the growth of algae or duckweed.

Challenge the students to design and conduct an investigation to determine the effect of nutrients on algal growth or the growth of aquatic plants such as duckweed or water milfoil. This could be an open-ended inquiry activity that is performed in groups.

An example of a student-generated investigation is found in the *Nutrients and Aquatic Plants* teacher resource. Another example is found at the *Building the Bloom* website. **Link 4C**

Some basic questions for students to consider as they design their investigations are:

- What question would we like to answer?
- What is the dependent variable? (amount of nutrients)
- What is the independent variable? (time)
- What aquatic organism will we use?
- What will be the source of nutrients?
- What is the design of our investigation?
- How will we monitor the results?

Have them brainstorm additional questions that need to be answered before beginning the investigation. Examples are: Where will we get the algae or duckweed? What materials are needed? How long will the investigation be run? How will we present the results? Also, they should do some research to become familiar with the topic of nutrients and algae or aquatic plants in general. A student resource page, *Investigate!* is available to guide students in creating their investigations.

If available, use test kits at collection time to determine levels of nitrate and phosphorus in the water from which the algae or duckweed have been harvested. These kits also could be used to test for nutrients from other water bodies or to monitor changes throughout the investigation.

Have the groups create a scientific poster about their investigation including:

- Title of the investigation
- Introduction
- Materials and Methods
- Results
- Discussion
- Summary/Conclusion
- References

4. Research the nutrient patterns in the Lower Grand River Watershed

Now that students have an idea of the sources and effects of excess nutrients, they can explore the patterns of nitrogen and phosphorus inputs in the Lower Grand River Watershed. They will look at the nitrogen and phosphorus loadings in selected subwatersheds and draw conclusions about which sites are critical areas for action to reduce nutrient inputs.

Divide students into small groups. Pass out the *Plan for Action: Subwatershed Research Project* (Student Resource). Provide groups of students with the *Exploratory Data Analysis* student activity, the *Locations of Subwatershed Management Units* (Student Resource), and the *Lower Grand River Watershed Management Plan* (Student Resource).

Once all groups have finished creating their visual representations to persuade the class why or why not their subwatershed should be a priority for nutrient reduction, have the small groups present their visuals to the class.

Once all presentations are complete, have the class vote to prioritize the subwatersheds for nutrient reduction action.

After students have prioritized their subwatersheds, share the following information from the Lower Grand River Watershed Management Plan (LGRWMP). Thirty one subwatershed management areas are addressed in the LGRWMP. In “Table 4.3 – Critical Areas of Restoration” in the LGRWMP, Buck Creek ranked #1 in nutrient load, Rogue River ranked #2, Indian Mill Creek ranked #4, and Rush Creek ranked #6. They were considered high priority. Sand Creek was #10 and the Lower Thornapple River was #11, which indicated medium priority. Lower priority rankings were #22 Bear Creek and #27 Deer Creek.

Point out that just looking at the total amount of phosphorus and nitrogen in each subwatershed unit doesn’t always give the answer as to the criteria used to prioritize areas for restoration. Some other things to consider are the pounds per acre of nutrient loading, other impairments in the subwatershed, cost of restoration, subwatershed size, and work already in progress.

5. Formulate a plan to reduce nutrient loads.

Take students outside to observe their school grounds and engage them in the *Increase in Stormwater with Urbanization* student activity. Make sure to make the connection that runoff from the school could eventually reach the Lower Grand River. Review ideas about stormwater best management practices and nutrients.

Using the *What Nutrients Are in Fertilizers?* student activity as an example of nutrients that could get into stormwater, have students look at fertilizer bags at home or at a store and report the nutrient content of these products. If it is not possible for students to find fertilizer bag examples at their homes or nearby stores, have them use the student resource *Fertilizer Bag Samples.* Discuss the questions in that activity as a class or in groups. Follow up with the *Examples of Outreach Materials* teacher resource to illustrate how people could be informed about over or improper use of fertilizers.

Assign the student reading: *Algal Blooms in Spring Lake.*

Engage students in a discussion of the reading and point out that Spring Lake connects with the Grand River. Let them know that this lake is generally considered to be **eutrophic,** as illustrated in the *Trophic Status of Lakes* and *Status of Lakes in Michigan* teacher resources.

Lake management continues to be an issue for the residents of Spring Lake. Pose the question: do you think there is anything homeowners around Spring Lake and other lakes can do to reduce putting excess nutrients into lakes? (Examples: reduce fertilizer use, increase pervious surfaces, put natural vegetation along the lakeshore, maintain septic systems, avoid attracting ducks and geese).

Note: there was an effort in Spring Lake (Rein in the Runoff) to educate homeowners about lake problems and what they can do.

Revisit the nutrient patterns in the Lower Grand River Watershed and ask students how they think the nutrient load in the Lower Grand River Watershed could be decreased overall. Present how the LGRWMP's *Information & Education Strategy to Address Nutrients* addresses this issue (see the teacher resource). Have students design an outreach plan that supports the priorities of the *Information & Education Strategy to Address Nutrients* in the LGRWMP. Additional ideas are found in *What Can You Do: in your home* and *What Can You Do: in your yard* resources.

Extensions

1. Monitor sites in the Lower Grand River Watershed for nutrients. Simple test kits are available for nitrate and phosphorus.

2. Do soil testing for nutrients with test kits to see if the soil needs fertilizer. A variety of kits are found online or at stores that sell gardening supplies. Michigan State University Extension also offers a mail-in soil test service.

3. Have students work through the *Marvelous Mud Data Nugget* lesson, in which a Michigan State University graduate student measured organic matter and phosphorus in mud from 16 ecosystems (four lakes, five ponds, and seven wetlands). She wanted to determine if there was a relationship between the amount of organic

matter and the amount of phosphorus in mud. **Link 4D**

4. Using the algal blooms in Lake Erie as an example, have students research news stories and assign a writing assignment for students to answer questions such as:

- What organisms caused the bloom?
- What were the symptoms of the bloom?
- What problems were caused by the bloom?
- What was the role of the state and local government in addressing these issues?
- What are the lessons learned from these blooms?
- What should happen next to prevent algal blooms?

5. Engage in a watershed festival in your community to raise awareness about the importance of nonpoint source pollution and watershed protection.

6. Use materials from EPA's Nonpoint Source Outreach Toolbox to create outreach materials such as poster, public service announcements, and placemats. **Link 4E**

Assessment

1. Have students create a mock marketing strategy or video public service announcement (PSA) to promote practices to reduce excess nutrient pollution in the Lower Grand River Watershed.

2. Have students write a persuasive essay about the importance of addressing excess nutrients in the Lower Grand River Watershed.

3. Identify the sources of excess nutrient pollution illustrated in the Assessment teacher resource.

Additional Resources

Website links can be found at: groundswellmi.org/lessonlinks

A Community in Crisis: Habport
In this simulation activity, students participate in a town meeting to address harmful algal blooms in a fictional community. A learning objective is to understand the broader ecological, social, and economic impact of a harmful algal bloom. **Link 4F**

Cyanobacteria Harmful Algal Blooms: CyanoHABs
EPA has compiled information on freshwater cyanoHABs including causes, detection, treatment, health and ecological effects, and current research activities in the United States. Policies and regulations for cyanotoxins at the state and international levels are listed as well. **Link 4G**

Data Nuggets
The Data Nugget site brings current research into the classroom, giving students the chance to work with real data – and all its complexities. Data Nuggets are activities designed to give students practice interpreting quantitative information and make claims based on evidence. The standard format of each Data Nugget provides a brief background to a researcher and their study system, along with a small, manageable dataset. **Link 4H**

Harmful Algal Blooms (HABs) in the Great Lakes
This Michigan Sea Grant site provides information to help students understand HABs. **Link 4I**

Lower Grand River Organization of Watersheds (LGROW)
Useful maps and summaries of subwatersheds of the Grand River Watershed are found at this site. **Link 4J**

Michigan Clean Water Corps
The Michigan Clean Water Corps (MiCorps) is a network of volunteer water quality monitoring programs in Michigan. It assists the Michigan Department of Environmental Quality (MDEQ) in collecting and sharing water quality data for use in water resources management and protection programs. MiCorps is comprised of two core volunteer monitoring programs: the Volunteer Stream Monitoring Program and the Cooperative Lakes Monitoring Program. Searchable online water quality monitoring data are available on this site. **Link 4K**

Michigan Department of Environmental Quality: Nonpoint Source Pollution
The information/education section of this site has numerous resources such as fact sheets, public service announcements (PSAs), and brochures relating to nonpoint source pollution. **Link 4L**

Michigan Natural Shoreline Partnership (MNSP)
The MNSP promotes natural shorelines through the use of green landscaping technologies and bioengineered erosion control for the protection of Michigan inland lakes. This can help to control nutrients. **Link 4M**

Michigan Nonpoint Source Best Management Practices Manual
This document provides guidance on dealing with nonpoint source pollution to restore impaired waters and protect high-quality waters in Michigan. **Link 4N**

Michigan State University Extension
MSU Extension can help with soil testing and advice on how to reduce fertilizer use. **Link 4O**

Nonpoint Source: Education and Outreach
U.S. EPA has assembled outreach materials as part of their Nonpoint Source Outreach Toolbox. The Toolbox contains a variety of resources to help develop an effective and targeted outreach campaign. **Link 4P**

Nonpoint Source Kids: Articles and Activities for Middle School Students
This is a collection of articles and related activity sheets for middle school students. *Improving Old McDonald's Farm* is a U.S. EPA Nonpoint Source Pollution activity for students to work through calculations to determine how much fertilizer is needed to meet a plant's nutrient requirements. From these calculations, students draw conclusions about the most cost-effective and environmentally sound farming practices. **Link 4Q**

Nutrient Framework to Reduce Phosphorus and Nitrogen Pollution
The steps that the Michigan Department of Environmental Quality (MDEQ) has taken and will be taken in Michigan to protect surface waters from excessive nitrogen and phosphorus pollution. **Link 4R**

Nutrient Pollution
This U.S. Environmental Protection Agency website presents the basics of nutrient pollution (problems, sources and solutions, effects, where it occurs); action items for the home, yard, community and classroom; and technical resources. **Link 4S**

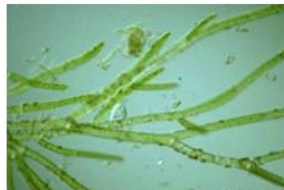
Rain to Drain – Slow the Flow
Rain to Drain - Slow the Flow is a hands-on stormwater education curriculum available from Penn State Extension and Pennsylvania 4-H. This experiment style series of activities leads youth and adults to a better understanding of the movement of stormwater in natural and developed communities. It also is an introduction to green infrastructure and stormwater best management practices. **Link 4T**

Watershed Investigations
These 12 investigations have been developed for a high school investigation-based environmental science curriculum. There is local flavor in this book in that the investigations highlight the Macatawa Watershed in Ottawa County, Michigan. Jennifer Soukhome, NSTA Press, National Science Teachers Association, 2009.

