Illinois Mathematics & Science Academy

Every Drop Counts

PBL

Problem-Based Learning

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The internationally recognized Illinois Mathematics and Science Academy® (IMSA) develops creative, ethical leaders in science, technology, engineering and mathematics. As a teaching and learning laboratory created by the State of Illinois, IMSA enrolls academically talented Illinois students (grades 10-12) in its advanced, residential college preparatory program, and it serves thousands of educators and students in Illinois and beyond through innovative instructional programs that foster imagination and inquiry. IMSA also advances education through research, groundbreaking ventures and strategic partnerships. (www.imsa.edu)

Acknowledgments

This PBL Design manual consists of materials conceived and developed by numerous individuals affiliated with IMSA's PBL Network over the past two decades. Whether internal IMSA faculty, educators from our partner schools, participants in Problem-Based Learning initiatives, or PBLNetwork staff, we acknowledge their participation and contributions to the conceptual and developmental process. We have all learned from one another.
This manual and professional development in problem-based learning at IMSA is grounded in the work of our former colleagues in their book:

Torp, L. & Sage, S. (2002). *Problems as Possibilities: Problem-Based Learning for K-16 Education.* Alexandria, VA: The Association for Supervision and Curriculum Development.

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Think of some of the "big ideas" from your entire curriculum. What are some of the themes you focus on during the year? What are some outcomes you and your school value enough to spend quality time on during the school year?

Notes

Unit Overview

Title: Every Drop Counts

Focus: Water Properties, Environmental Awareness, and Aquatic Life

Embedded Problem: Develop a plan to either remove or prevent pollution affecting Lake Michigan.

Overarching questions:

- What are several basic properties of water?
- What types of pollution affect the water quality of Lake Michigan?
- What aquatic habitats are found in Lake Michigan?
- What factors impact water quality?

Role and Situation: The students are asked to collect information regarding water properties, aquatic habitats, water quality, and pollution sources to develop a play to either remove or prevent pollution affecting Lake Michigan.

Grade Level/s and Content Area/s: Grades 4^{th}-5^{th}

Science: Life Cycles and Traits, Environmental Impacts on Organisms, Earth's Systems

Math: Data Collection, Ratios and Proportions, Number Sense and Operations

Language Arts: Research, Writing, Presentation Skills

Curriculum Outcomes: Throughout a Problem Based Learning (PBL) experience, learners are actively engaged in discovering the content, developing self-directed learning dispositions and applying thinking and reasoning skills.

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Standards

3-LS4-4., *Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*
4.RL.1., *Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.*
4.RI.3., *Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.*
4.RI.7., *Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.*
4.SL.1., *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on* grade 4 topics and texts*, building on others' ideas and expressing their own clearly.*
5.RI.7., *Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.*
5.SL.1., *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on* grade 5 topics and texts*, building on others' ideas and expressing their own clearly.*
5.RI.4., *Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.*
3-LS4-4., *Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*
4-ESS2-2., *Analyze and interpret data from maps to describe patterns of Earth's features.*
4.NF.A.2., *Compare two fractions with different numerators and different denominators, e.g., by creating common denominators or numerators, or by comparing to a benchmark fraction such as 1/2.*
4.NF.B.3.D., *Solve word problems involving addition and subtraction of fractions referring to the same whole and having like denominators.*
4.RI.3., *Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.*
4.SL.1., *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on* grade 4 topics and texts*, building on others' ideas and expressing their own clearly.*
5.SL.1., *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on* grade 5 topics and texts*, building on others' ideas and expressing their own clearly.*
5-PS1-3., *Make observations and measurements to identify materials based on their properties.*
4.RI.7., *Interpret information presented visually, orally, or quantitatively and explain how the information contributes to an understanding of the text in which it appears.*
4.SL.1., *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on* grade 4 topics and texts*, building on others' ideas and expressing their own clearly.*

