Port Exploreum

PORT WASHINGTON, WISCONSIN

Lake Michigan Learning Lab

Follow the Drop: A Watershed Odyssey

Teacher Lesson Guidebook

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Wisconsin Coastal Management Program

National Oceanic and Atmospheric Administration U.S. Department of Commerce NOAA

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Background

The **Lake Michigan Learning Lab** is a project of the Port Exploreum in Port Washington that provides an innovative, interactive set of learning experiences for middle and high school students, particularly grades 6 to 9, in southeastern Wisconsin.

The Lake Michigan Learning Lab offers students an opportunity to study Lake Michigan ecology and maritime heritage as a scientist would—making predictions, gathering data, analyzing results, drawing conclusions, and identifying relationships between concepts.

The Port Exploreum has selected the theme of **Follow the Drop: A Watershed Odyssey** as a focus for student learning based on input from local stakeholders. A watershed focus provides an opportunity for students to study an array of issues associated with both the natural and human factors affecting water quality for our region.

Through this program, students have the opportunity build understanding and expertise on the causes, effects, and possible solutions for issues such as flooding, erosion, and water pollution using a set of **3 thematic exhibits** at the Port Exploreum and 18 pre-/post-visit lessons. These resources are provided to teachers and students in the form of this **Teacher Lesson Guidebook**, which is a collection of existing and new resources, and a **Student Science Notebook** that serves as a resource for data collection, reflection, and analysis.

The Watershed Odyssey program has been designed to facilitate student understanding of science concepts, a "macro" level awareness of watershed issues and connections to local organizations where they can learn more and take action to improve water quality.

GUIDING QUESTIONS

- How do natural factors and human actions affect how water travels through our environment?
- Where do the different types of water pollution come from and why are they a source of concern for our community?
- What can we do to improve and preserve our freshwater so it is a resource for future generations?

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2.2. Causes and effects of water quality

2.3 Southeastern Wisconsin watersheds

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During Visit – Lab and Exhibit Experiences

Infiltration Station
(1st Floor)

Students conduct a set of experiments to study how water travels through various types of soil "media" and to understand the composition and functioning of green infrastructure using a rain garden model.

Virtual Watershed
(2nd Floor)

Students use an interactive touchscreen exhibit to make a series of land use choices in 1 of 4 scenarios—suburban, urban, agricultural and industrial—and view the effects on water pollution levels and ecological health of the watershed.

Freshwater Scavenger Hunt
(Maritime Level)

Students use the Exploreum's interactive exhibits to complete a scavenger hunt and learn about Lake Michigan ecology and heritage, including native/invasive species, shipwrecks, Port Washington history, and the physics of sailing.

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Effect
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6.3 Eco(nomy)-Friendly?

Pre-Visit Lesson 1.1

Exploring the Water Cycle

<table>
<tr><th colspan="4">Summary</th></tr>
<tr><td colspan="4">In this lesson, students will learn about the water cycle and how energy from the sun and the force of gravity drive this cycle.</td></tr>
<tr><th colspan="4">Objectives</th></tr>
<tr><td colspan="4">Describe how the properties and movements of water shape Earth's surface and affect its systems.
Explain how water transforms from one phase to another within the natural water cycle.
Discuss the planet's limited freshwater resources.</td></tr>
<tr><th colspan="2">Vocabulary</th><th colspan="2">Materials</th></tr>
<tr><td colspan="2">Evaporation
Precipitation
Transpiration
Infiltration
Solar Radiation</td><td>1 per student:
Post Assessment
Student Capture Sheet</td><td>Teacher Materials for:
Evaporation demonstration*
Condensation demonstration*
*See EWC Teacher Guide (page 6-7)</td></tr>
<tr><th colspan="4">Sequence</th></tr>
<tr><th>Intro</th><td colspan="3">Students participate in a think-pair-share (T-P-S) to answer the question "What is precipitation?" (PPT slide 2) view a video (1:24) about the water cycle (slide 3) and then T-P-S to answer the question "Why is it important to study and understand the water cycle?" (slide 4)</td></tr>
<tr><th>Activity</th><td colspan="3">1) After viewing and discussing a short Water Cycle simulation video (3:00) (slide 5), the teacher guides students in labeling a diagram and answering comprehension questions from the EWC student capture sheet (page 2) related to the effects of solar energy and gravity on the water cycle. The EWC PowerPoint Presentation provides guidance for this discussion (slides 6-8).

2) Teacher provides a demonstration evaporation and/or condensation, as outlined in the EWC Teacher Guide (page 7) while students complete student capture sheet (page 1). Explain to students that they will create their own water cycle model to observe infiltration. Show students the example of a completed water cycle model. If there is time, have students begin constructing their model (see LMLL Pre-visit Lesson 1.3 for materials and instructions).</td></tr>
<tr><th>Wrap-up</th><td colspan="3">Use the Water, Water Everywhere video (6:31) to demonstrate aspects of the water cycle from a global perspective, including a review of "why we study the water cycle." Teachers may want to review and use only select portions of the video for a more targeted discussion.</td></tr>
<tr><th>Assessment</th><td colspan="3">Students complete the EWC Post Assessment by labeling a water cycle diagram, answering multiple-choice questions (page 3), and/or completing the Exit Card (page 4).</td></tr>
<tr><th>Extension</th><td colspan="3">Students complete a mini-project of creating a comic strip or a poster that uses water as a character describing its journey through the water cycle (see description and rubric on page 3 of the EWC Student Capture Sheet).</td></tr>
<tr><th colspan="2">Instructional Resources</th><th colspan="2">Source Materials and Notes</th></tr>
<tr><td colspan="2">EWC Teacher Guide (pdf)
EWC Student Capture Sheet (pdf)
EWC Presentation (ppt)
EWC Post Assessment (pdf)
Intro video, activity video, and wrap-up video</td><td colspan="2">NASA Global Precipitation Measurement Mission
Exploring the Water Cycle (EWC) Lesson

Not used: EWC pre-assessment and infiltration and transpiration demos, which will be conducted later by students using their own water cycle models, which they may begin constructing during this lesson.</td></tr>
</table>

Pre-Visit Lesson 1.2

Natural & Urban Stormwater Cycles

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<table>
<tr><th colspan="4">Summary</th></tr>
<tr><td colspan="4">Students examine in detail the water cycle components and phase transitions, and then learn how water moves through the human-made urban environment.</td></tr>
<tr><th colspan="4">Objectives</th></tr>
<tr><td colspan="4">• Describe how humans affect the movement of water within the urban water cycle.</td></tr>
<tr><th colspan="2">Vocabulary</th><th colspan="2">Materials</th></tr>
<tr><td colspan="2">• Stormwater runoff
• Wastewater treatment
• Storm sewer
• Combined sewer</td><td>1 per student:
• “The Watershed Story”
• Graphic organizer
1 per group:
• Large tablet paper with graphic organizer boxes</td><td>Teacher Materials:
• Visual model of water cycle electronically projected (optional: trace onto butcher paper as an anchor chart*)</td></tr>
<tr><th colspan="4">Sequence</th></tr>
<tr><td>Intro
(XX min)</td><td colspan="3">Use an LCD projector or document camera to project share “detailed” water cycle diagram for whole class to see. Review the water cycle diagram and terms from the prior lesson’s EWC Student Capture Sheet. Ask students to identify differences between the two diagrams.</td></tr>
<tr><td>Activity</td><td colspan="3">1) After listing and discussing water cycle diagram differences identified by students, use Urban Stormwater reading, taken from “slide 15 notes” from Teach Engineering’s Urban Stormwater Management (lesson 1) web page to introduce how stormwater travels in an urban setting and model the completion of the urban stormwater path graphic organizer.

2) Explain to students that they will be reading more about how stormwater travels through the 3 other paths—natural, rural and wastewater—by working within a small group to read a brief description, complete a graphic organizer and present their findings to their classmates. Students should summarize their graphic organizer results on a large piece of tablet paper that has the graphic organizer template pre-drawn out for students.</td></tr>
<tr><td>Wrap-up</td><td colspan="3">Discuss with students the differences between the 4 paths and, if using the traced water cycle diagram anchor chart, add their graphic organizer summary to the chart for future reference.</td></tr>
<tr><td>Assessment</td><td colspan="3">Students’ completed graphic organizers and/or student group presentations serve as assessments. See student presentation rubric for an example of assessment guidelines.</td></tr>
<tr><td>Extension</td><td colspan="3">The Metropolitan Milwaukee Sewerage District (MMSD) offers tours of its Jones Island Water Reclamation Facility and classroom resources (i.e., Watershed booklets with Teacher Guide, Enviroscape Watershed Model demonstrations, etc.). Contact Cora Lee Palmer at cpalmer@mmsd.com for more information.</td></tr>
<tr><th colspan="2">Instructional Resources</th><th colspan="2">Source Materials and Notes</th></tr>
<tr><td colspan="2">• LMLL Water Path Graphic Organizer (one side with urban path, other side with group’s path)
• Reading for “we do”: TE’s slide 15 notes
• Reading: “The Watershed Story” (basic)
• Student presentation rubric</td><td colspan="2">Teach Engineering Urban Stormwater Management Lesson 1

Original lesson from Teach Engineering was in a lecture format with a PowerPoint and a pre/post student capture sheet, which may serve as a resource.