Algal and Cyanobacterial Blooms

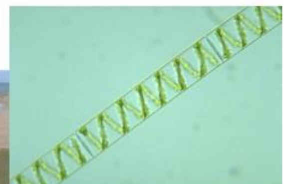
Not all algae forms Harmful Algal Blooms

Examples of Lake Michigan Algae



Cladophora is a branching, green filamentous alga found naturally along the coastline of most of the Great Lakes.

Source: http://www.glwi.uwm.edu/research/aquaticecology/cladophora/



Spirogyra

Source: http://msue.anr.msu.edu/news/not_all_beach_muck_is_created_equal

Harmful Algal Blooms

Microcystis

- Globular colonies that can adjust their buoyancy to move up and down through the water column
- Cannot fix nitrogen from the atmosphere
- Most dominant cyanobacteria in Ohio's Lake Erie waters

Anabaena

- Colonies of hair-like filaments that can be planktonic or form mats along the bottom or near shore
- Can fix nitrogen from the atmosphere using specialized cells

Aphanizomenon

- Colonies of planktonic filaments that often bundle together
- Can fix nitrogen from the atmosphere using specialized cells
- Sometimes sold as a dietary supplement. Consuming could be dangerous because this supplement is not regulated and may contain cyanobacterial toxins. *Consumers beware!*

Lake Erie's most prevalent HAB-forming organisms include *Anabaena, Aphanizomenon,* and *Microcystis* (this trio is sometimes known as "Annie, Fannie, and Mike").

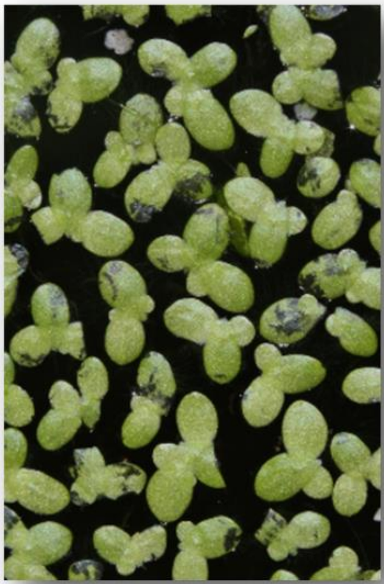
Source: http://www.miseagrant.umich.edu/downloads/hab/Ohio-Sea%20Grant-HABBrochure.pdf

Harmful Algal Bloom: *Microcystis*	Muck: *Cladophora* or *Spirogyra*
◆ Blooms tend to stay in water column	◆ Can wash up on shore in mats
◆ Can produce liver, skin, or nervous system toxins	◆ Not known to produce toxins
◆ Blooms not known to harbor *E. coli*	◆ Mats (on beach and in water) have contained *E. coli*
◆ Peak growth often occurs late summer	◆ Peak growth often occurs early summer
◆ When blooms die, sink to bottom, often responsible for depleted oxygen on bottom	◆ When blooms die, float to surface, final location depends on wind and water bottom circulation
◆ Colonial (circular cells)	◆ Filamentous (end to end), branched
◆ Grows in response to nutrients, light	◆ Grows in response to nutrients, light
◆ Planktonic (passively moves in water)	◆ Benthic (bottom dwelling)
Microalgae (microscopic cells)	◆ Macroalgae (grow up to 3 ft. long)
◆ Zebra mussels promote by selectively filtering other algae, leaving toxic cyanos and rapidly recycling nutrients that stimulate growth.	◆ Zebra mussels promote by providing substrate for growth and providing localized nutrient source.

Michigan Sea Grant: http://www.miseagrant.umich.edu/downloads/hab/HAB_Muck-2009.pdf