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5.SL.1., *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on* grade 5 topics and texts*, building on others' ideas and expressing their own clearly.*
5.RI.4., *Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.*
5-PS1-3., *Make observations and measurements to identify materials based on their properties*
5-ESS2-1., *Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact*
4-ESS2-1., *Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation*
5-PS1-3., *Make observations and measurements to identify materials based on their properties*
4-ESS2-2., *Analyze and interpret data from maps to describe patterns of Earth's features.*
4.MD.A.1., *Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit.*
4.MD.A.2., *Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.*
4.RI.4., *Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area.*
4.RI.7., *Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.*
5.RI.4., *Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.*
5.RI.7., *Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.*
3-LS3-2., *Use evidence to support the explanation that traits can be influenced by the environment.*
3-LS4-3., *Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.*
3-LS4-4., *Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*
4.NBT.B.4., *Fluently add and subtract multi-digit whole numbers using the standard algorithm.*
4.NBT.B.5., *Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers, using strategies based on place value and the properties of operations.*
5.NBT.B.6., *Fluently multiply multi-digit whole numbers using the standard algorithm.*

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5.NBT.B.7., *Find whole-number quotients of whole numbers with up to four-digit dividends and two-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division.*
4.RL.1., *Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.*
4.RI.1., *Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.*
4.RI.2., *Determine the main idea of a text and explain how it is supported by key details; summarize the text.*
4.RI.7., *Interpret information presented visually, orally, or quantitatively and explain how the information contributes to an understanding of the text in which it appears.*
4.SL.2., *Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.*
5.RL.1., *Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.*
5.SL.2., *Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.*
3-LS4-4., *Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*
4.RL.1., *Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.*
4.RI.3., *Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.*
4.RI.7., *Interpret information presented visually, orally, or quantitatively and explain how the information contributes to an understanding of the text in which it appears.*
5.RI.7., *Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.*
4.SL.1., *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on* grade 4 topics and texts, *building on others' ideas and expressing their own clearly.*
5.SL.1., *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on* grade 5 topics and texts, *building on others' ideas and expressing their own clearly.*
4.W.2.B., *Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.*
5.W.2., *Write informative/explanatory texts to examine a topic and convey ideas and information clearly.*
4.RF.4., *Read with sufficient accuracy and fluency to support comprehension.*
5.RF.4., *Read with sufficient accuracy and fluency to support comprehension.*

Notes

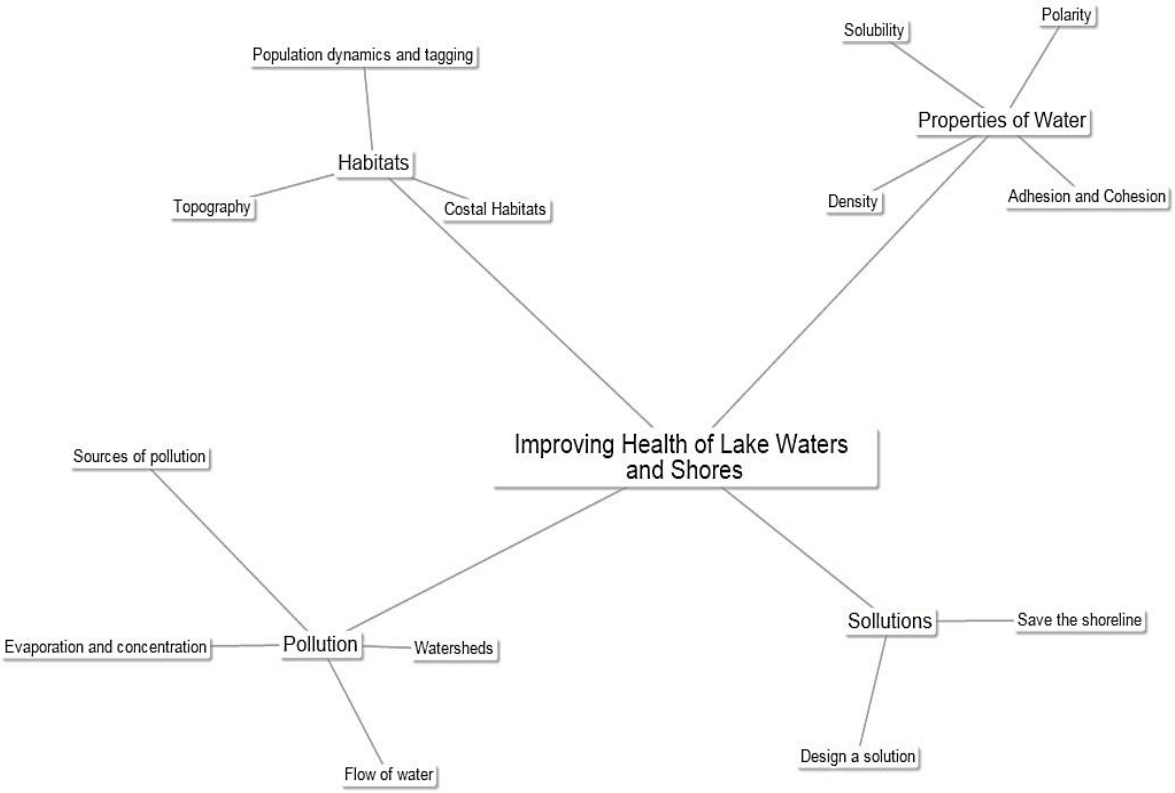
Common Core Mathematical Practices:

MP1: *Make sense of problems and persevere in solving them.*
MP2: *Reason abstractly and quantitatively.*
MP3: *Construct viable arguments and critique the reasoning of others.*
MP4: *Model with mathematics.*
MP5: *Use appropriate tools strategically.*
MP6: *Attend to precision.*
MP7: *Look for and make use of structure.*
MP8: *Look for an express regularity in repeated reasoning.*

NGSS Science and Engineering Practices:

SEP1: *Asking questions and defining problems.*
SEP2: *Developing and using models.*
SEP3: *Planning and carrying out investigations.*
SEP4: *Analyzing and interpreting data.*
SEP5: *Using mathematics and computational thinking.*
SEP6: *Constructing explanations and designing solutions.*
SEP7: *Engaging in argument from evidence.*
SEP8 : *Obtaining, evaluating, and communicating information.*

Map of the Problem



Notes

Meet the Problem

Class Age/Size: 4th-5th Grade/Whole Group

Materials:

- Meet the Problem Artifact(s)

Time: 15 minutes

Location: Classroom

Objectives/Standards:

- *Students are introduced to the problem and begin to make sense of it.*
  - **NGSS: SEP1, SEP8**
  - **Math: MP1**
  - **ELA: 4.RI.1, 4.RI.2, 4.RI.7, 4.SL.2, 4., SL.3, 5.RI.1, 5.RI.2, 5.RI.7**

Introduction:

The students will meet the problem through a letter from a poster. In order to "hook" the students, make the situation and role as authentic and believable as possible, using the letter and/or video, guest speakers, field trips, etc. However, be sure to avoid information overload, and "giving away" the whole problem. After sharing the letter with the whole group, it is helpful to have the students, individually or in small groups, highlight or underline key information.

Coaching Questions:

- What problem factors do we need to consider?
- What issues connect to this problem?

Assessment:

- Are the students aware that the situation is problematic; did they get "hooked"?
- Can learners participate in a team discussion of the problem situation?

Notes

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Dear students,

I am ***(place personal information here).***

I have heard that you are studying water and habitats in your classes, and I would like your help with a related issue that affects the Chicago region. Beach closures due to low water quality have been a long-standing problem in Illinois. In 2012, a reported 33 out of 40 beaches that were monitored had instances of beach actions (either contamination advisories or closures). During the swim season, these closures and advisories affect the general economy. Summer beach activity generates approximately $35 a day per individual, which has been estimated to result in an economic loss of approximately $37,000 a day.

While the economic side is important to the city, the environmental state of the lake is the larger concern. Water conditions are currently monitored by assessing various water quality measurements, such as the levels of E.Coli bacteria, clarity, pH levels, etc. Several water quality pollutants can cause health issues. Also, bacterial growth can be impacted by other pollutants and can affect not only the human population, but also the organisms that live in and depend upon the water in this Great Lake.

There may be multiple reasons for the increase of harmful pollutants in this water habitat, but we have yet to identify the exact source or sources of pollution. We are curious to understand the conditions that lead to the pollution of the lake.

As we currently are struggling to identify the sources of pollution to the water habitat, we are at a loss as to how to prevent it from reoccurring. We need help in determining from where the pollution might arise. Finding appropriate solutions to prevent, or decrease, the effects of this pollution on our lake and beach habitats is important, as well. Any help that you and your classmates can offer with this obstacle is greatly appreciated. I will be available to see and hear your assessments and solutions on ***(enter date of completion and presentation here)***.