* Student volunteers prior to the lesson can trace the watershed on butcher paper. It may provide a useful anchor chart for future reference, with tablet paper graphic organizer results added.</td></tr>
</table>

Pre-Visit Lesson 1.3

Natural & Urban Stormwater Models

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Summary

Students apply their understanding of the natural water cycle and the urban "stormwater" water cycle to hypothesize how the flow of water is affected by altering precipitation.

Objectives

- Develop and test hypotheses about how the intensity of precipitation affects the runoff and groundwater flow in the natural and urban water cycle models; analyze and explain experiment results.

Vocabulary

- Media layer
- Impervious surface
- Porous surface

Materials

1 per student:
- Science Notebook, page X

Teacher Materials:
- Projector/Internet

Lab materials (per student or group):
- 3 2-liter bottles; 2 beakers
- 2 cups potting soil
- 4 in x 4 in piece of tinfoil
- 1 ft. plastic tubing

Sequence

Intro	Use projector to show two diagrams from top left of Teach Engineering Lesson 1 web page. Ask students to describe why there is a difference between the percentage of runoff, infiltration and evapotranspiration in the urban versus the natural diagram based on previous lessons.
Activity *(XX min)*	1) Introduce liter bottle water cycle model and ask students to identify each stage of the cycle within the model by filling in the blanks of the natural water cycle diagram in their student Science Notebook. Once completed, ask students to predict which will be higher after pouring 2 liters of water into the model—***runoff or infiltration***—and then complete the simulation of the natural water cycle model as a class, measuring the amount of water in each. 2) Tell students that they will now demonstrate the urban stormwater cycle by using the tinfoil to simulate an impervious surface with their own constructed water cycle models and ask students to make the same prediction once again. Have students conduct this experiment, record results in their Science Notebook and compare results with the natural cycle.
Wrap-up *(XX min)*	Discuss with students their experimental results and use Teach Engineering Activity 1 web page notes ("engineering connection", and #10 "Explore") to connect water cycle simulations to the real world role of engineers who predict rainfall and design safe infrastructure.
Assessment	Students complete the two "draw conclusions" questions in their science notebook as an exit ticket (quick end of lesson assessment) for this activity.
Extension *(XX min)*	The student's water cycle model offers opportunities to study a number of different aspects of the interaction between soil, plants, and the water cycle, including plant uptake and evapotranspiration. See the "Water Cycle Model – Experiment Ideas" resource for alternate model designs and variables that can be manipulated to investigate how stormwater flows.

Instructional Resources

- LMLL Student Science Notebook, page X
- Teach Engineering Urban Stormwater Management: Activity 1
- Projected diagrams from top left of Teach Engineering Lesson 1 web page
- Water Cycle Model – Experiment Ideas

Source Materials and Notes

Teach Engineering Urban Stormwater Management Activity 1

As noted in the resource list for this experiment on page X of this Guidebook, there are different ways to assemble this water cycle model that affect what materials are needed (e.g. number of 2-liter bottles) and what steps are taken in the assembly process (size of holes in the bottle bottom and/or cap, etc.). ***It is highly recommended that teachers pre-build and test their own model to identify what will work for them and their class.***

Pre-Visit Lesson 2.1

What is a Watershed?

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Summary

Students apply close analytical listening and vocabulary development strategies for the first part of a video titled After the Storm *and then simulate a watershed using a crumpled piece of paper, sprayed water, and colored pens.*

Objectives

- Use close reading strategies to make sense of water quality case studies that are presented in a video.
- Explain various landforms that shape the boundaries of a watershed.

Vocabulary

Students use dictionaries to define words that are pre-selected from the *After the Storm* video and listed in the Student Recording Form.

Materials

Student materials:

- Recording form (for video)
- Scratch paper or tinfoil
- Blue, black, brown, red water-based pens

Teacher materials:

- Projector/internet
- *Achieve the Core* lesson agenda
- Relief map of the U.S.
- 2 or 3 spray bottles

Sequence

Intro	Students respond to the question "What is a watershed and why are they important?" in writing and then conduct a think-pair-share to discuss their answers.
Activity	1) The teacher guides students in viewing the first 4-minute segment of the *After the Storm* video three times, using the **Recording Form** to: • 1. Identify important vocabulary words • 2. Identify the cause and effect of specific water quality issue being presented • 3. Listen/record solutions that citizens are taking to protect their watershed. 2) Students work individually or in a group to simulate a watershed by crumpling up a piece of scratch or tinfoil and trace the ridges with colored pens. They then use the spray bottle to simulate a rain event and observe how the water and ink react.
Wrap-up	Teacher guides a discussion about how water flow in the crumpled watershed simulation relates to an actual watershed. Use projection of U.S. relief map to explain.
Assessment	Students complete a "3-2-1 exit ticket" by defining 3 new vocabulary words, describing 2 causes of water pollution, and answering 1 question they have about watersheds.
Extension	Teachers may wish to facilitate a "Science Talk"—an instructional strategy that provides students with a framework to discuss scientific concepts among themselves, similar to a literature circle. The Talk Science Primer, from TERC, provides helpful guidance for implementation, especially pages 11 to 20.

Instructional Resources

- Achieve the Core - Water is Life, Unit 2 **Module, Lesson 1 agenda** (pp. 9-12)
- Achieve the Core - Water is Life, Unit 2 **Appendix B: Video Recording Form**
- Crumple a Watershed Activity (pp. 5-6)
- *After the Storm* Video (The Weather Channel & U.S. EPA)

Source Materials and Notes

Achieve the Core – Water is Life:
The Earth's Hydrosphere and Its Impact on Living Systems
Unit 2 (Grades 6-8 Earth Science Module)

The Achieve the Core module provides more detail about lesson sequence, discussion questions, etc. The "Crumple a Watershed" activity document provides a slightly different use of the colored pens compared to the module, as well as its own discussion questions for use with your class.

Pre-Visit Lesson 2.2

Causes & Effects of Water Quality

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<table>
<tr><th colspan="2">Summary</th></tr>
<tr><td colspan="2">Students apply close analytical listening and vocabulary development strategies for the next part of the "After the Storm" video focused on Santa Monica Bay, CA and then orient themselves to this watershed using the EPA's MyWATERS Mapper.</td></tr>
<tr><th colspan="2">Objectives</th></tr>
<tr><td colspan="2">Describe how water moves from one watershed to another.
Describe how water quality in one watershed can influence water quality in multiple watersheds.
Use geoscience data/models to explain how human and natural changes in a watershed impact water quality.</td></tr>
<tr><th>Vocabulary</th><th>Materials</th></tr>
<tr><td>Students select their own vocabulary words from the After the Storm video segment and use dictionaries to look up definitions.</td><td>Student materials:
Student Recording Form
Computer/internet access
Dictionaries
Teacher materials:
Projector/internet
Achieve the Core lesson agenda
EPA web links</td></tr>
<tr><th colspan="2">Sequence</th></tr>
<tr><td>Intro</td><td>Students respond to the question "What is water pollution and why should we care if our water is polluted or not?" in writing and then conduct a think-pair-share to discuss their answers. Then, ask the whole class, "How and why can water issues in one watershed affect other watersheds? And solicit responses.</td></tr>
<tr><td>Activity</td><td>1) The teacher guides students in viewing the next segment (3:58-7:20) of the After the Storm video three times, using the Student Recording Form to:
1. Identify important vocabulary words
2. Identify how human activity impacts water quality
3. Listen/record solutions that citizens are taking to protect their watershed.
2) Teacher then guides students using their computer to access and become familiar with the MyWATERS Mapper web tool, answering questions in the Student Recording Form. Students then locate the Santa Monica Bay watershed, the subject of the video segment and answer questions about how the water flows in that part of the country.</td></tr>
<tr><td>Wrap-up</td><td>Instruct students to view the "fishbone" water pollution diagram in their Student Recording Form packet and circle the issues affecting Santa Monica Bay.</td></tr>
<tr><td>Assessment</td><td>Students complete a "3-2-1 exit ticket" by describing 3 causes and 2 effects of water quality issues and thinking of 1 question about water quality in their own watershed.</td></tr>
<tr><td>Extension</td><td>As an alternative wrap-up or extension activity, the teacher can share with students the following Wisconsin Sea Grant video about a more local Wisconsin example of runoff, including the identification of pollutants and affects on beaches.</td></tr>
<tr><th>Instructional Resources</th><th>Source Materials and Notes</th></tr>
<tr><td>Achieve the Core - Water is Life, Unit 2 Module, Lesson 2 agenda (pp. 13-16)
Achieve the Core - Water is Life, Unit 2 Appendix B: Student Recording Form
MyWATERS Mapper U.S. EPA
"Surf Your Shed." U.S. EPA
After the Storm Video (The Weather Channel & U.S. EPA)</td><td><u>Achieve the Core – Water is Life:</u>
The Earth's Hydrosphere and Its Impact on Living Systems
Unit 2 (Grades 6-8 Earth Science Module)
It is highly recommended that teachers take time to navigate the EPA web tools prior to the lessons to more easily assist students in navigating them during the lesson. The Student Recording Form may also include more questions than time available, so teachers may want to select the questions that match their students' level.</td></tr>
</table>