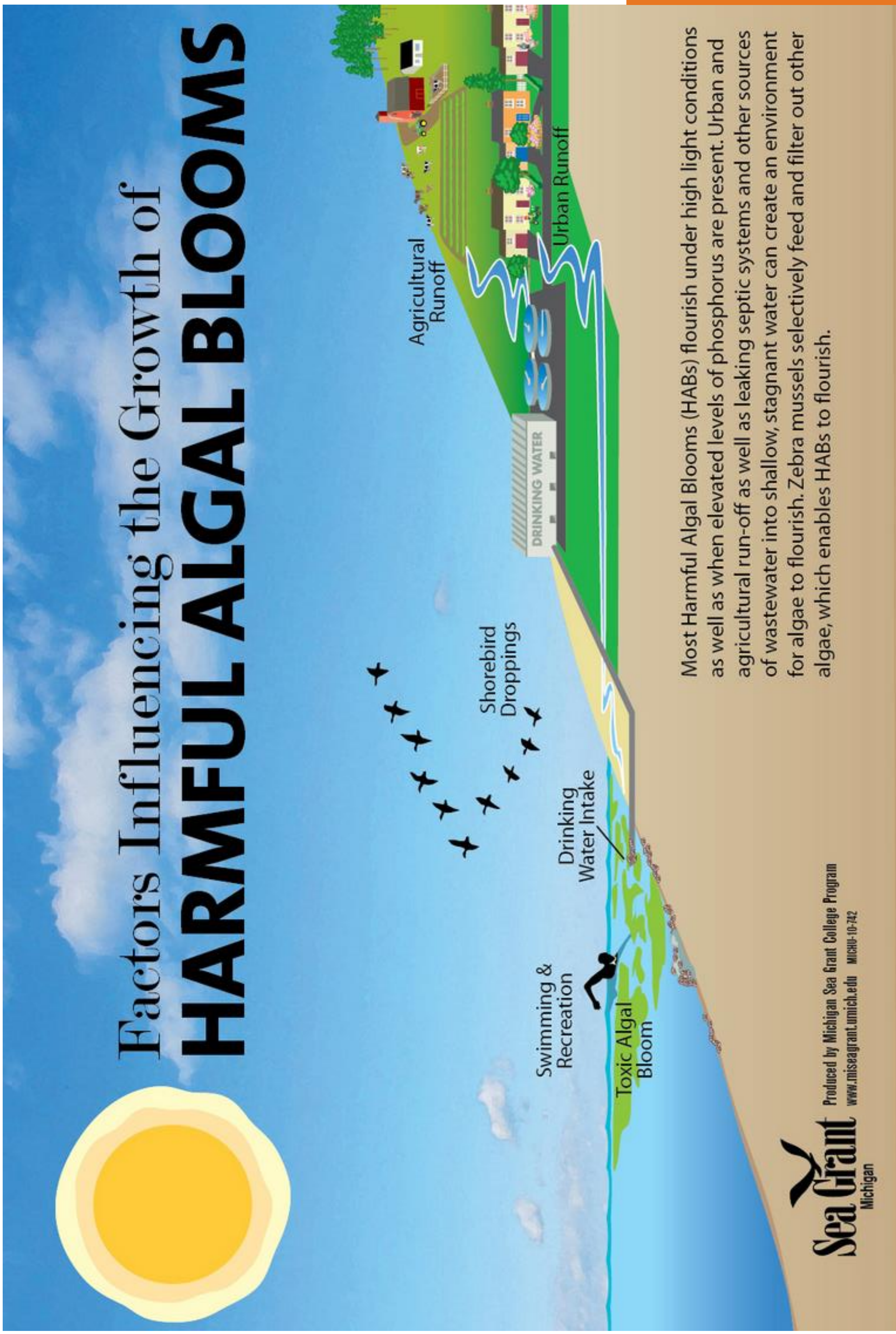
Duckweed

J. Vail

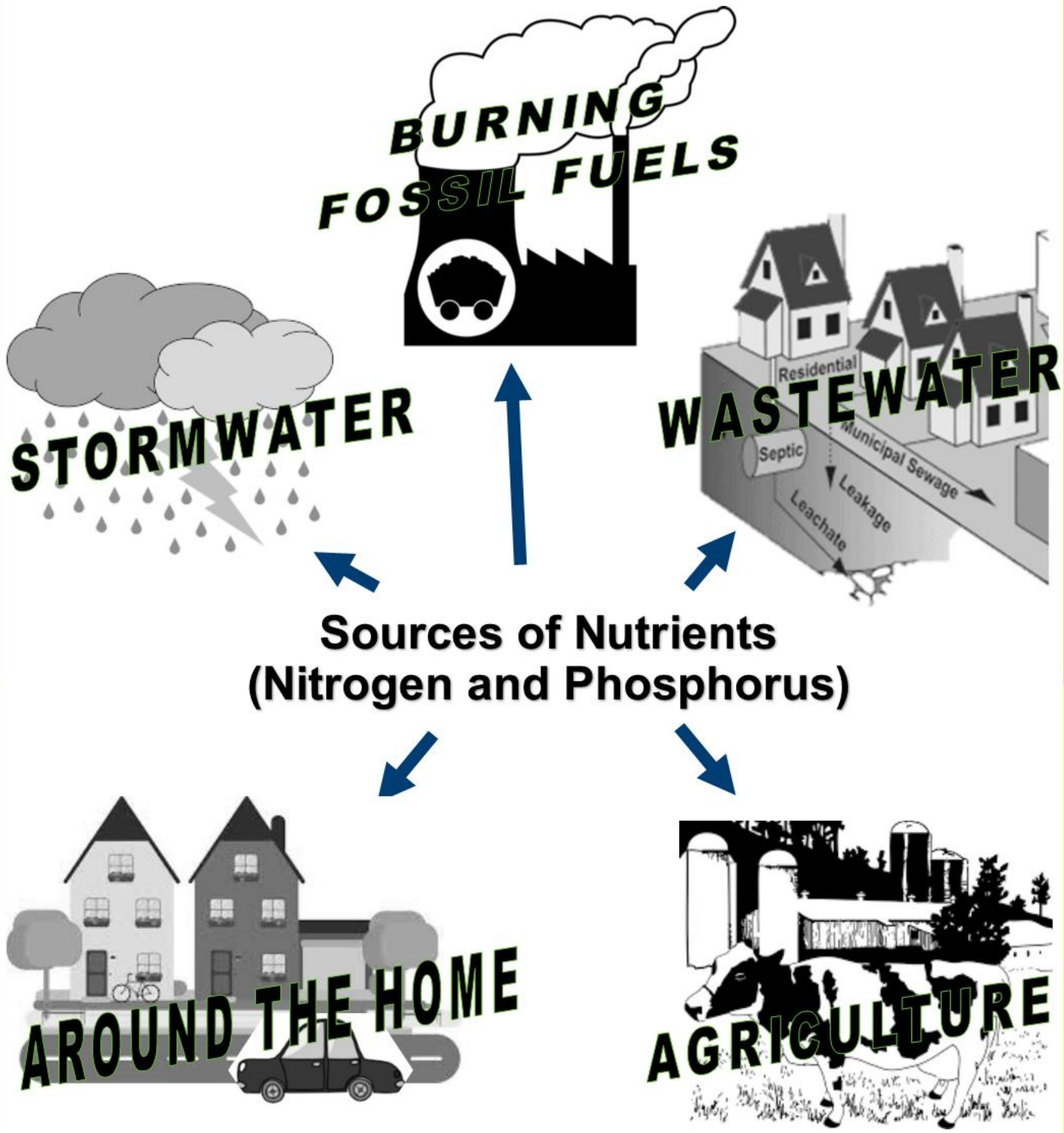


http://michiganflora.net/species.aspx?id=174

J. Vail



Harmful Algal Blooms in the Great Lakes: http://www.miseagrant.umich.edu/wp-content/blogs.dir/1/files/2012/05/10-742-Harmful-Algal-Bloom-illustration-1579px.jpg



Nutrients come from multiple sources.

Sources of Nutrients (Nitrogen and Phosphorus)

The *Sources of Nutrients (Nitrogen and Phosphorus)* diagram illustrates five main sources of nutrients (nitrogen and phosphorus). Interpret the *Sources of Nutrients (Nitrogen and Phosphorus) diagram* to fill in the following table:

General Type of Source	**What Contributes the Nutrients?**

Your teacher will provide a student reading on *Nutrients*. Re-visit your table and revise your "Type of Source" and "What contributes to the nutrients?" columns to reflect the new information.

Sources of Nutrients (Nitrogen and Phosphorus)

The *Sources of Nutrients (Nitrogen and Phosphorus)* diagram illustrates five main sources of nutrients (nitrogen and phosphorus). Interpret the *Sources of Nutrients (Nitrogen and Phosphorus) diagram* to fill in the following table:

General Type of Source	What Contributes the Nutrients?
Agriculture	• Fertilizer • Soil erosion • Animal waste
Stormwater	• Fertilizer • Soil erosion • Animal waste • Car washing
Wastewater	• Human waste • Other waste • Garbage disposal waste • Leaking sewers and faulty septic systems
Burning of fossil fuels	• Burning of fossil releases nitrogen compounds (NOx) into the air. • Factories, cars, trucks, and many power plants burn fossil fuel
In and around the home	• Fertilizer • Faulty septic systems • Leaves and grass clippings • Cleaning supplies • Pet waste

Nonpoint Source Pollution: Nutrients

Nutrient pollution is one of America's most widespread, costly and challenging environmental problems, and is caused by excess nitrogen and phosphorus in the air and water.

Nitrogen and **phosphorus** are nutrients that are natural parts of aquatic ecosystems. Nitrogen is also the most abundant element in the air we breathe. Nitrogen and phosphorus support the growth of algae and aquatic plants, which provide food and habitat for fish, shellfish and smaller organisms that live in water.

But when too much nitrogen and phosphorus enter the environment - usually from a wide range of human activities - the air and water can become polluted. Nutrient pollution has impacted many streams, rivers, lakes, bays and coastal waters for the past several decades, resulting in serious environmental and human health issues, and impacting the economy. Excess nitrogen in the atmosphere can produce pollutants such as ammonia and ozone, which can impair our ability to breathe, limit visibility and alter plant growth. When excess nitrogen comes back to earth from the atmosphere, it can harm the health of forests, soils and waterways.

Too much nitrogen and phosphorus in the water causes **algae** and **cyanobacteria** (formerly called blue-green algae) to grow faster than ecosystems can handle. Significant increases in algae and cyanobacteria harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive. Large growths of algae and cyanobacteria are called **algal** and **cyanobacterial blooms** and they can severely reduce or eliminate oxygen in the water, leading to illnesses in fish and the death of large numbers of fish. Some algal blooms are harmful to humans because they produce elevated toxins and bacterial growth that can make people sick if they come into contact with polluted water, consume tainted fish or shellfish, or drink contaminated water. Blooms which can injure animals or the ecology are called "harmful algal blooms" (HABs).

Excessive nitrogen and phosphorus that washes into water bodies is often the direct result of human activities. The primary sources of nutrient pollution are:

Agriculture: Animal manure, excess fertilizer applied to crops and fields, and soil erosion make agriculture one of the largest sources of nitrogen and phosphorus pollution in the country.

Stormwater: When precipitation falls on our cities and towns, it runs across hard surfaces - like rooftops, sidewalks and roads - and carries pollutants, including nitrogen and phosphorus, into local waterways.

Wastewater: Our sewer and septic systems are responsible for treating large quantities of waste, and these systems do not always operate properly or remove enough nitrogen and phosphorus before discharging into waterways.

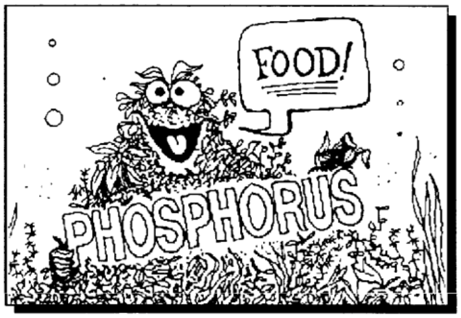
Burning of Fossil Fuels: Electric power generation, industry, transportation and agriculture have increased the amount of nitrogen in the air through use of fossil fuels.

In and Around the Home: Fertilizers, yard and pet waste, and certain soaps and detergents contain nitrogen and phosphorus, and can contribute to nutrient pollution if not properly used or disposed of. The amount of hard surfaces and type of landscaping can also increase the runoff of nitrogen and phosphorus during wet weather.

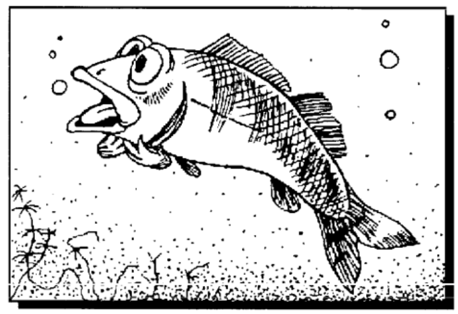
Source: U. S. EPA. Nutrient Pollution.
https://www.epa.gov/nutrientpollution

NUTRIENTS

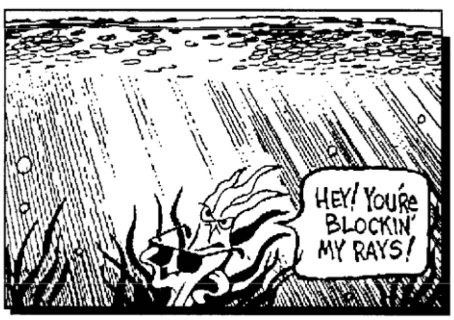
Nutrients such as phosphorus and nitrogen come from manure, pet wastes, improperly maintained septic systems and misapplication of fertilizers on lawns or farm fields. Nutrients can also be carried off the land with eroding soil. When these nutrients reach our lakes and streams they do more than turn the water green with weeds and algae.



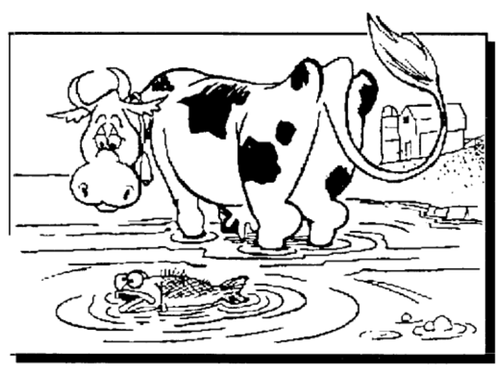
- Phosphorus contributes to the eutrophication (over-fertilization) of lakes and streams. This leads to an increase in undesirable weed and algae growth. Excess weeds and algae are harmful to fish, and make a lake or stream less attractive for swimming, boating and other activities.



- When algae and aquatic weeds die, they are broken down by bacteria. During this process, bacteria consume oxygen. Lower oxygen levels can make it difficult for fish and other aquatic organisms to survive. Excess weeds also contribute to winter fish kills in shallow lakes.



- Excess algae can reduce populations of bottom-rooted plants by blocking sunlight. Bottom-rooted plants provide food and habitat for fish and waterfowl.



- When organic materials such as manure, pet wastes, leaves and grass clippings enter a lake or stream they are broken down by bacteria. The decomposition process reduces oxygen levels in the water and may increase ammonia levels. Low oxygen levels and high ammonia levels, combined with warm temperatures, can kill fish.

Source: http://www.michigan.gov/documents/deq/wb-nps-brown-water-green weeds_250578_7.pdf

Investigate!

Question: What are the effects of nutrients on algal growth or the growth of aquatic plants such as duckweed or water milfoil?

1. When designing your investigation, consider the following:

- What question would we like to answer?
- What is the dependent variable?
- What is the independent variable?
- What aquatic organism will we use?
- What will be the source of nutrients?
- What is the design of our investigation?
- How will we monitor the results?
- Where will we get the algae or duckweed?
- What materials are needed?
- How long will the investigation be run?
- How will we present the results?

Before beginning your investigation, conduct research to become familiar with the topic of nutrients and the algae or aquatic plant you will be using in your investigation.

2. Conduct your investigation!

3. Create a scientific poster about your investigation. Be sure to include the following:

- Title of the investigation
- Introduction
- Materials and Methods
- Results
- Discussion
- Summary/Conclusion
- References

Nutrients and Aquatic Plants Investigation Sample

The following is an excerpt of an outline for an investigation designed by a high school student to observe the effect of fertilizer on the growth of aquatic plants (duckweed).