Thanks for your help with this problem.

Sincerely,

(Place personal information here.)

Notes

Know/Need to Know

Class age/size: 4th-5th Grade/whole class

Materials:

- Chart Paper
- Markers
- K/NK

Time: 45 minutes

Location: Classroom

Safety: No known issues

Objectives/Standards:

- *Students will list their prior knowledge and questions they have whose answers will help them solve the problem.*
  - **NGSS: SEP3, SEP8**
  - **Math: MP.1**
  - **ELA: 4.RL.1, 4.RI.1, 4.RI.2, 4.RF.4, 5., RF.4, 5.RI.1, 5.RL.1**

Introduction:

In this lesson students will develop a list of Know and Need to Know items relating to the problem. The purpose of the activity is to have students think deeply about what they will need to know in order to solve the problem, and to provide a guide for their investigations. Student engagement is increased when they can see the connections between learning activities and questions they have about the problem. The list should be posted in the classroom, and as the questions are addressed, they can be crossed off of the Need to Know list and added to the Know list. Need to Know items can be added to the list as they arise, and the students should refer to the list before and after learning activities. It may be necessary to coach students to particular Need to Know items relating to learning activities.

Activity/Activities:

1) Using the handout, the students will individually fill out Know and Need to Know items. Reminds students that it is all right if there are more items on the Need to Know list than the Know list.
2) Pairs of students will compare their lists and add as needed.
3) Small groups (4-6) of students will compare their lists. The groups will come to a consensus as to which items are the top 3 on each list.

4) As a whole class, generate a master K/NK list on chart paper that will be posted in the classroom.
5) As an extension, or as an initial activity, students could draw concept maps of the problem, individually or in small groups.

Coaching Questions:

- What do you know about the problem? How do you know that information?
- What questions do you still have? Why do you need to know?
- Are there other areas that you should consider? Why do you think so?

Assessment:

- Can learners identify key elements from the Meet the Problem artifacts and situation? Can they identify key areas of investigation?
- Concept maps and K/NK lists—for breadth and depth of understanding
- Do the students validate and respect the contributions of all individuals?

Notes

Anticipated Needs to Know items addressed by unit:

Unit	Need To Know
Pollution: a) Pollution Problems b) Lake Michigan Mess	• What are pollutants? • What pollutants are affecting Lake Michigan? • Where do these pollutants come from? • What do they do to the lake?
Water Travels: a) Build a Shed b) Where's it Flow c) Evaporation and Concentration	• How do pollutants move from land to water? • Where is the water going with the pollutants? • Is there a connection between how water cycles through the environment and pollutants?
Water Properties: a) Drag Race and Polarity Pull b) String Theory	• What is water and how does water behave? • What is it about water that makes it behave as it does?
Solubility: a) Now You See It, Now You Don't b) Density of Water	• How do pollutants exist or mix in the water? • What do these pollutants do to the properties of water?
Habitats: a) Where's It At? b) Are You Shore Habitat? c) Save the Shore	• What organisms are affected by the pollution? • What lives in the lake or relies upon the lake water? • How can we prevent movement of these pollutants into the habitats?
Aquatic Life: a) Tag You're It! b) Algal Bloom: A Big Problem	• How does water quality affect aquatic life? • How can we monitor the aquatic life in Lake Michigan? • Is all aquatic life essential, or beneficial?
Solution: a) What Are Your Suggestions?	• What are current solutions to the problem? • How can we help to decrease the pollution that affects Lake Michigan?

Problem Statement

Class age/size: 4th 5th Grade/whole class

Materials:

- Chart Paper
- Markers
- Problem Statement handouts

Time: 45 minutes

Location: Classroom

Objectives/Standards:

- *Students will define the problem that will guide their investigation.*
  - **NGSS: SEP1**
  - **Math: MP.1**
  - **ELA: 4.RL.1, 4.RI.1, 4.RI.2, 4.RF.4, 5., RF.4, 5.RI.1, 5.RL.1**

Introduction:

The Problem Statement is the key document that will guide the students through the problem. It consists of an overall task, and the factors to be considered in successful completion of the task. The students should carefully consider the information given in the Meet the Problem documents when writing their Problem Statement. Having the students draw concept maps, with the problem in the middle and the factors around it, can help the student clarify their thinking. The Problem Statement should be posted, and can be changed if the need arises.