Pre-Visit Lesson 2.3

Southeastern Wisconsin Watersheds

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<table>
<tr><th colspan="4">Summary</th></tr>
<tr><td colspan="4">Students apply close analytical listening and vocabulary development strategies for the last part of the After the Storm video focused on the Lower Mississippi River and then use the EPA web tools to investigate their own watershed.</td></tr>
<tr><th colspan="4">Objectives</th></tr>
<tr><td colspan="4">Describe how water quality in one watershed can influence water quality in multiple watersheds.
Use geoscience data/models to explain how human and natural changes in a watershed impact water quality.</td></tr>
<tr><th>Vocabulary</th><th colspan="3">Materials</th></tr>
<tr><td>Students select their own vocabulary words from the After the Storm video segment and use dictionaries to look up definitions.</td><td colspan="3">Student materials:
Student Recording Form
Computer/internet access
Dictionaries
Science Notebook, page X
Teacher materials:
Projector/internet
Achieve the Core lesson agenda
EPA web links</td></tr>
<tr><th colspan="4">Sequence (Total Duration: 120 min)</th></tr>
<tr><td>Intro
(10 min)</td><td colspan="3">Students respond to the following prompt: “Describe the relationship between rivers and streams and watersheds” in writing and then conduct a think-pair-share to discuss their answers.</td></tr>
<tr><td>Activity
(95 min)</td><td colspan="3">1) Prior to viewing the next video segment (7:20-13:49), the teacher uses the MyWATERS Mapper to project the Lower Mississippi River and asks students to predict this watershed’s water quality issues. This time, the class will only watch the video twice and students will break up into groups to collect new vocabulary, issues/effects, causes and solutions and discuss their findings. Have students revisit the “fishbone” pollution diagram and circle the issues in a different color pen/pencil.
2) Students will work in pairs and use the MyWATERS Mapper to complete the lesson 3 portion of the Student Recording Form for their own watershed, including the identification of monitoring stations and waters designated as “impaired.”</td></tr>
<tr><td>Wrap-up
(15 min)</td><td colspan="3">View and discuss with students the end of the After the Storm video (18:35-21:33) about actions that community members can take to address water quality issues.</td></tr>
<tr><td>Assessment</td><td colspan="3">Students complete page X in their Science Notebook, labeling the sub-watersheds in the Milwaukee River Basin and answering the remaining questions.</td></tr>
<tr><td>Extension</td><td colspan="3">The Achieve the Core module includes an assignment (end of Lesson 5) for students to design their own scientific conceptual model. A graphic organizer, sample conceptual models and a “gallery walk” peer review protocol are also included.</td></tr>
<tr><th colspan="2">Instructional Resources</th><th colspan="2">Source Materials and Notes</th></tr>
<tr><td colspan="2">Achieve the Core - Water is Life, Unit 2 Module, Lesson 1 agenda (pp. 17-20)
Achieve the Core - Water is Life, Unit 2 Appendix B: Student Recording Form
MyWATERS Mapper & Surf your Shed U.S. EPA
After the Storm Video (The Weather Channel & U.S. EPA)
LMLL Student Science Notebook, page X</td><td colspan="2">Achieve the Core – Water is Life:
The Earth’s Hydrosphere and Its Impact on Living Systems
Unit 2 (Grades 6-8 Earth Science Module)

In the Achieve the Core materials, there are two additional lessons (4 and 5) as part of this unit that focus on snow, flooding, and the After the Storm video segment of 13:50-18:34. These have been omitted and the final segment added to the “wrap-up” section above with the Student Notebook activity replacing the original Lesson 3 assessment.</td></tr>
</table>

Pre-Visit Lesson 3.1

Water Pollution Primer

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Summary
Students will learn about the various types and sources of water pollutants as well as how scientists measure them, with a particular emphasis on phosphorus, its role plant growth and how excess nutrients lead to watershed impairments.

Objectives
• Describe and compare different types of water pollutants and how they are related to water quality.

Vocabulary	Materials	
• Threshold • Contaminant • Pesticides • Coliform Bacteria • Nutrient	Student materials: • Computer/internet access • Virtual Lab Pollutant Descriptions (reading) • Virtual Lab Worksheet	Teacher materials: • Projector/internet • Green Bay Dead Zone video and news article web link

Sequence	
Intro	Ask students to recall as many water pollutants as they can from Lessons 2.2 & 2.3 "fishbone" diagram. Explain that phosphorus is one type of water pollutant that has been rising to alarming levels in recent years. Show the Green Bay dead zone video.
Activity	1) Share Green Bay Dead Zone news article with the class (via projector and/or handouts), read and discuss the causes, effects and proposed solutions for this phenomenon. Ask students to identify 3 reasons why dead zones are more likely to occur in the Green Bay. Explain that pollutants are problematic when they reach a "threshold" that harms the biological functioning of aquatic life and humans. 2) Print and distribute the left-hand column pollutant descriptions for pesticides, pH, coliform bacteria, nitrates and metals from the Virtual Lab. Ask students to fill in causes, effects for each pollutant and then predict which pollutant is affecting each of the 5 scenarios using the virtual lab worksheet. Model the Virtual Lab's test and treatment steps, then have students complete this process for the remaining scenarios.
Wrap-up	Ask students to share their findings. How many of their predictions were correct? Why were certain pollutants connected to their scenarios? Review threshold concept. *
Assessment	Have students choose a pollutant and describe why it was connected with the scenario in the virtual lab using a 2 to 3 sentence (cause-effect-treatment) paragraph.
Extension	Teachers can work with local groups and resources--such as Riveredge Nature Center's Testing the Waters program and Gateway Technical College's water quality equipment lending library--to test water samples for these and other water quality indicators.

Instructional Resources	Source Materials and Notes

• Glencoe Virtual Lab - Water Quality Testing
• Virtual Lab Worksheet
• Green Bay Dead Zone – Video and Article
• Advanced Readings:
  ○ Turbidity (Fondriest.com)
  ○ Measures (Achieve the Core, Unit 2 Central Texts)
• Gateway Technical College Lending Library for Water Quality Test Equipment (8 documents)
	Milwaukee Journal Sentinel
	Green Bay Dead Zone – Video and Article
	
	Glencoe
	Virtual Lab – Water Quality Testing
	
	* Teachers may wish to discuss with students how nutrients compare to other water pollutants. As a nutrient, phosphorus isn't a "chemical" in the way that many people think about pollution but it does affect the environment—e.g. algal growth and then decay, which consumes dissolved oxygen—by harming aquatic life.