Duckweed is a small green floating plant found in still or slow moving waters. Duckweed can rapidly reproduce in optimal conditions, quickly covering a body of water. So what conditions are optimal for duckweed?

Question: How will different amount of nutrients affect the growth of duckweed?

Hypothesis: Lower amounts of nutrients will yield a lower amount of growth whereas higher amounts of nutrients will yield a greater amount of growth.

Materials: clear plastic egg cartons, permanent marker, liquid plant food* (dilute according to manufacturer instructions), distilled water, graduated cylinder, small spoon, live duckweed

*Originally performed with Miracle-Gro – Liquid Houseplant Food 8-7-6

Methods:

1. Design a preliminary investigation to look at the effects of fertilizer on the growth of duckweed.
2. Collect duckweed.
3. Label each pocket in the egg carton “1-12” with a permanent marker.
4. Fill each pocket with 15 mL of distilled water.
5. Add liquid plant food into each pocket as corresponding to the Data Table.
6. Remove duckweed from the culture by dipping spoon into the water.
7. Place 5 individual duckweed plants into each pocket.
8. Close or cover egg carton to prevent evaporation.
9. Photograph each pocket at the start and the conclusion of the investigation.
10. Observe for one week or more counting the number of plants.
11. Compare photographs and record findings including the appearance of plants.
12. Revise the experimental design based on the results of the preliminary investigation.
13. Re-run the investigation making sure to use replicates.

<u>Results</u>:

1. Preliminary investigation:

Pocket #	Amount of liquid plant food added	Duckweed after one week	Duckweed change
Pocket 1	0 drops	7 Plants	+2 Plants
Pocket 2	0 drop	6 Plants	+1 Plants
Pocket 3	0 drops	11 Plants	+6 Plants
Pocket 4	1 drops	9 Plants	+4 Plants
Pocket 5	1 drops	9 Plants	+4 Plants
Pocket 6	1 drops	10 Plants	+5 Plants
Pocket 7	2 drops	10 Plants	+5 Plants
Pocket 8	2 drops	8 Plants	+3 Plants
Pocket 9	2 drops	10 Plants	+5 Plants
Pocket 10	3 drops	12 Plants	+7 Plants
Pocket 11	3 drops	11 Plants	+5 Plants
Pocket 12	3 drops	7 Plants	+2 Plants


Pocket #1 Before


Pocket #1 After


Pocket #9 Before


Pocket #9 After

Plants with greater amounts of fertilizer tended to turn brown and appeared unhealthy.

2. Actual investigation:

Pocket #	**Amount of liquid plant food added**	**Initial number of duckweed (Date:)**	**Final number of duckweed (Date:)**	**Duckweed change**
Pocket 1	0 drops			
Pocket 2	0 drop			
Pocket 3	0 drops			
Pocket 4	1 drops			
Pocket 5	1 drops			
Pocket 6	1 drops			
Pocket 7	2 drops			
Pocket 8	2 drops			
Pocket 9	2 drops			
Pocket 10	3 drops			
Pocket 11	3 drops			
Pocket 12	3 drops			

<u>Discussion</u>:

<u>Conclusion</u>:

Exploratory Data Analysis

Below is information from the Subwatershed Management Unit Summaries for the Lower Grand River Watershed. See the *Locations of Subwatershed Management Units* maps for their locations. Taking into account the information below, your group's task is to:

- Look at the information that is currently in the Nutrient Load table, determine the **top four** management units that should be priorities for nutrient reduction, and explain in detail why you have made your selections.

- Calculate the missing columns in the table and re-visit your selection for the **top four** management units.

Nutrient Load

Management Unit	Acres	Phosphorus lbs/year	Phosphorus lbs/acre	Nitrogen lbs/year	Nitrogen lbs/acre	Agri-culture %	Urban %
Bear Creek	20,332	3,690		21,600		34	12
Buck Creek	32,392	28,061		153,436		18	64
Deer Creek	22,374	3,600		20,913		79	8
Indian Mill Creek	10,979	7,545		42,689		39	43
Rogue River	139,522	50,936		291,252		42-45	5-19
Rush Creek	38,041	18,330		103,000		38	46
Sand Creek	35,085	12,620		75,200		64	14
Lower Thornapple River	93,534	22,890		133,690		43	14

1. How did calculating the loads in lbs/acre influence your choices?

2. What influenced your discussion about the sources of the nutrient loads?

ANSWER KEY

Exploratory Data Analysis

Below is information from the Subwatershed Management Unit Summaries for the Lower Grand River Watershed. See the *Locations of Subwatershed Management Units* maps for their locations. Taking into account the information below, your group's task is to:

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- Calculate the missing columns in the table and re-visit your selection for the **top four** management units.

Nutrient Load

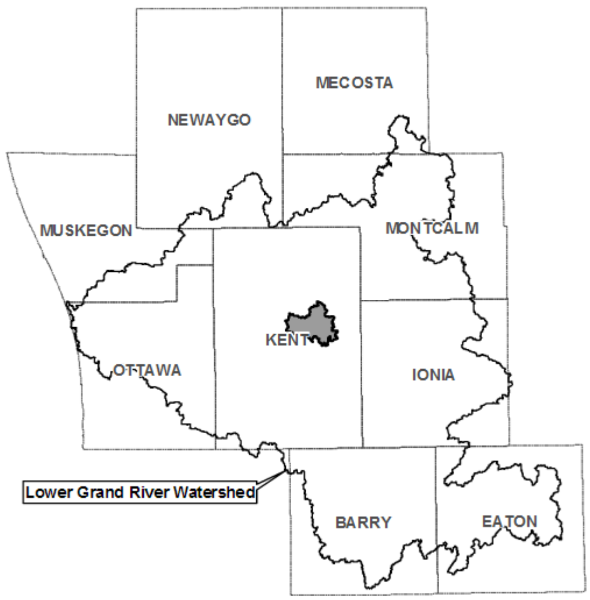
Management Unit, *(Rank)*	**Acres**	**Phosphorus lbs/year**	**Phosphorus lbs/year/acre**	**Nitrogen lbs/year**	**Nitrogen lbs/year/ acre**	**Agri-culture %**	**Urban %**
Bear Creek *22*	20,332	3,690	*0.18*	21,600	*1.06*	34	12
Buck Creek *1*	32,392	28,061	*0.87*	153,436	*4.74*	18	64
Deer Creek *27*	22,374	3,600	*0.16*	20,913	*0.93*	79	8
Indian Mill Creek *4*	10,979	7,545	*0.69*	42,689	*3.89*	39	43
Rogue River 2	139,522	50,936	*0.37*	291,252	*2.09*	42-45	5-19
Rush Creek *6*	38,041	18,330	*0.48*	103,000	*2.71*	38	46
Sand Creek *10*	35,085	12,620	*0.36*	75,200	*2.14*	64	14
Lower Thornapple River *11*	93,534	22,890	*0.24*	133,690	*1.43*	43	14

1. How did calculating the loads in lbs/year/acre influence your choices?

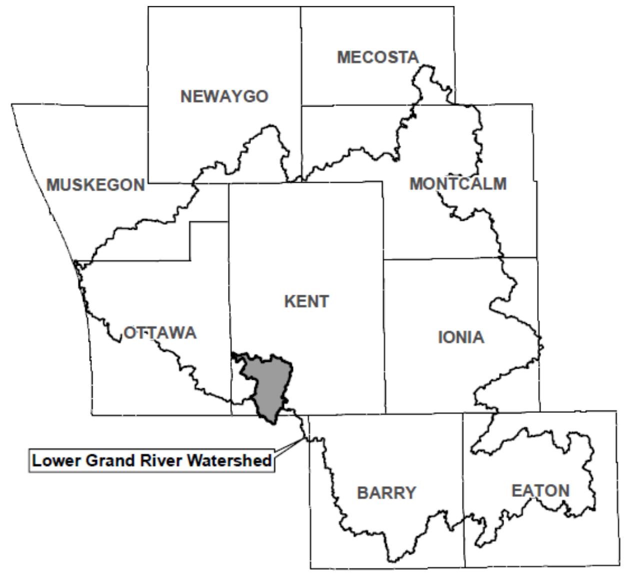
2. What influenced your discussion about the sources of the nutrient loads?