Activity/Activities:

The students will draw a concept map of the problem.

1. Distribute the Problem Statement handouts.
2. The students will fill in the columns individually, then with a partner, and then with a small group of 4-6 students.
3. Each group of students will present their proposed Problem Statement to the class. The teacher will then work with the class to develop a whole class Problem Statement.
4. The Problem Statement will be revisited on a daily basis to guide the class' investigations.

Notes

The stem for the Problem Statement is:

"How can we as (role) [overall task], in such a way that we consider [factors]…"

Coaching Questions:

- What have we been asked to do? (overall task)
- Are there other areas to consider? (factors)
- Who else could be affected by this problem?
- Are there other problem conditions to consider?

Assessment:

- Does the problem statement identify most of the key issues of the problem? (individual and group)
- Do they have a working problem statement?
- Do the students validate and respect the contribution of all individuals?
- The Problem Statement worksheet can be used to assess the learners' overall understanding of the "big picture" of the problem and key factors for solutions.

Final Anticipated Problem Statement:

How can we, as students, develop a plan to either remove or prevent pollution affecting Lake Michigan…

… ***in such a way that we consider:***

- Sources of Pollution
- Impact of the pollutants on the lake and beach habitats
- Impact on biologic life within the habitat
- Feasibility (Appropriateness)

Plan for Information Gathering

Class age/size: 4th-5th Grade/whole class

Materials:

- Chart Paper
- Markers
- K/NK handouts, Problem Statement Handouts from previous sessions

Time: 15 minutes

Location: Classroom

Objectives/Standards:

- *Students will design a plan for answering their need to know items and solving the problem.*
  - **NGSS: SEP3, SEP8**
  - **Math: MP.1**
  - **ELA: 4.RI.7, 4.SL.1, 5.RI.7, 5.RI.9, 5.SL.1,**

Introduction:

In this lesson students will develop a plan for gathering information. The students will usually come up with the Internet as the first option. The key understanding is that there are other sources of information, such as experts, lab activities, books, surveys, etc. that can be used. The students may need some coaching to get to these ideas.

Activity/Activities:

1. The students will brainstorm ideas for gathering information to address the Need to Know items and the Problem Statement. The teacher will capture the ideas on chart paper.
2. The students will develop a plan for gathering information at the teacher's discretion. Options include assigning individual students or groups of students to address particular items, investigating as a whole class, etc.
3. The Need to Know list and the Problem Statement will be revisited on a daily basis, with completed items being checked off, and new items added as needed.

Notes

Pollution

Logistics:
Class grade/age: 4th – 5th Grade
Class size: Approximately 30 students
Instructional Time: 120 minutes
Location: Classroom and Computer Lab (or other location that allows for use of technology with internet access)
Safety: No safety issues in this lesson.

Curriculum Objectives and Need to Know Items Addressed

The students will:

- What are pollutants?
- What pollutants are affecting Lake Michigan?
- Where do these pollutants come from?
- What do they do to the lake?

Standards:

NGSS: 3-LS4-4, SEP1, SEP3, SEP7, SEP8
ELA: 4.RL.1, 4.RI.3, 4.RI.7, 5.RI.7, 4.SL.1, 5.SL.1, 4.W.2.B, 5.W.2, 4.RF.4, 5.RF.4

Introduction:

Lake Michigan is the second largest of the Great Lakes, approximately 307 miles in length and 118 miles in width. With an average depth of 279 feet and containing approximately 1,180 cubic miles of water, Lake Michigan is a valuable resource of drinking water for human, a home for a variety of aquatic species, and place of recreation for many Chicagoans.