Pre-Visit Lesson 3.2

Predicting Runoff, Part 1 - *Land Cover*

<table>
<tr><th colspan="3">Summary</th></tr>
<tr><td colspan="3">Students are introduced to "land cover" as a factor that affects stormwater runoff and water pollution, using the Wiki Watershed Micro Site app to predict and compare how 4 different land cover types react to two levels of storm intensity.</td></tr>
<tr><th colspan="3">Objectives</th></tr>
<tr><td colspan="3">• Identify how land cover, rainfall totals and soil texture determines the path that water travels.
• Explain the impact of land cover and soil texture on the health of the watershed.</td></tr>
<tr><th>Vocabulary</th><th colspan="2">Materials</th></tr>
<tr><td>• Land cover
• Saturated
• Tilled
• Wetland</td><td>Student materials:
• Computer/internet access
• Science Notebook, page X</td><td>Teacher materials:
• Projector/internet
• Innovative Technology in Science Inquiry & Wiki Watershed links</td></tr>
<tr><th colspan="3">Sequence</th></tr>
<tr><td>Intro
(X min)</td><td colspan="2">Review with students some of the factors influencing how water travels in watersheds—sunlight, gravity and topography. Inform students that they will be studying 3 more factors over the next 2 lessons—land cover, soil type and rainfall.</td></tr>
<tr><td>Activity
(X min)</td><td colspan="2">1) Project the paragraph defining "land cover" on the ITSI Activity Part IV (Collect Data I section) web page and ask students to read this paragraph and summarize its meaning, including examples. Explain to students that they will be studying 4 types of land cover using a "Micro Site" web tool that models runoff and infiltration.
2) Model for students the functioning of the Micro Site app and ask them to a) try and fill in the blanks for each of the 4 land cover examples in their Science Notebook and b) predict which will have the most and least runoff. Have students read about each of these land covers by clicking on their icons in the app and then review/correct their answers. Students should then complete the table for each land cover scenario and answer the "draw conclusions" questions in their Science Notebook.</td></tr>
<tr><td>Wrap-up
(X min)</td><td colspan="2">Ask students to share which land-cover scenarios had the most and least runoff. How did the amount of rainfall affect likely flooding, as indicated by the "!" in the app?</td></tr>
<tr><td>Assessment</td><td colspan="2">The Science Notebook page can serve as an assessment for this lesson.</td></tr>
<tr><td>Extension</td><td colspan="2">Students may select additional land cover examples from the Micro Site app—e.g. forest, developed-high, pasture/hay, scrub or others—make predictions and use the blank data tables on page X to compare the level of runoff for each.</td></tr>
<tr><th colspan="2">Instructional Resources</th><th>Source Materials and Notes</th></tr>
<tr><td colspan="2">• LMLL Student Science Notebook, page X
• Innovative Technology in Science Inquiry (ITSI) Activity Part IV - Managing Water
• Wiki Watershed – Model Micro Site Runoff App
• Using the Micro Site Storm Model</td><td>Wiki Watershed – Model Micro Site Runoff App
(Stroud Water Research Center)
Innovative Technology in Science Inquiry (ITSI)
(The Concord Consortium)
The ITSI web site hosts 5 lessons for use with the Wiki Watershed app. For the Science Notebook, rainfall levels were adjusted to 3 cm and 8 cm to show the change in flooding risk by land cover. IFSI offers the ability to graph out students' data, though they may need help with this.</td></tr>
</table>

Pre-Visit Lesson 3.3

Predicting Runoff, Part 2 - *Soil Type*

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PORT WASHINGTON, WISCONSIN

Summary

Students are introduced to "soil type" as a factor that affects stormwater runoff and water pollution, using the Wiki Watershed Micro Site app to analyze soil composition and compare runoff for 2 different soil groups.

Objectives

- Identify how surface cover, rainfall totals, and soil texture determines the path that water travels.
- Explain the impact of surface cover and soil texture on the health of the watershed.

Vocabulary	Materials	
• Silt • Loam • Clay	Student materials: • Computer/internet access • Science Notebook, page X	Teacher materials: • Projector/internet • Innovative Technology in Science Inquiry & Wiki Watershed links

Sequence

Intro	Ask students to brainstorm and write down different types of soil or "media" (e.g. sand, clay, gravel, rock, etc.). Have students think-pair-share (T-P-S) to answer the question: How are these different types of soil formed and where do they come from?
Activity	1) Have students share T-P-S answers regarding how soils are formed and then project and explain the "Factors that Build our Soil" graphic (page 18). Next, project the 1882 "Soils of Wisconsin" map (page 2) and review the soil types indicated. Where are soil types located in Wisconsin and why would people care about this information? 2) Explain to students that the Wiki Watershed tools use 4 different "soil groups" to help model how water runs through the land. Have the students read about each of the soil groups—A, B, C and D*—and complete the bar graph in their Science Notebook. Next, have students re-run the 8 cm rainfall event in the Micro Site app with Soil Group A and Soil Group D, complete the table and questions in their Science Notebook.
Wrap-up	Discuss the soil group table findings and students' conclusions based on this data, particularly related to how clay affects infiltration and runoff. Tell students that they will have a chance to compare water flow and soils when they visit the Exploreum.
Assessment	Ask students to answer the following question as an exit ticket: If you were going to buy land and build a new house, what type of soil would you want it to be on? Why?
Extension	Students can learn more about the geological history of Wisconsin and the Niagara Escarpment by reading the A Look at the Ledge article. How has this landform affected people over time and how might it positively and negatively affect our use of water?

Instructional Resources	Source Materials and Notes
• LMLL Student Science Notebook, page X • Wiki Watershed – Model Micro Site Runoff App • Dirt: Secrets in the Soil, Utah Ag in the Classroom (Factors that Build Our Soil graphic, page 18) • Soil Maps of Wisconsin, UW-Madison Soil Dept. (Wisconsin Soil Map - 1882, page 2) • Wisconsin Natural Resources Magazine, Oct 2010 (A Look at the Ledge) • Advanced soil resource: The Vegetation of Wisconsin: an Ordination of Plant Communities	**Wiki Watershed – Model Micro Site Runoff App** (Stroud Water Research Center) **USDA Hydrology National Engineering Handbook** Chapter 7: Hydrologic Soil Groups ** It should be noted that there are also soil group B/C and A/B in the Wiki Watershed web tools – these categories have been omitted in the Science Notebook tables for this activity and future activities to help students more easily grasp the concepts.*

Port Exploreum Visit

Virtual Watershed - 2nd Floor

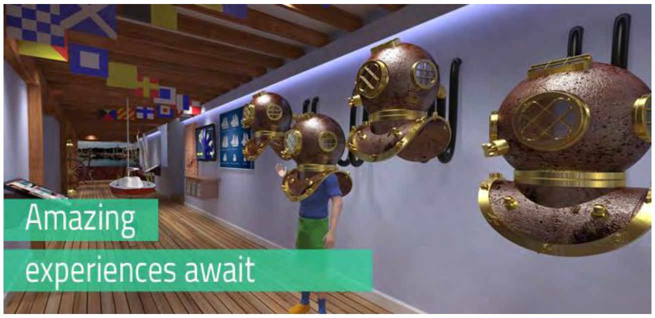
Port Exploreum

PORT WASHINGTON, WISCONSIN

Summary	
Students use the Virtual Watershed touchscreen exhibit to make land use choices and see the effect on water quality in 4 different scenarios. Students then discuss the causes, effects and ways of measuring water pollution.	
Objectives	
• Describe the trade-offs and relationships between land use choices and their effects on water quality. • Identify biological indicators of water quality and their role in determining if water is fishable and swimmable.	
Sequence *(Total Duration: **40 min**)*	
Intro *(5 min)*	Students are asked: "What is a watershed?" The facilitator explains that land use choices have an impact on the water quality within the entire watershed area. Students will use the Virtual Watershed exhibit to identify relationships between land use choices in four different scenarios—agricultural, suburban, urban and industrial—and how these choices affect the quality of water for swimming and fishing.
Activity *(25 min)*	Students are introduced to the functioning of the Virtual Watershed touchscreen exhibit by the facilitator who models a scenario for students by reading land use choices, selecting an option, identifying unknown vocabulary and documenting the water quality outcomes in their science notebooks. Students are split into 4 groups and asked to complete all of the scenarios. Afterwards they participate in a discussion about the cause and effect relationships within the Virtual Watershed simulation. The facilitator introduces students to the interpretive chart in their Science Notebook and describes how scientists and citizen scientists use biological indicators like macro-invertebrates to determine whether water quality is sufficient to support various species of fish and other aquatic life. Lastly, students view the Life in Our Lake video on the touchscreen table to learn about how mussels have "invaded" and transformed the ecosystems in the Great Lakes.
Wrap-up *(10 min)*	The facilitator asks students about the trade-offs involved with land use decisions. Specifically, if we know about land use choices that improve water quality, what are some reasons that these actions have not been taken? What can be done to promote options that work for people of all "scenarios" while also protecting water quality?
Assessment	Students complete the remaining questions (#2-4) in their science notebooks using their observations of the exhibit and the post-activity discussion.
Extension	Back in the classroom, students can research newly introduced concepts using the graphic organizer on page X in their Science Notebook. Topic examples include: - Agricultural: grass waterways, no-till, buffer strips, concentrated animal feed lots - Suburban: cluster housing, single family vs. multi-family housing, beach erosion - Urban: transit-oriented city design (New Urbanism), transportation and energy use - Industrial: energy production, wetlands, dams and aquatic connectivity