Locations of Subwatershed Management Units

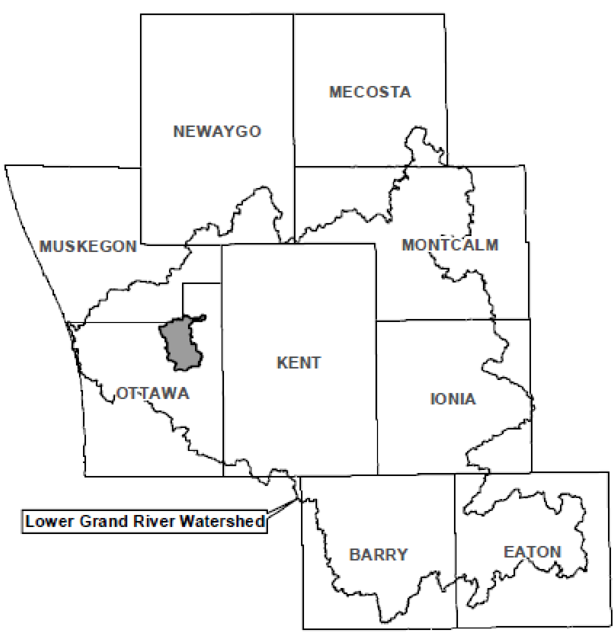
Bear Creek



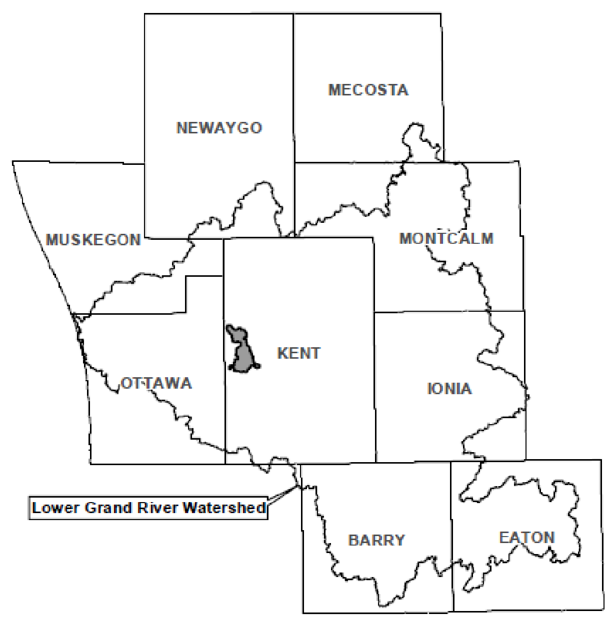
Buck Creek



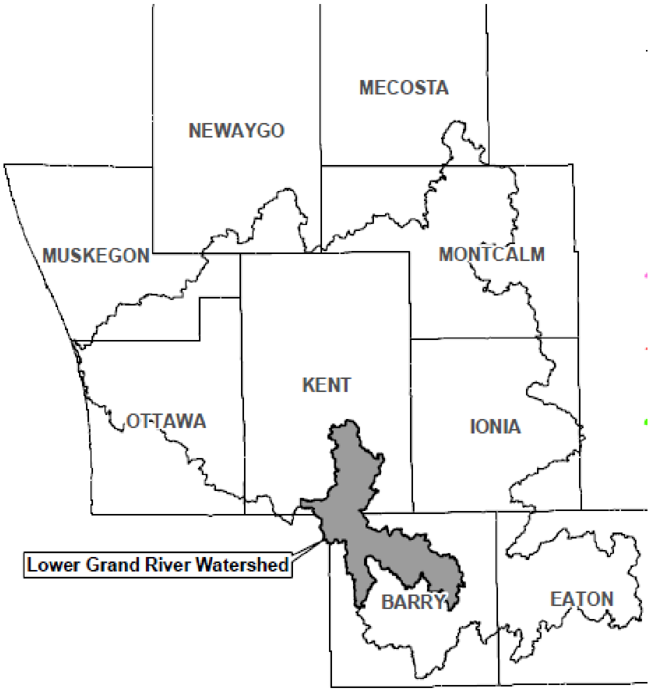
Deer Creek



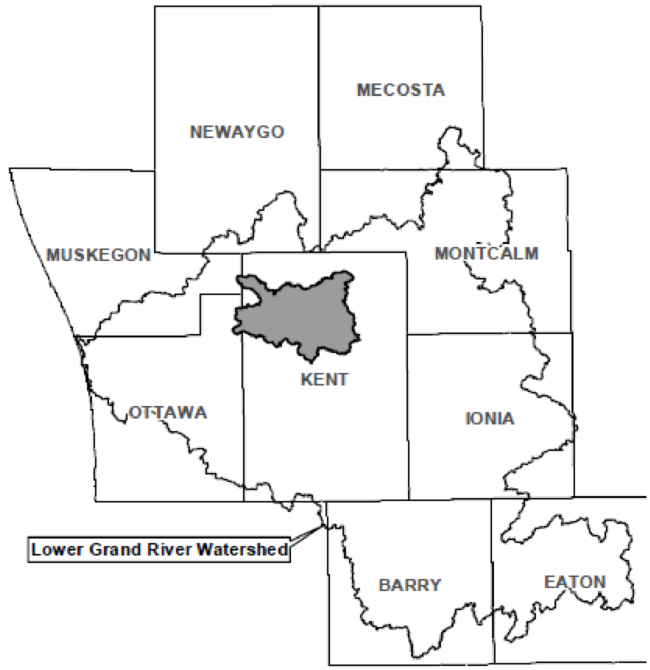
Indian Mill Creek



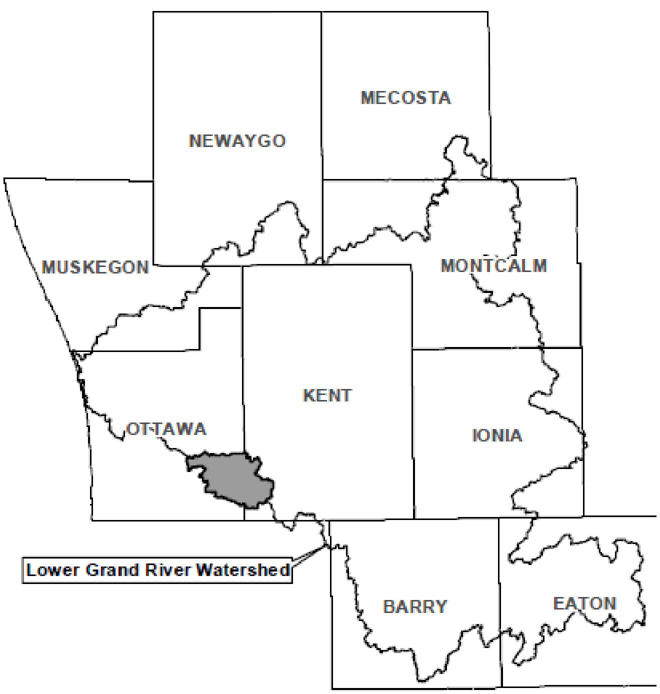
Lower Thornapple River



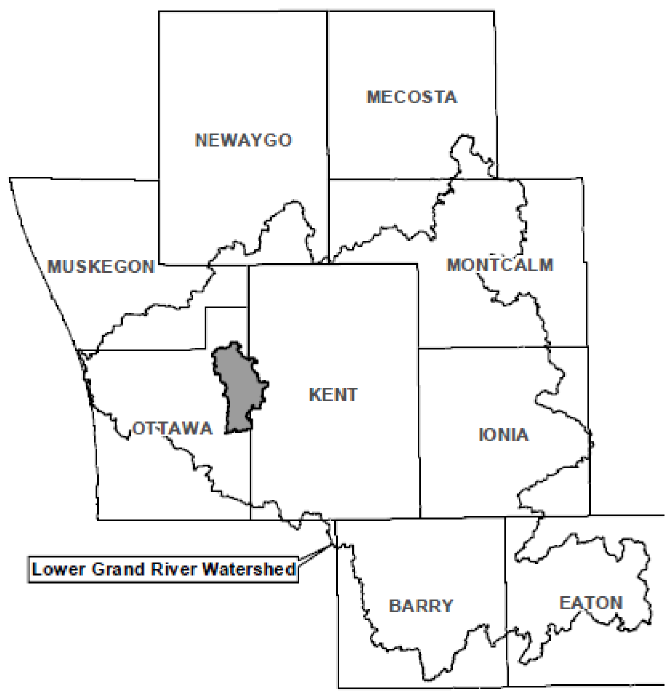
Lower Rogue River



Rush Creek



Sand Creek



Lower Grand River Watershed Management Plan

Below are excerpts from the Lower Grand River Watershed Management Plan. You can find the entire report at https://www.gvsu.edu/wri/isc/lower-grand-river-watershed-management-plan-312.htm.

2.1 CULTURAL HISTORY

The Lower Grand River Watershed (LGRW or Watershed), home to the mound-building Hopewell Indian Tribe and later to the European settlers, is a region rich in cultural history and natural resources. Native Americans and European settlers alike depended on the Grand River for food, transportation, and recreation.

By the mid 1960s, the Grand River needed a massive cleanup effort. Using funds from the 1968 Clean Water Bond, many municipal wastewater treatment plants were able to upgrade technologies, and volunteers had supplies they needed to clean up trash and debris and plant trees along the river's banks.

An ambitious project called the Grand River Salmon Plan began in 1977, and brought salmon and other sport fish all the way to the state capitol by constructing a series of fish ladders over the six dams that obstructed fish passage upstream of Grand Rapids.

In the 1990s, the City of Grand Rapids began a massive undertaking of removing combined sewers. The combined sewers delivered both sanitary and storm water to the City of Grand Rapid's Wastewater Treatment Plant. During periods of heavy rainfall, the sewers would overflow into the Grand River. Occasionally, this would result in bacteria counts that warranted beach closures downstream.

2.2 GEOGRAPHIC SCOPE AND BOUNDARIES

The LGRW encompasses 1,861,468 acres (2,909 square miles) and encompasses large portions of Ottawa, Muskegon, Kent, Montcalm, Ionia, Barry, and Eaton Counties. The main branch of the LGR is 51 miles long, and the major tributaries flow for a total of 209 miles.

2.3 GEOLOGY AND TOPOGRAPHY

The topography within the LGRW is influenced by glacial deposition of sediment and the effect of water deposition and drainage over time. The elevations in the Watershed range from 780 feet, at the most eastern edge of the Watershed, to 571 feet at its confluence with Lake Michigan at the City of Grand Haven.

2.6 NATURAL RESOURCES

Wetlands

Wetlands are a critical component to watershed health, as they improve water quality by trapping pollutants and serving as natural detention areas. The Watershed is home to numerous types of wetlands. Wetlands are invaluable for a variety of water quality functions they naturally perform. These include, but are not limited, to the following:

- Denitrification: Studies show that in certain instances, wetlands can remove from 70 to 90 percent of nitrates.
- Trapping sediments can keep large amounts of phosphorous from entering adjacent rivers and reduces sedimentation.

Fish and Wildlife

A diversity of aquatic and terrestrial habitat types are found throughout the Watershed that harbors various amphibian, reptile, avian, mammal, and fish species. Many of these species are important from a recreational and economical perspective.

Protected Species

Michigan has a number of significant natural features located across the state. These natural features can provide public benefits that may include bird watching, hunting, fishing, camping, hiking, off-roading, and water sports. However, these areas also include critical habitat for different species of plants, mammal, amphibians, reptiles, birds, fish, and macroinvertebrates.