Port Exploreum Visit

Scavenger Hunt - Maritime Level



Summary	
Students develop an awareness of the ecology and maritime history of Lake Michigan and Port Washington by interacting with Maritime level exhibits, noting important facts and answering related questions in the Interactive Quiz exhibit.	
Objectives	
• Identify native and invasive species of Great Lakes aquatic life • Describe Port Washington maritime history including the area's people, navigation and shipwrecks	
Sequence *(Total Duration: **50 min**)*	
Intro *(2-3 min)*	Students are introduced to the exhibits on the Maritime level and split into two groups of 4 to 6 students and told that they are completing a Scavenger Hunt for facts about Port Washington's maritime history.
Activity *(45 min)*	1) Each group is assigned to 2 of the exhibits (Group A: Fish Daze and Shipwreck Helmets; Group B: Physics of Sailing and Types of Ships) for a time period of 12 to 15 minutes. Students answer the questions in their Science Notebooks associated with their assigned exhibits. 2) Groups A and B are asked to switch and conduct the scavenger hunt for the remaining 2 exhibits, answering the questions in their Science Notebook for another 12- to 15-minute period. 3) After this second time period, one of the student groups is invited to view the Port Washington history movie while the other group of students completes the interactive quiz exhibit to test their knowledge. After 10 minutes, these groups are again swapped, so each group completes their remaining activity.
Wrap-up *(2-3 min)*	Students are asked to share a few of the facts that they learned about maritime history and their scores from the Fish Daze and Interactive Quiz exhibits.
Assessment	The interactive quiz exhibit includes a total of over 15 questions. These questions are available to teachers via Google Drive if they want to use them in post-visit lessons.
Extension	For additional lessons focused on invasive species, see Michigan Sea Grant's Teaching Great Lakes Science "Great Lakes Most Unwanted" lesson (this lesson is also included in the Project FLOW resources (pp. 17-37). For interested teachers, the "Mussel Madness" board game is available–see contact information for Michael Timm in the Curriculum Connections section of this Guidebook (page X).

Port Exploreum Visit

Infiltration Station – 1st Floor

Port Exploreum

PORT WASHINGTON, WISCONSIN

Summary	
Students will predict and measure infiltration rates through 4 different soil media types. A demonstration of infiltration through two rain garden models illustrates how human manipulation of soil composition can prevent adverse water events.	
Objectives	
• Make predictions and observations on infiltration rates of 4 different soil media types. • Develop an understanding of how soil composition within green infrastructure features affects water flow.	
Sequence *(Total Duration: **40 min**)*	
Intro *(4 min)*	Ask students to use their senses—sight and touch—to observe the 4 types of “media” on display and write down their observations in their Science Notebooks. Discuss their answers and explain the concept of **pore space** and how greater pore space allows for faster infiltration but also doesn’t hold water as long. Explain the difference between infiltration and retention of water in the soil. Explain how this will affect plants.
Activity *(30 min –will require measurement by 1 or 2 students for longer period)*	PART 1: COMPARING WATER FLOW BY SOIL MEDIA Ask students: Which soil/media will: Infiltrate water fastest? Retain the greatest amount of water? 1) Have the students make predictions of infiltration rates for 250 mL of water and how much water will remain in the soil. Revisit soil types from Lesson 3.3. 2) Have students conduct the experiment and enter the data for the 4 soil columns and 7 measurement periods (a couple of students may need to be tasked to go back to infiltration station for the “total” measurement, which may make take over an hour). PART 2: USING RAIN GARDENS TO MANAGE STORMWATER 3) Students view a demonstration of water infiltrating through 3 rain garden “mini-yard” models and compare soil composition and amount of runoff/infiltration. See the Infiltration Station facilitator guide/script for detailed instructions of this activity.
Wrap-up *(5 min)*	Discuss if the results matched up with predictions. Why or why not? Did the soils vary more in infiltration rates or soil water retention? Help students understand how soil types affect the amount of flooding, erosion and thus pollution (including total suspended solids) in our watershed.
Assessment *(5 min)*	Ask the students which soil they would use if they were constructing a green infrastructure feature such as a rain garden. Which would be best for infiltration? Which would be best for the plants? Have them write this answer in their Notebooks.
Extension	Have students select two or more of the model’s green infrastructure features—trees, rain barrels, green roof—and compare how much water is absorbed using the chart in their Science Notebook (page X).

Post-Visit Lesson 4.1

Post-Visit Analysis & Discussion

Port Exploreum
PORT WASHINGTON, WISCONSIN

Summary
Students debrief their learning from the Infiltration Station exhibit by graphing out the infiltration and calculating an infiltration rate and storage capacity for each of the 4 media types. Students then design their own multi-media mix.

Objectives
• Describe the key soil mechanics and properties of media that determine infiltration rate and storage volume. • Calculate the storage capacity and infiltration rate of different types of media and media combinations.

Vocabulary	Materials	
• Infiltration rate • Soil retention • Porosity/pore space • Field capacity	Student materials: • Computer/internet access • Science Notebook, page X	Teacher materials: • Projector/internet • *Optional:* buckets, media types or "magic sidewalk" materials

Sequence	
Intro	Ask students to recall why some media types allowed more infiltration than others. To help illustrate the concept of porosity, have students act out different soil particle densities by having them attempt to pass through a group of students tightly and then loosely clustered together. (Source: Project WET Activity Guide K-12, pp. 136-141)
Activity	1) Use content and (blue and orange circle) diagram from Teach Engineering Urban Stormwater Management Activity 3 to provide the scientific explanation why different types of soil absorb water at different infiltration rates. Tell students that they will be graphing their results from the Infiltration Station lab activity to a) identify the relationship between media type and water flow and b) calculate infiltration rate. 2) Model the setup of the Y axis in their Science Notebook, page X and assist them in plotting the first few data points. Next, have students use the total amount of time the water took to infiltrate and divide it by the amount of water that drains through the media to calculate the infiltration rate. Students may also want to calculate the storage capacity and field capacity of each media (see Activity 3 instructions).
Wrap-up	Discuss the relationships between infiltration over time on the graph and the various infiltration rates and storage capacity levels for each media type. Why is this information useful to engineers designing roads, buildings and other structures?
Assessment	Ask students to draw their own "media mix" in the bucket diagram in their Science Notebooks to **retain** as much water as possible. They must use at least 3 of these media types—sand, mulch, gravel, clay—and show how the media would be layered.
Extension	Have students use their bucket diagrams from the assessment and test the amount of actual water retention using real media and buckets per the instructions in Activity 3. Alternative: Activity 4 guides students in developing their own permeable pavement.

Instructional Resources	Source Materials and Notes

• LMLL Student Science Notebook, page X
• Teach Engineering Urban Stormwater Mgmt.
  ○ Activity 3: Does Media Matter?
  ○ Activity 4: Making Magic Sidewalks
• Project WET Activity Guide K-12
	Teach Engineering Urban Stormwater Management Activity 3 & Activity 4

Post-Visit Lesson 4.2

Watershed Detective (Part 1)

Port Exploreum
PORT WASHINGTON, WISCONSIN

Summary

Students revisit the Wiki Watershed web tools, this time using the Model My Watershed app to analyze two local watersheds and determine how the land cover and soil types relate to the likelihood of flooding in Ozaukee County.

Objectives

- Identify the conditions of local watersheds and compare factors contributing to possible ***flooding***.

Vocabulary

- *Risk management*
- *Risk assessment*

Materials

Student materials:

- Computer/internet access
- Science Notebook, page X
- Calculators

Teacher materials:

- Projector/internet
- Links to Ozaukee County flooding video and Model My Watershed app

Sequence

Intro	Review with students the 3 factors affecting infiltration/runoff that they studied using the Micro Site Model app—size of rain event, soil type, and land cover. Share video of flooding in Ozaukee County and ask students how these 3 factors may have impacted where flooding occurs.
Activity	1) Provide overview of the Pigeon Creek and Grafton sub-watersheds (via map in Model My Watershed app and in their Student Science notebooks) and tell students that one of them is more likely to experience flooding. Which one do they think it is? 2) Students will use the Model My Watershed app to compare the two sub-watersheds and determine which is more prone to flooding and why. Introduce students to the functioning of the app and guide them in using it to identify the values for "Cultivated Crops" and "Deciduous Forest," then have students complete the rest of the tables. Once all values are identified, have students compare the two sub-watersheds to calculate the differences using the +/- and by answering the Notebook questions.
Wrap-up	Discuss with students their findings (e.g., that the Grafton Sub-Watershed has soil types that allow for much less infiltration and therefore is more likely to flood while land cover is mostly similar with the largest differences in forest and pasture uses).
Assessment	The Science Notebook entry can serve as the assessment for this lesson. An additional option is to have students complete a mid-unit self-assessment to reflect on what they have learned, liked and what needs they have related to this unit of study.
Extension	Share with students the Ozaukee County Flood Insurance Study (page 10-11) and discuss how these values reinforce their watershed findings.* Discuss how insurers, land developers and others use this information to make "risk management" decisions.

Instructional Resources

- LMLL Science Notebook
- Wiki Watershed – Model My Watershed App
- YouTube video of flooding in Ozaukee County
- Student Self Assessment – Mid Unit
- FEMA – Ozaukee County Flood Insurance Study

Source Materials and Notes

Wiki Watershed – Model My Watershed App

(Stroud Water Research Center)

** For the flood insurance study, teachers may want to have students compare the Ulao River (at outlet – Pigeon Creek) to the Mole Creek (at Pleasant Valley Road – Grafton) as these locations relate to the phosphorus analysis in the next lesson. Students can also view and discuss why the discharge increases (stream width, speed) as the locations move downstream. The chart allows teachers to discuss what 10-year, 2-year, 100-year events mean. Statistically speaking, a 10-year event has a 1 in 10 chance of occurring in a given year (10%). A 2-year event has a 1 in 2 chance (50%), etc.*

Post-Visit Lesson 4.3

Watershed Detective (Part 2)

Port Exploreum
PORT WASHINGTON, WISCONSIN

Summary	
Students analyze charts depicting total phosphorus levels from two local sub-watershed reports to determine which has higher level of pollutants. Students use their prior knowledge to identify why one test site is higher than the other.	

Objectives

- Identify the conditions of local watersheds and compare factors contributing to ***water pollution***.

Vocabulary	Materials	
• Scale • Standard • Median • Confidence Interval	Student materials: • Computer/internet access • Science Notebook, page X • Milwaukee Riverkeeper Report Card	Teacher materials: • Projector/internet • Detective/scientist, Milwaukee Riverkeeper Report Card, DNR and Ulao River web links

Sequence

Intro	Ask the class to think about detectives – how do they do their work? After soliciting some answers from students, ask them to conduct a Think-Pair-Share about ways that the work of scientists is similar and different than detectives. Optional resource (p. 4).
Activity	1) Explain to students that they have been following a procedure just like a detective would – gathering information, making inferences and drawing conclusions. Distribute copies of Milwaukee Riverkeeper 2014 Report Card and read pages 8-9 and 25. What do they notice about seasonal phosphorus levels? What might be causing these trends? 2) Ask students to view the two sub-watershed charts in their Student Notebook and predict which has higher levels of phosphorus. Explain the meaning of the two charts and provide clues about how to interpret the data (e.g., define confidence interval and median, noting the scale on the Y axis, etc.). Have students draw their final conclusion and complete the inference question using their knowledge from previous lessons.
Wrap-up	Discuss with students how down-river locations are more likely to have stronger flow levels than up-river because more water has entered from the watershed, which means more phosphorus may have also entered, depending on nearby land use.
Assessment	Have students answer the final question in their science notebook to summarize what they have learned about how to correctly read a chart.
Extension	Students can investigate more phosphorus reports for the Milwaukee River South watershed via the DNR web site (documents tab) and learn about strategies to address watershed challenges via the Ulao Creek Stewardship Plan (pp. 6-8; pp. 63-66).

Instructional Resources	Source Materials and Notes
• LMLL Student Science Notebook, page X • John Wiley.com - Detective/Scientist Resource • Milwaukee Riverkeeper 2014 Report Card • Milwaukee South Watershed – DNR Documents • Ulao Creek Stewardship Plan	**DNR Total Phosphorus Monitoring Reports** Milwaukee South Watershed **Milwaukee Riverkeeper** 2014 Report Card *The Ulao Creek Stewardship Plan offers an opportunity for teachers to discuss distinctions between warm- and cold-water habitats for Wisconsin fish. Ulao is a warm-water stream. Teachers/students can discuss the fish species that inhabit warmer waters and what temperature changes to cold-water habitats can mean for cold-water species.*

Post-Visit Lesson 5.1
Design a Fish Habitat

Port Exploreum
PORT WASHINGTON, WISCONSIN

Summary		
Students will visualize a pond habitat from a story read by the teacher and then study the types of conditions that fish need to survive. They will use this information and fish summary information to construct their own fish habitat diorama.		
Objectives		
• Summarize the conditions under which a freshwater fish is able to survive and thrive.		
Vocabulary	**Materials**	
• Habitat • Limiting resources • Eutrophic • Aquatic connectivity	Student materials: • Fish survival needs reading • Shoebox • Crafting materials (colored pencils, scissors, glue, etc.)	Teacher materials: • Fish information summary pages • Crafting materials: 3 shades of cellophane, pipe cleaners, sticks, sand, rocks, clay, etc.

Sequence	
Intro	Teacher reads aloud "Field Trip to a Pond" from the MinnAqua lesson plan (p. 11) and asks students to write down all of the living organisms they hear in the story. Explain that students will study fish survival needs and build their own fish habitat diorama.
Activity	1) Teacher models note-taking for 1 or 2 of the 4 "survival needs of fish" reading selections in the MinnAqua lesson (pp. 1-2)—food, water, cover, space. Students then record notes for remaining 2 to 3 reading selections (all paragraphs for all students or split them up by groups). Summarize and discuss findings as a class. 2) Teacher introduces performance task: students will create a diorama of a fish habitat by selecting a fish type from fish identification summary pages and matching habitat conditions (food, cover, etc.) based on what their fish needs to survive. In addition to the factors identified in the MinnAqua diorama assessment rubric, have students include water flow (fast, slow) and temperature (color of cellophane).
Wrap-up	Display students' dioramas and have students conduct a "gallery walk" to view each other's final products. What similarities and differences do they notice about the various fish habitats? Optional: Introduce and discuss concept of aquatic connectivity.
Assessment	Students write a paragraph about their fish, describing how its needs are met by its habitat and how these needs can limit the number and sizes of fish living in an area.
Extension	Classrooms can visit Riveredge Nature Center to conduct pond studies to view microorganisms and fish habitat firsthand. See these links for more resources about fish identification (Wisconsin, Michigan), life cycle and population change.

Instructional Resources	Source Materials and Notes
• MinnAqua: Design a Habitat Chapter 1 Lesson 1 • Fish summaries - www.fish-identification.com • Michigan Sea Grant: Teaching Great Lakes Science • Wisconsin Sea Grant: Fish ID web site and app • StreamContinuity.org: Aquatic Connectivity	**Minnesota DNR: MinnAqua** Chapter 1 Lesson 1 *The MinnAqua lesson is designed for slightly younger grades, so fish summary readings and additional factors (water flow, temperature) were added to provide more depth. Advanced level students can additionally study the volume and surface area of the diorama model and number/size of fish based on carrying capacity estimates to achieve greater accuracy.*

Post-Visit Lesson 5.2

Freshwater Food Chains & Webs

Port Exploreum

PORT WASHINGTON, WISCONSIN

Summary

Students develop a basic understanding of the relationship between producers and consumers by studying and comparing the concepts of food chains and food webs using organisms from an aquatic ecosystem.

Objectives

- Construct a food chain using the categories of herbivores, carnivores, and producers.
- Describe the interaction and interdependence of members of a food chain.

Vocabulary	Materials	
• Carnivore • Herbivore • Consumer • Producer • Food Web • Food Chain	Student materials: • Computer/internet access • Food Chain Shapes doc. • Large Paper (11 x 17) • Scissors • Glue or tape	Teacher materials: • Projector/internet • Ball of yarn or string • IFAS Extension and Project FLOW lesson resources

Sequence

Intro	Prior to the lesson, cut out and distribute food web pictures to students from the "Food Webs: Strings Attached" lesson (p. 50, IFAS Extension). Students stand in a circle and pass a ball of yarn around to create a food web based on instructions from the lesson. Have students pull the web tight and ask to predict what would happen if one of the organisms became extinct and cut the line for that organism. Discuss the results.
Activity	Explain to students that the web they created is made up food chains of predator-prey relationships between 4 levels of organisms—carnivore, herbivore, large carnivore and producers. Have students cut out the shapes from the Food Chain Shapes document, label them according to Project FLOW Lesson 1 (pp. 3-4). Have students read the "Food Chains and Food Webs: Additional Background Information" (pp. 17-18), order the shapes and affix them to a larger piece of paper. Based on their reading, have them use the pictures from the "Strings Attached" intro activity and determine which organisms go in which category and write them into the shapes. Review with students where they placed the organisms to confirm the correct answers.
Wrap-up *(X min)*	Read for students the "background" section for Project FLOW Lesson 2 "Who's eating whom?" (p. 9) and discuss the similarities, differences and uses of food chains and food webs as scientific models as well as the role of energy transfer within each model.*
Assessment	Ask students to write 2 to 3 sentences answering the following prompt: "Which part of the food web do you think is most important? Why?"
Extension	Students can learn more about food webs by participating in the food token game detailed in in Project Lesson 2. Advanced resources include the introductory reading on pp. 6-9 of the IFAS Extension unit and this ITSI carrying capacity simulation activity.