3.3.4 Stream Inventory

Table 3.3 – NPS Inventory Summary

Pollutant Source	Number of Sites per Subwatershed Management Unit										
	Plaster Creek[1]	Buck Creek[2]	Coldwater River[3]	Indian Mill Creek[4]	Sand Creek[5]	Upper and Lower Rogue River[6]	Upper and Lower Thornapple River[7]	Spring Lake[8]	Deer Creek[9]	Bass River[9]	Total
Nonpoint Agriculture Source	2		1	9	3	9	127		9	16	**176**
Streambank Erosion	8	16	1	16	19	1	42	7	2		**112**
Tile Outlet	2	2		5	3			62	4	2	**80**
Livestock Access		1	15	1	5	7	14		4		**47**
Debris/Trash/Obstructions	41	60	60	37	6		122				**326**
Urban/Residential	14	12	2	59	39		42		7	19	**194**
Construction	6	4		1					2		**13**
Other	4					6					**10**
Gully Erosion	1	3	4	1	6						**15**
Rill Erosion				3							**3**
Downcutting					1	4					**5**
Stream Crossing/Road Stream Crossing	6	1			13	5	170	13	2	1	**211**
Total NPS Sites	**84**	**99**	**83**	**132**	**95**	**32**	**517**	**82**	**30**	**38**	**1,192**

[1] Grand Valley Metropolitan Council (GVMC), Plaster Creek Watershed Management Plan, 2008

[2] GVMC, Buck Creek Watershed Management Plan, 2004.

[3] GVMC, Coldwater River Watershed Management Plan, April 2009.

[4] Sievert, Mary & Janice Tompkins. 2010. Summary of Indian Mill Creek Watershed Assessment. MNDRE, Field Operation Section, Water Division, Grand Rapids, MI.

[5] GVMC, Sand Creek Watershed Management Plan, July 2004.

[6] Annis Water Resources Institute, Rogue River Watershed Management Plan, December 2000.

[7] Barry Conservation District, Thornapple River Watershed Management Plan Draft, July 2009.

[8] Progressive AE. *Spring Lake Watershed Management Plan*. 2001

[9] Inventory of main branches of Deer Creek and Bass River was completed for this project.

4.1 IDENTIFYING SOURCES AND CAUSES

Once specific pollutants were identified, the focus of investigation turned to possible sources. In order to reduce the pollutants impairing the designated uses of the Watershed, it was necessary to determine where the pollutants originate as well as why the pollutant is impairing the Watershed. By identifying the cause of the pollutant source, implementation efforts can be directed to correct the condition that is generating the pollutant. This helps to ensure the most appropriate designs and successful control measures are implemented or installed.

Table 4.1a – Sediment and Nutrient Loadings by Source - NPS Sites

Subwatershed	Sediment Loading (tons/yr)						Phosphorus Content (lbs/yr)	Nitrogen Content (lbs/yr)
	Streambank Erosion	Gully Erosion	Tile Outlet	Road/Stream Crossing	Livestock Access	Total (tons/yr)		
Rogue River (Lower & Upper Rogue)	556			1,491	99	2,146	1,826	3,652
Coldwater River	453				30	483	427	854
Plaster Creek	13.5	1.1	0.2	15.8		31	27	54
Buck Creek	18	0.3			6.6	25	21	36
Bass River			0.1	0.6		0.7	0.6	1
Indian Mill Creek	110.9	2.1			0.3	113	95	189
Deer Creek	0.1		1	0.1	6	7	6	13
TOTAL	**1,151.5**	**3.5**	**1.3**	**1507.5**	**141.9**	**2,806**	**2,396**	**4,798**

Plan for Action: Subwatershed Research Project

Instructions:

A Lower Grand River Watershed meeting will be held in your classroom. You and your team members will represent one of the subwatersheds of the Lower Grand River. You need to create a visual (poster, PowerPoint, brochure, etc.) to explain why or why not your subwatershed should be a priority for nutrient reduction. Your group will present this visual representation to the class. The class will then vote prioritize all of the subwatersheds for nutrient reduction from #1 (high priority) to #8 (lower priority).

There are many factors to consider when making watershed management decisions. To learn more about the subwatershed you are representing, complete the following:

- Calculate the missing values in the *Exploratory Data Analysis* (Student Activity)
- Examine the *Locations of Subwatershed Management Units* (Student Resource)
- Read the *Lower Grand River Watershed Management Plan* (Student Resource)
- Visit the LGROW website at http://www.lgrow.org/ and click on your subwatershed under the watersheds heading to read more about the subwatershed you are representing.

Once you have completed the above tasks, begin your visual representation. You need to make sure that everyone in your group has a role in creating and presenting your visual.

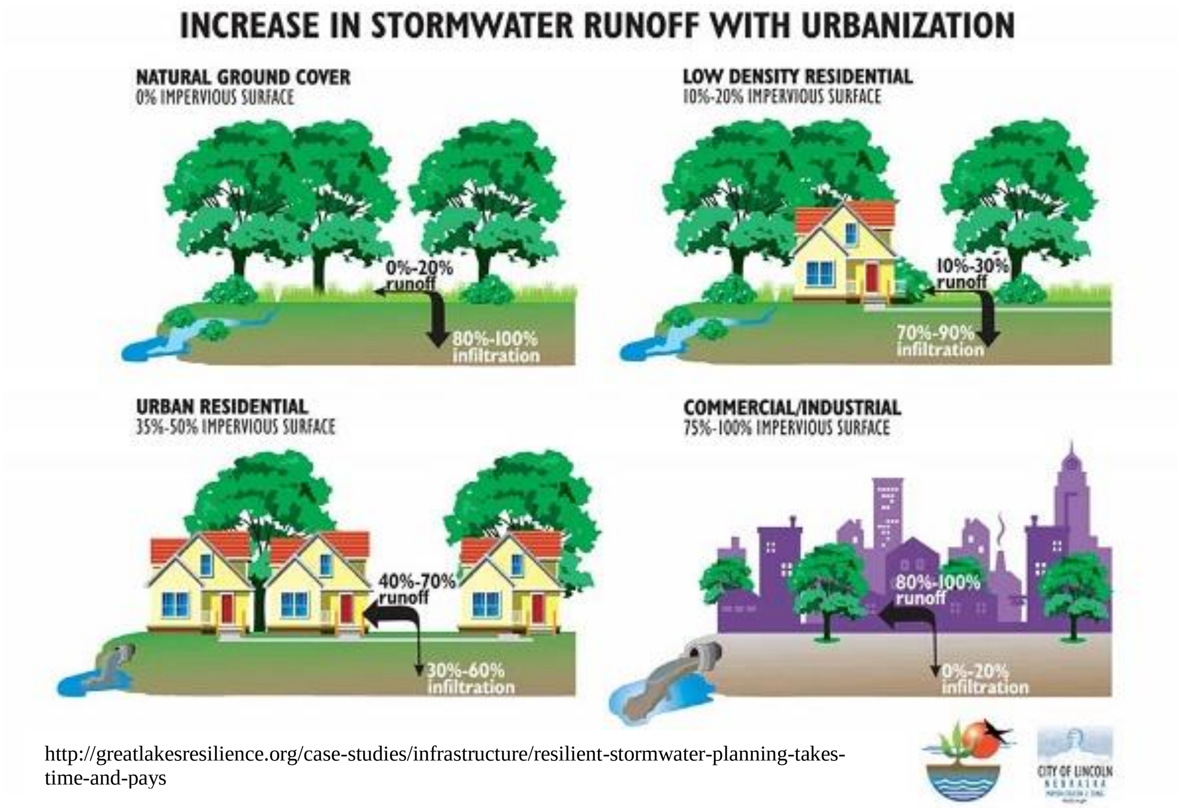
Subwatershed:

____

Group Members:

____

____



http://greatlakesresilience.org/case-studies/infrastructure/resilient-stormwater-planning-takes-time-and-pays

Visualize rain falling on a field. Where does the rain go? Now visualize rain falling on an asphalt parking lot. Where does the rain go? Not all surfaces within a watershed respond to water in the same way. Surface type can be roughly broken down into two categories:

1) **Pervious surfaces** (wetlands, fields, forests, boardwalks, wood-chipped walkways) allow water to soak into the ground (a process called infiltration). **Infiltration** decreases the amount of surface runoff, reduces the flow of water over the landscape, and increases groundwater recharge.
2) **Impervious surfaces** (roads, rooftops, parking lots, and other hard surfaces) do not allow water to soak into the ground, which means more water flows over the surface of the landscape. Increased surface runoff also increases the speed at which water moves through the watershed.

Impervious surfaces also decrease groundwater recharge. Whether or not water ends up as groundwater or surface water is a big deal. Water in the ground creates what we call “groundwater” and the “water table.” This water is our source of well water, and it provides water (“baseflow”) to our streams, rivers, and lakes during the winter and in between rainstorms in the summer. Without it, streams could stop flowing during droughts and over winter.

Cities build lots of roads, buildings, houses, driveways, parking lots, etc. All of these things are impervious surfaces and they prevent rainwater from soaking into the ground and reaching the groundwater. When rain hits these surfaces, the water flows rapidly across them and into storm drains, instead of soaking into the ground and becoming groundwater. All of this

STUDENT ACTIVITY

water greatly alters the natural flow of the stream, making the flow more dependent on intermittent rainfall than on the steady flow of groundwater.

In many cases, storm sewers empty into streams and lakes, carrying any pollutants picked up along the way. **Stormwater** in these pipes does not get treated by the wastewater treatment plant- it goes straight into natural waters. Anything that the stormwater picks up while flowing across lawns and parking lots or down streets, such as pet waste, fertilizer, soil, motor oil, and pesticides will directly enter into streams, rivers, or lakes.

Stormwater also enters streams and rivers in high volumes and fast velocity during a storm. This causes erosion of stream banks, which destabilizes the channel, muddies the water, and degrades habitat for plants and animals. Soil in the water clogs the gills of fish; fills in the area around rocks where all the bugs, young fish, and crayfish live; and blocks light needed for plants to photosynthesize. The soil also settles to the bottom, filling in the channels of streams, lakes, and reservoirs.

Impervious and Pervious Walking Tour
(Note: Questions for you to answer and areas that your need to write down observations/comments are in the bold text.)

1. You are going on an impervious surface hunt! You are looking at how many impervious surfaces exist around the school or where you live.
2. Make a map of your schoolyard (or where you live). Or obtain a map of your area from a site such as Google Earth.
3. Take a cup of water outside and pour some of it onto to different surfaces. **Make observations about what happens. Can you tell what is pervious or impervious?**

   ____
   ____
   ____
   ____

4. Now look at your map. **Predict which surfaces around the school will be pervious or impervious in the table below.**

Pervious	**Impervious**

5. Using the cup of water, explore different surfaces to see if they are pervious or impervious. **When you find an impervious surface, color that part of the map. Put a check mark on your chart above if you were correct in your prediction for that surface.**
6. **Are there more pervious or impervious surfaces around the school?**

   ____
   ____
   ____

7. Where does water go when it rains on impervious surfaces? Find an impervious surface. Pour water on it and watch where it goes.
8. **Do you see any storm sewers anywhere, if so, where?**

   ____
   ____

9. **Where do storm sewers go?**

   ____
   ____
   ____
   ____

10. **Why is it important to know if this water goes directly to river, streams, and lakes?**

   ____
   ____
   ____
   ____
   ____

11. Look for potential pollution problems from stormwater (pet or wildlife waste, soil erosion, evidence of fertilizer, car oil, leaves clogging up the storm drain) in your schoolyard.
12. **Estimate the percentage of impervious surface on your map.**

   ____
   ____

Advanced lesson: Calculate the area of impervious surfaces then determine the volume of water that would flow off the site during a 1 inch rainfall.

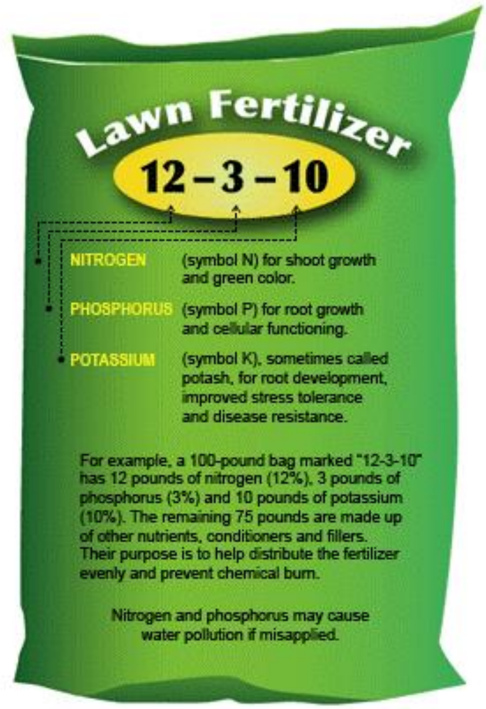
Source: Adapted from *A very impervious surface*, Science Institute 2012-2013.

What nutrients are in fertilizers?

Many people use fertilizer to make their lawns and gardens grow. Did you know that fertilizers have different amounts of nutrients and that there are three numbers on the bag or bottle that tell you how much of each nutrient is in the bag?

***Check out this bag*:**

All fertilizer labels have three bold numbers. The first number is the percent of available nitrogen (N), the second number is the percent of available phosphate (P_2O_5) and the third number is the percent of available potash (K_2O). These three numbers represent the primary nutrients: (nitrogen (N) – phosphorus (P) – potassium (K).



Fertilizer Detectives

See if you can locate some fertilizer or house plant food (or use the student resource *Fertilizer Bag Samples*) and fill in the following along with the pounds of each nutrient. See the sample in the first row using the bag to the right.

Fertilizer Brand/ lbs in bag	Nitrogen	Phosphorus	Potassium
Lawn Fertilizer/ 100 lbs	*12% / 12 lbs*	*3% / 3 lbs*	*10% / 10 lbs*

In 2012, a Michigan law was passed banning phosphorus in lawn fertilizers for most domestic (residential) and commercial uses. The new law also regulates applying phosphorus-containing fertilizers on frozen ground, water-soaked soil or near any surface water. The law also indicates phosphorus can be used if there is a recent soil test to indicate it is needed.

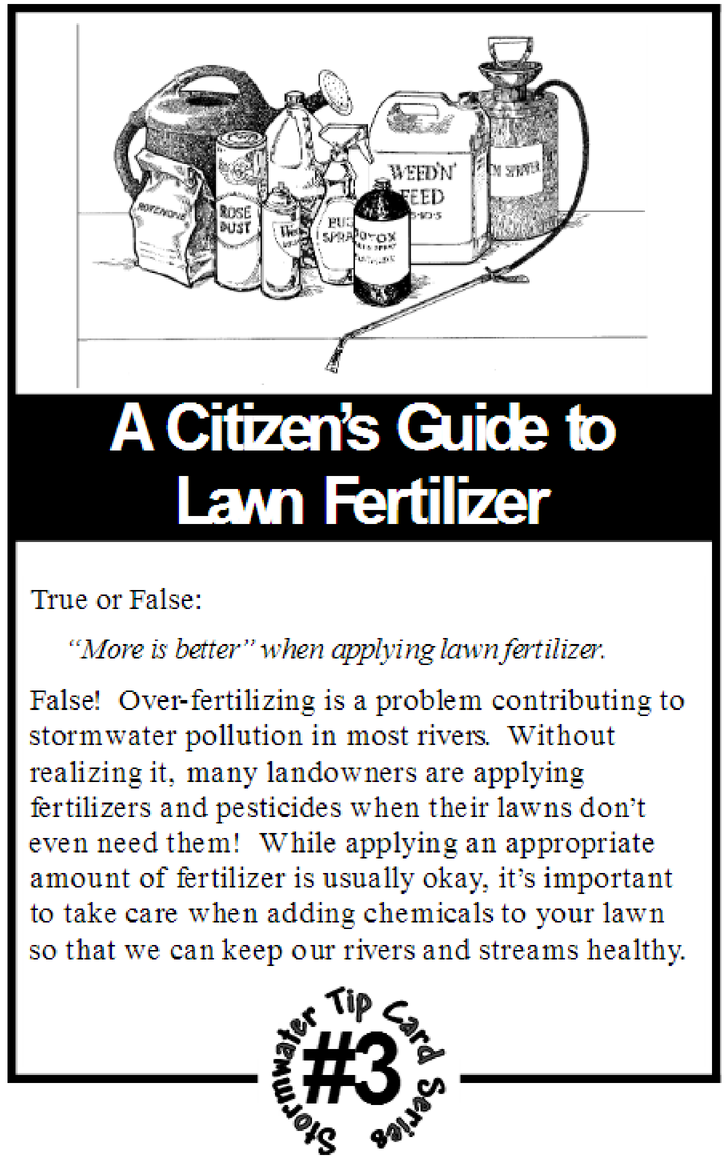
1. Is there phosphorus in any of your fertilizer examples?

2. What are some examples of the appropriate use for fertilizers that have phosphorous?

Extra: Use the Michigan State University's fertilizer calculator to determine how much nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) (in lbs./1000 ft.^{2}) the fertilizer analysis you choose will supply. http://www.msusoiltest.com/tools/fertilizer-calculator/

Fertilizer Bag Samples

Examples of Outreach Materials



Source: Michigan Department of Environmental Quality. https://www.michigan.gov/documents/deq/ess-nps-savvy-fertilizer_209418_7.pdf, http://www.michigan.gov/documents/deq/ess-nps-savvy-spread-color_209517_7.pdf

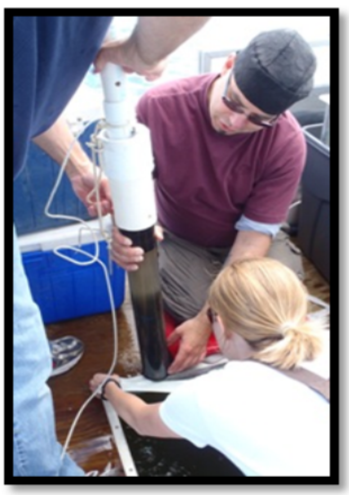
Spring Lake Phosphorus Project

Background Information

Spring Lake is a highly eutrophic lake in the Lower Grand River Watershed that is impacted by high phosphorus levels. Spring Lake is connected to the Grand River near its mouth. The excess phosphorus and other nutrients cause algal blooms in the lake, which degrade its recreational value and ecological health.

In highly eutrophic lakes such as Spring Lake, internal loading can account for a substantial amount of the total phosphorus load.

Historically, investigations of phosphorus loads in water bodies have focused on external sources of phosphorus from the area of the watershed draining to that lake. However, many studies have shown that reductions in external nutrient loads do not result in immediate reductions of algal growth because of the sediment at the bottom of the lake continues to release phosphorus (i.e., internal loading).



Sediment Cores

The Spring Lake – Lake Board first contacted Dr. Alan Steinman's Lab at Grand Valley State University Annis Water Resources Institute in 2003 to study the importance of internal phosphorus loading in Spring Lake. Based on initial findings, the community approved an alum treatment in the lake to limit internal phosphorus loading. Chemical applications are intended to bind the phosphorus and usually include aluminum sulfate (alum). This treatment, conducted in November 2005, was found to work very well, and has resulted in lower phosphorus concentrations and reduced algal blooms in Spring Lake. Additionally, there was an effort to educate homeowners on how to reduce their input of phosphorus to the Lake.

Monitoring data in 2015 suggest that lake conditions have started to degrade, and it is possible that after 10 years, the alum treatment is starting to lose its effectiveness. As a consequence, AWRI will be measuring internal phosphorus loading in September 2016 and comparing results to previous measurements.

Questions

1. What would you want to know to figure how the phosphorus got into Spring Lake?

2. What should the Lake Board do if the phosphorus levels increase again?

3. What questions about the situation would you have if you were a homeowner on Spring Lake? If you were a marina owner on Spring Lake?

For more information, see **https://www.gvsu.edu/wri/director/spring-lake-phosphorus-project-31.htm**

Trophic Status of Lakes

A lake's ability to support plant and animal life defines its level of productivity, or *trophic state*. Lakes are commonly classified based on their productivity. Low productive *oligotrophic* lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient *dissolved oxygen* in the cool, deep-bottom waters during late summer to support cold water fish, such as trout and whitefish. By contrast, high productive *eutrophic* lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish, such as bass and pike. Lakes that fall between these two classifications are called *mesotrophic* lakes.

Oligotrophic

Mesotrophic

Eutrophic

The above information was taken directly from the 2008 Annual Summary Report of Michigan's Cooperative Lakes Monitoring Program, published by the Michigan Department of Environmental Quality (Report No. MI/DEQ/WB-09/005)

Status of Lakes in Michigan

Lake Superior is Oligotrophic

Source:
http://www.seagrant.umn.edu/superior/overview

Lake Erie is Eutrophic

Source:
https://coastalscience.noaa.gov/news/climate/new-report-addresses-re-eutrophication-hypoxia-lake-erie/

Table 5.1 Trophic status of the Great Lakes bordering Michigan.