Instructional Resources	Source Materials and Notes
• Food Chain Shapes Document (PPT) • Project FLOW: Fisheries Learning on the Web – Great Lakes ecosystem, fisheries and stewardship • IFAS Extension – Aquatic/Marine Lessons • ITSI Carrying Capacity Simulation	**Project FLOW: Fisheries Learning on the Web** (Michigan Sea Grant/NOAA) Lessons 1 and 2 **University of Florida - IFAS Extension** Lesson 1: Aquatic and Marine Ecosystem Connections **Advanced topic: students can discuss how we measure trophic levels from freshwater organism samples. For example, see this thesis about stable isotope analysis.*

Post-Visit Lesson 5.3

Where did all the fish go?

Port Exploreum
PORT WASHINGTON, WISCONSIN

<table>
<tr><th colspan="3">Summary</th></tr>
<tr><td colspan="3">Students investigate the role that phosphorus plays in disrupting the balance of aquatic ecosystems by reading 2 selections and completing a chart in their Science Notebook to the show relationships and “chain reaction” harming fish habitat.</td></tr>
<tr><th colspan="3">Objectives</th></tr>
<tr><td colspan="3">Identify the relationships between environmental conditions, water pollution, and fish habitat.</td></tr>
<tr><th>Vocabulary</th><th colspan="2">Materials</th></tr>
<tr><td>Eutrophic
Sediment
Turbidity
Channelization</td><td>Student materials:
Computer/internet access
Science Notebook, page X
Eutrophic/Healthy diagram and Fondriest reading</td><td>Teacher materials:
Projector/internet
Plum Creek, Eutrophic/Healthy diagram, Fondriest, IBI, and Habitat Restoration web links.</td></tr>
</table>

<table>
<tr><th colspan="2">Sequence</th></tr>
<tr><td>Intro
(X min)</td><td>Have students read the Plum Creek runoff news article and conduct a Think-Pair-Share to answer the question of why the fish died, how community members are addressing the situation, and which solutions, if any, they think are most likely to be successful.</td></tr>
<tr><td>Activity
(X min)</td><td>1) Remind students of the food web intro activity from the previous lesson and how cutting the piece of yarn affected the web. Explain to students that in this lesson they will be studying how water pollution, specifically phosphorus, can interrupt these relationships in an aquatic ecosystem and have dramatic effects on fish and humans.

2) Use the projector to share with students the eutrophic/healthy aquatic ecosystem diagram and explain that many factors are interacting to affect fish health, just like in the earlier food web example. Guide students through the diagram and the completion of the first few blanks on page X in their Science Notebook to show how and phosphorus disrupts the water body’s ecological balance. Have students complete the rest of the blanks using the diagram and, optionally, the reading from Fondriest.com (sections: “Factors that influence turbidity” and “Consequence of unusual levels.”)</td></tr>
<tr><td>Wrap-up
(X min)</td><td>Explain to students that while Hazardous Algal Blooms are rare due to conditions other than phosphorus (water depth, circulation, temp.), pollution in lesser amounts can still disrupt aquatic life. Discuss the Index of Biological Integrity (p. 6).</td></tr>
<tr><td>Assessment</td><td>Ask students to write a paragraph answering: Which of the following strategies do you think is the best way to address phosphorus pollution in rural areas and protect fish habitat? (policy/enforcement, habitat restoration, education for farmers). Why?</td></tr>
<tr><td>Extension</td><td>Students can investigate the Ozaukee County Fish Passage Program, its efforts to restore fish and wildlife habitat on Ulao and Mole Creeks and interview Ozaukee County staff to learn more about it. Additional information on aquatic life passage and habitat connectivity can be found via the Fish Passage Program’s educational video.</td></tr>
</table>

<table>
<tr><th>Instructional Resources</th><th>Source Materials and Notes</th></tr>
<tr><td>LMLL Student Science Notebook, page X
Turbidity, TSS and Water Clarity - Fondriest.com
NPR news article: Plum Creek runoff incident
Eutrophic/healthy aquatic ecosystem diagram
Index of Biological Integrity – Watershed Science Institute
Habitat restoration resources – Mole Creek, Cty. Fish Passage video, MO Streams Fact Sheet</td><td>Multiple Source Materials
(← See Instructional Resources)

For another (agricultural/economic) perspective on ways to prevent/address watershed pollution, have students read this interview with Dan Stoffel, a local farmer and board member of the Southeastern Wisconsin Watersheds Trust. This could serve as a good model for the types of questions students can use if they interview city/county officials, farmers or other watershed stakeholders in their area.</td></tr>
</table>

Post-Visit Lesson 6.1

Green Infrastructure in the Schoolyard

Port Exploreum

PORT WASHINGTON, WISCONSIN

<table>
<tr><th colspan="3">Summary</th></tr>
<tr><td colspan="3">Students revisit rain garden design from their Exploreum visit and learn about other types of green infrastructure. Students analyze a map of their own schoolyard for porous and impervious spaces and begin creating their own GI plan.</td></tr>
<tr><th colspan="3">Objectives</th></tr>
<tr><td colspan="3">Explain the purpose and advantages of green infrastructure compared to traditional stormwater infrastructure.
Select location-appropriate green infrastructure and low-impact development technologies.</td></tr>
<tr><th>Vocabulary</th><th colspan="2">Materials</th></tr>
<tr><td>Green infrastructure
Bioswale/vegetative basin
Green roof</td><td>Student materials:
Science Notebook, page X
Large printed map of schoolyard (from MMW)
Colored pencils</td><td>Teacher materials:
Projector/internet
Teach Engineering PowerPoint for Lesson 2 and web links (school video, ITSI, MMW app)</td></tr>
<tr><th colspan="3">Sequence</th></tr>
<tr><th>Intro</th><td colspan="2">Ask students to recall the purpose of the rain garden model from the Exploreum's Infiltration Station exhibit. Tell students that they will be studying other types of green infrastructure to help them design a virtual "GI plan" for their schoolyard to reduce stormwater runoff. Show the schoolyard map with Model My Watershed (MMW).</td></tr>
<tr><th>Activity</th><td colspan="2">1) Introduce the students to a schoolyard GI project by viewing the Albert Greenfield Elementary video (0:00 to 1:40 and pause on schoolyard design; continue from 1:40 to 2:00 and then 2:45 to 5:10). Ask students to identify examples of green infrastructure from the video as they watch. Solicit their responses once the video is complete.

2) Present the different types of green infrastructure using the PowerPoint and notes from Lesson 2 of the Teach Engineering Urban Stormwater Management unit. During the presentation, have students complete the "What does it do?" and "Where best to locate?" columns in their chart on page X of their Science Notebook. Distribute the printed large maps of the schoolyard and ask students to mark and/or shade the impervious (i), porous (p) and existing conservation practices (c), if any.</td></tr>
<tr><th>Wrap-up</th><td colspan="2">Discuss what students have noticed about their schoolyard and ask them where they think there might be more likelihood of issues with runoff on their schoolyard. Where are there opportunities for increased infiltration and water pollution prevention?</td></tr>
<tr><th>Assessment</th><td colspan="2">Ask students to reflect on what they have learned and answer the question: "What GI features would you like to incorporate into your schoolyard design? Where?"</td></tr>
<tr><th>Extension</th><td colspan="2">As students prepare to work on their schoolyard GI plans, have them consult with experts (engineers, school groundskeepers) about GI feature placement, lawn/grounds maintenance (e.g. use of fertilizers, pesticides, etc.) and any existing challenges.</td></tr>
<tr><th colspan="2">Instructional Resources</th><th>Source Materials and Notes</th></tr>
<tr><td colspan="2">LMLL Student Science Notebook, page X
Innovative Technology in Science Inquiry (ITSI) Activity Part I – Exploring Watersheds
Greenfield Elementary GI Plan video
Wiki Watershed - Model My Watershed app
Teach Engineering: Urban Stormwater Management – Lesson 2, PowerPoint presentation</td><td>Innovative Technology in Science Inquiry (ITSI) Activity Part I – Exploring Watersheds

Teach Engineering: Urban Stormwater Mgmt. – Lesson 2

The GI categories in the Science Notebook chart correspond to the virtual tools that students will be able to use when the design their own plan. It may also be helpful to project or printout the descriptions and pictures of these from ITSI Activity Part II for students as a reference.</td></tr>
</table>

Post-Visit Lesson 6.2

My Schoolyard Virtual GI Plan

Port Exploreum
PORT WASHINGTON, WISCONSIN

Summary

Students conduct a tour of their schoolyard to observe the path of stormwater and use this information, along with their knowledge of green infrastructure features, to develop their own virtual GI plan and calculate the environmental impact.