Lake	Trophic Status (nutrient level)
Superior	Oligotrophic[*] (low)
Huron	Oligotrophic[*] (low)
Saginaw Bay	Eutrophic[†] (high)
Michigan	Oligotrophic[*] (low)
Erie (Central Basin)	Oligotrophic/mesotrophic[*] (moderate)
Western Basin	Mesotrophic[*] (moderate)

[*]USEPA, 2011a; [†]USEPA, 2011b

Table 6.1 Trophic status summary of Michigan's public access lakes sampled from 2001 through 2010 (N=730).

Trophic Status	Number of Lakes
Oligotrophic (low nutrients)	129 (18%)
Mesotrophic (moderate nutrients)	399 (54%)
Eutrophic (high nutrients)	174 (24%)
Hypereutrophic (excessive nutrients)	28 (4%)

Source: Water quality and pollution control in Michigan 2014 Sections 303(d), 305(b), AND 314 integrated report http://www.michigan.gov/documents/deq/wrd-swas-ir2014-final_455859_7.pdf

Information & Education Strategy to Address Nutrients

Source: Lower Grand River Watershed Management Plan

Goals: Restore and maintain waterbodies for other indigenous aquatic life and wildlife use, for coldwater fishery use, and for warmwater fishery use.

Pollutant 3: Nutrients

Objectives:

1) Implement manure management planning and implementation,

2) Implement livestock management practices at access sites,

3) Implement vegetative buffering practices,

4) Encourage proper septic tank management,

5) Implement proper fertilizer application practices,

6) Implement MDEQ population management practices for waterfowl, and

7) Implement sanitary sewer maintenance practices.

Message: Human actions increase nutrients in waterbodies. Nutrient-rich waters encourage excessive plant growth, deplete oxygen, and impair aquatic habitats.

Critical Areas: Impaired Uses: Lake Creek, Deer Creek, Upper Thornapple River (low dissolved oxygen); Threatened uses: Bass River, Buck Creek, Coldwater River, Plaster Creek, Upper/lower Rogue River, Spring Lake/Norros Creek, Sand Creek

Information and Education Examples:

<table>
<tr><td colspan="2">Topics: proper use and application of fertilizers, management of yard and pet waste, benefits of buffer strips along streams, septic system maintenance, not feeding waterfowl, use of phosphorus-free products including fertilizer, soil testing before using fertilizer</td></tr>
<tr><td>• Brochures
• Social media
• Postcards
• Create videos
• Websites</td><td>• Participation in public events (Earth Day, water festival
• Workshops for riprarian landowners
• Tree plantinng for runnoff filtration
• Demonstration projects</td></tr>
</table>

What You Can Do: In Your Home

Cleaning Supplies-Detergents and Soaps

- Choose phosphate-free detergents, soaps, and household cleaners.
- Select the proper load size for your washing machine.
- Only run your clothes or dish washer when you have a full load.
- Use the appropriate amount of detergent; more is not better.

Pet Waste

- Always pick up after your pet.
- Avoid walking your pet near streams and other waterways. Instead, walk them in grassy areas, parks or undeveloped areas.
- Inform other pet owners of why picking up pet waste is important and encourage them to do so.
- Take part in a storm drain marking program in your area to help make others aware of where pet waste and other runoff goes when not disposed of properly.

Septic Systems

- Inspect your septic system annually.
- Pump out your septic system regularly. (Pumping out every two to five years is recommended for a three-bedroom house with a 1,000-gallon tank; smaller tanks should be pumped more often).
- Do not use septic system additives. There is no scientific evidence that biological and chemical additives aid or accelerate decomposition in septic tanks; some additives can in fact be detrimental to the septic system or contaminate ground water.
- Do not divert storm drains or basement pumps into septic systems.
- Avoid or reduce the use of your garbage disposal. Garbage disposals contribute unnecessary solids to your septic system and can also increase the frequency your tank needs to be pumped.
- Don't use toilets as trash cans. Excess solids can clog your drainfield and necessitate more frequent pumping.
- When installing a septic system, maintain a safe distance from drinking water sources to avoid potential contamination. Avoid areas with high water tables and shallow impermeable layers.
- Plant only grass in the drain field and avoid planting trees, bushes, or other plants with extensive root systems that could damage the system's tank or pipes.
- Visit EPA's Septic Smart website to learn more about how your septic system works and simple tips on how to properly maintain it. You can also find resources to launch a local septic education campaign.

Source: U.S. EPA, https://www.epa.gov/nutrientpollution/what-you-can-do-your-home

What You Can Do: In Your Yard

Lawn care:

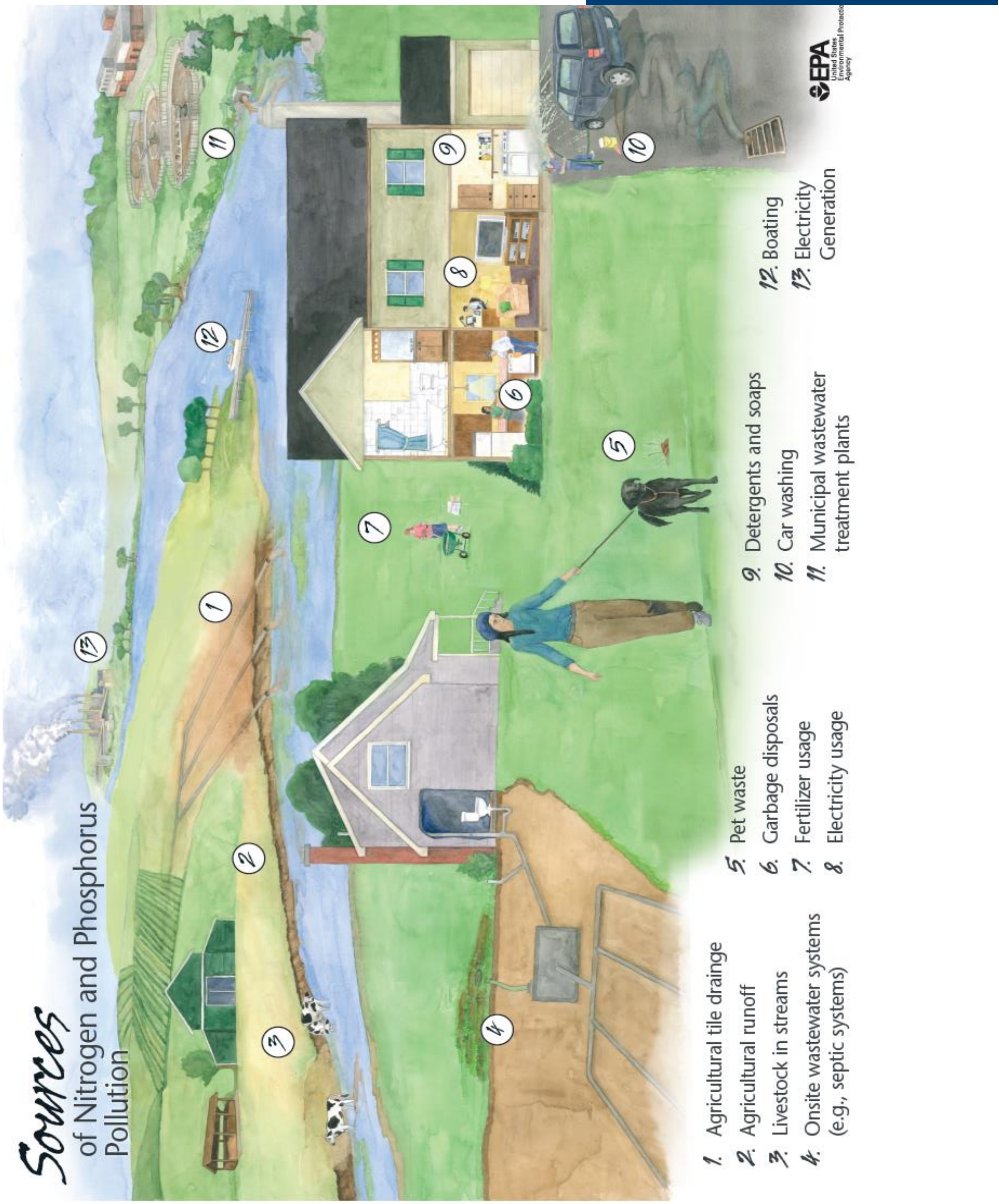
- Apply fertilizers only when necessary and at the recommended amount.
- Don't apply fertilizer before windy or rainy days.
- Apply fertilizer as close as possible to the period of maximum uptake and growth for grass and other plants, which is usually spring and fall in cool climate, and early and late summer in warm climates.
- Avoid applying fertilizer close to waterways.
- Do not overwater lawns and garden; use a soaker hose, a porous hose that releases water directly to the ground, which can reduce overwatering that carries away fertilizers that would otherwise enrich lawns and gardens.
- Fill fertilizer spreaders on a hard surface so that any spills can be easily cleaned up.
- Properly store unused fertilizers and properly dispose of empty containers.
- Maintain your lawn mowers, snow blowers, chain saws, leaf vacuums and similar outdoor power equipment to reduce nitrogen oxide emissions.

Garden care:

- Plant a rain garden of native plants, shrubs and trees that reduce the amount of fertilizer needed and provide a way for water to soak into the ground.
- Install a rain barrel to collect rainwater; the rainwater can later be used to wash your car or water your plants and lawn.
- Adopt techniques that utilize natural processes to manage stormwater runoff and reduce the impact of impervious surfaces on water quality.
- Use pervious pavers for walkways and low traffic areas to allow water to soak into the ground.
- Install a green roof on your home or business.
- Incorporate best management practices, such as grassed swales, filter strips, or buffer strips on your property to control and temporarily store stormwater runoff.
- Use yard waste, which includes grass clippings and leaves, in mulch or compost for your garden. If this is not an option, prepare all clippings and leaves for community composting, or in barrels or secured papers bags for disposal, which keeps them from washing into streams.

Source: U.S. EPA, https://www.epa.gov/nutrientpollution/what-you-can-do-your-yard

Name the nutrient sources.


Sources of Nitrogen and Phosphorus Pollution
1. Agricultural tile drainge
2. Agricultural runoff
3. Livestock in streams
4. Onsite wastewater systems (e.g., septic systems)
5. Pet waste
6. Garbage disposals
7. Fertilizer usage
8. Electricity usage
9. Detergents and soaps
10. Car washing
11. Municipal wastewater treatment plants
12. Boating
13. Electricity Generation
EPA United States Environmental Protection Agency