Objectives

- Propose conservation practices to lessen the impact of school site stormwater runoff in the local watershed.
- Model possible changes in conservation practices on their watershed and describe the impact of these changes.

Vocabulary	Materials	
• Scientific Model	Student materials: • Computer/internet access • Science Notebook, page X • Large map of schoolyard	Teacher materials: • Projector/internet • Wiki Watershed, and ITSI Activity III and V web links

Sequence

Intro	Take students on a brief tour of their schoolyard and ask them to make observations about factors that affect water flow—pooled water (after a storm), topography, storm drains, vegetation, etc.—and discuss how stormwater flows through the schoolyard.*
Activity	1) Ask students to use what they learned on their schoolyard tour to draw rectangles for where they would like to place each of the 4 types of green infrastructure—green roof, porous pavement, bioswale, and rain garden—on their printed schoolyard map. 2) Have students use the Model My Watershed app to pull up the 1 square km for their schoolyard, calculate the **current** amount of runoff, total phosphorus (TP) and total suspended solids (TSS); and record in their Science Notebooks. Now have students draw GI features from their printed map onto their virtual schoolyard, calculate/ record the square meters for each and the **updated** total runoff, TP and TSS.** Lastly, have students calculate the change from the current to the updated maps in the table.
Wrap-up	Have students share the amount of change in runoff, TP and TSS in their respective plans via a table on the board/projector and compare which plans seemed to improve environmental outcomes the most. Why were some plans more successful than others?
Assessment	Have students develop and share with their class a presentation—PowerPoint, Prezi, etc.—that includes: 1) the current state of the schoolyard, 2) their GI features/plan, 3) change in environmental impact and 4) what they learned during the activity.
Extension	Students can work with their schools/districts and any other groups (parents, engineering firms, etc.) to provide input into the development of an actual rain garden or other GI feature for their school and participate in the installation and maintenance.

Instructional Resources	Source Materials and Notes

• LMLL Student Science Notebook, page X
• Wiki Watershed - Model My Watershed App
• Innovative Technology in Science Inquiry (ITSI) Activity III and Activity V
• UW-Madison Arboretum - Earth Partnership Rain Garden Curricular Sampler
  ○ Schoolyard tour
  ○ Installation of a rain garden
	Wiki Watershed – Model My Watershed App
	Innovative Technology in Science Inquiry (ITSI) Activity III and Activity V
	**As students conduct the tour of their schoolyard, the following resources may be helpful: Earth Partnership Rain Garden Curricular Sampler (pp. 23-24) and ITSI Activity Part III, "Tracking Water in My Schoolyard."*
	*** You may want to limit the total number of square meters of GI to make for easier comparison between student designs and discussion of relative benefits of GI features.*

Post-Visit Lesson 6.3

Eco(nomy)-Friendly?

Summary

Students will study the economic impacts of pollution on the water recreation industry by analyzing an informational video, reading about E. coli and researching Wisconsin beach closings to better understand the concept of "triple bottom line."

Objectives

- Identify the economic impact of water pollution on the recreation industry in Wisconsin
- Develop a letter or video that provides information and persuades an audience to reduce water pollution.

Vocabulary

- Recreation industry
- Triple bottom line

Materials

Student materials:
- Computer/internet access
- Science Notebook, page X

Teacher materials:
- Projector/internet
- Bradford Beach data set

Sequence

Intro	Ask students to raise their hand if they have ever been fishing, boating or swimming at the beach. Explain that these are examples of the water based recreation industry that makes up about $7 billion of business in Wisconsin. Have students Think-Pair-Share and list the things they bought or rented during their last water recreation trip.
Activity	1) Have students view the Clean Marinas program video and ask them to consider: • Who is the audience for this video and what do they want this audience to do? • How do these actions benefit businesses financially and/or environmentally? • What strategies are they using to convince their audience? 2) Another popular water recreation use is visiting the beach. Wisconsin beaches are monitored on a daily basis and may be shut down for a pollutant called *E. coli* that can make swimmers sick. Have students read the paragraph in the Science Notebook about *E. coli* and introduce them to the Bradford Beach advisory data set. Ask students to predict how often this happened at Bradford Beach in Milwaukee in 2016 and then review and enter the data in the table. Space is provided in their Notebooks for students to enter additional beach advisory data to compare with Bradford Beach.*
Wrap-up	Discuss beach advisory data trends and ask students about causes (e.g., rain storms). Indicate that sometimes *E. coli* is found, but the beach is not closed because it did not meet a threshold. Show students to how to check if a beach is safe for swimming.**
Assessment	Have students write a persuasive letter convincing a person—family member, legislator, business owner, farmer, etc.—about the actions they can take to ensure that stormwater runoff does not lead to health, environmental and/or economic problems.
Extension	Students can also study rip current levels, another swimming hazard. Advanced readings on the water based recreation industry: GL Jobs Report, Economic punch. News article about how scientists are measuring *E. coli* levels in Lake Michigan.

Instructional Resources

- LMLL Science Notebook, page X
- WI Beach Advisory – Bradford Beach data set
- Clean Marinas informational video
- WI Beach Health
  - Report – searchable data sets
  - Map – graphic of advisories
- Advanced readings:
  - Great Lakes Jobs Report
  - Great Lakes Rec. Boating's Economic Punch

Source Materials and Notes

**Note that beach data includes "preemptive" closings, which occur due to heavy rainfall and beach modeling/forecasting. While scientists are working to speed up the process, it currently takes 24 hours to culture E. coli so beach warnings may lag behind actual exposure risks.*

***It may be helpful to introduce students to the concept of the "**triple bottom line**"—e.g. the idea that businesses can take profits, social factors, and environmental impact into account in its decision-making and still be successful. This article from Cultivating Capital provides a history and a weighing of the benefits of this approach.*

Curriculum Connections

Content Exploration and Service Learning Opportunities

Program Partners	
Sunny Knutson Director of Education 262.416.1101 skutson@riveredge.us	Riveredge Environmental Education Field Trips offer students the opportunity to experience and investigate the natural environment under the guidance of Environmental Educators. Emphasizing outdoor experiences in all seasons, the Riveredge "style" is characterized by small group learning that encourages inquiry, exploration and problem solving. Through the process of systems-thinking and hands-on inquiry, learners construct their own answers throughout our programs. Our goal is to help students understand our human connection to the environment and how our actions can make a difference. **Pond Interactions,** Grades 4-6 **River Reflections,** Grades 5-8 **Wetland Wonders,** Grades 6-8 **Determining Water Quality,** Grades 6-12 **Testing the Waters,** Grades 9-12 **The Dirt on Soils,** Grades 5-8 Engineered Wastewater Treatment System on-site, Lake Sturgeon Streamside Rearing Facility tours, Annual Sturgeon Release at Lakeshore State Park
Ryan Wallin Stewardship Director 262.338.1794 rwallin@owlt.org	The Ozaukee Washington Land Trust offers services to property owners and communities throughout Ozaukee and Washington Counties in the areas of land conservation, education and stewardship. In 25 years, more than 6,200 acres of forests, wetlands and open space have been protected through acquisition and conservation easements. We have opportunities for students and their parents to connect with the natural world in our very own community. Whether beating back the spread of Invasive Species, helping with prairie seed collection, blazing new paths with our Trail Crew, or through Wildlife Monitoring there's something for everyone.

Resources and Speakers		
MATT AHO **Ozaukee County Planning and Parks Department** 262.236.2005 maho@co.ozaukee.wi.us Fish Passage Program, habitat restoration projects	MICHAEL TIMM **Writer, Game Designer** 414.378.0495 michaelalantimm@yahoo.com Water science engagement and project management	JUSTIN HEGARTY **Reflo Sustainable Water Solutions, Inc.** 262.573.9955 justin.hegarty@refloh2o.com Green infrastructure outreach, planning and installation
PETER HILL **Great Lakes Watershed Opportunities, LLC** 202.841.7752 GLWatershedOps@gmail.com Soil infiltration and green infrastructure models	CORA LEE PALMER **Milwaukee Metropolitan Sewerage District** 414.225.2191 cpalmer@mmsd.com Water science resources, water reclamation facility tour	JAKE FINCHER **Southeastern Wisconsin Watersheds Trust** 414.382.1766 fincher@swwtwater.org Respect Our Waters campaign, PSAs, persuasive communications

Acknowledgements

Port Exploreum Team

Wayne Chrusciel Bill Moren Dave Libert Peter Hill Michael Timm	Executive Director Lake Michigan learning Lab Leader Education Consultant Technical and Exhibit Consultant Technical and Exhibit Consultant	**Contact** Bill Moren billmoren65@gmail.com 262-573-3130 118 N. Franklin Street Port Washington, WI, 53074

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