However, Lake Michigan is habitually impacted by several pollutants, which ultimately compromise the water quality. Through their studies of other science units, students should be familiar with several types of pollutants that may impact Lake Michigan, or at least, freshwater bodies. Additional categories of pollutants that may be identified include:

- **Point Source** – a single, identifiable source of pollution, such as toxic chemicals that resulted from a faulty pipe or drain within an industrial plant.
- **Non-Point Source** – pollutants that are typically diffuse or spread to cover a large

area, such a rainfall run-off that contains large amounts of car oil, gasoline, dust, animal waste, and chemicals from construction sites.

- **Invasive Species** – these include aquatic life that is foreign to the natural habitat, such as zebra and quagga mussels. Additionally, the recent increase of algal blooms would be considered an invasive species as it negatively impacts the natural aquatic environment.
- **Shoreline Developments** – while the creation of wetlands and coastlines are naturally beneficial to aquatic life, man-made structures are often harmful to the environment.

Materials:

Per Student:

- 10 post-it notes
- **Note:** There are no student pages for these activities.

Per Group of 3 or 4 Students:

- 1 piece of 11”x17” paper
- Presentation Materials (poster board, PowerPoint, Prezi, etc.)

Activity 1: *Pollution Problems*

Estimated Time: 45 minutes

Procedure:

To prepare for this activity, place students in groups of three or four and provide each team with the necessary materials.

Explain to the students that they will work with their team members to identify pollutants that would affect water quality. The students will compile a list of these items by writing each pollutant on an individual post-it note. All post-it notes should be placed on the 11”x17” piece of paper. Provide the students with approximately ten minutes to complete this task.

After all groups have finished, ask the students to categorize their post-it notes. During this time, it is important to encourage the students to create their own lists. Refrain from guiding students to create these categories. Student groups should label each category.

Notes

Once all groups have created their categories, select several volunteer groups share. It is suggested that you create a class list of these categories on chart paper or a whiteboard to be referenced throughout the activity.

Next, select a group to read one pollutant of their choosing. The other groups will also look at their list. If another group has a similar pollutant, then those groups will cross out the similar responses, as in the game of *Scattergories*®. All challenges to acceptable reasons or similarity of responses should be voted on by student consensus. Cycle through each groups in the same manner until all pollutants have been identified. Teams are awarded a point for each unique pollutant they have written. Teams will add up their points to determine the "winning" team.

Conclusion:

Once all groups have shared their list of pollutants, pose the following questions to evaluate their understanding of pollution and how it may, or may not, affect the water quality of Lake Michigan.

- ***Which pollutants are man-made?***
- ***Which pollutants are caused by nature?***
- ***What is a point source pollutant? Give an example.***
- ***What is a non-point source pollutant? Give an example.***
- ***How do you think pollutants affect water quality?***

Activity 2: *Lake Michigan Mess*

Estimated Time: 75-90 minutes

Procedure:

Prior to introducing the activity to the students, prepare the materials that students may need to complete their presentations.

Students will work in small groups of three or four. Explain to the students that they will now be exploring the different types of pollution that affect the water quality of Lake Michigan. To do this, they will have to research this topic using the Internet or other available resources.

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Recommended websites:

- http://environmentreport.org/topten.php
- http://www.epa.gov/oaqps001/gr8water/xbrochure/lakes.html
- https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=12&ved=0CCIQFjABOApqFQoTCLS0wsbZjccCFQOLkgod4RUFng&url=http%3A%2F%2Fwww.nps.gov%2Findu%2Flearn%2Fmanagement%2Fupload%2Flakemichwaterquality.pdf&ei=9Me_VbTqFoOWygThq5TwCQ&usg=AFQjCNGeRhCksudGa_e7FzWjaUYZ4g_Lvg&sig2=ODT5C8JZUnwXfQN7VV2KLw&cad=rja

Prior to dismissing the students to begin their research, pose the following questions:

- **What is water quality?**
- **Why do you think water quality is important?**
- **Which of the pollutants that you identified in *Pollution Problems* do you think have the largest impact on the water quality of Lake Michigan? Why?**

Allow the students time to conduct their research and prepare their presentation. When all groups have finished, encourage each group to present their information to the class.

Conclusion:

Once all groups have presented their information, debrief with the following questions:

- ***Which pollutants have the largest impact on the water quality of Lake Michigan?***
- ***Which pollutants can be controlled?***
- ***Which pollutants cannot be controlled?***
- ***Which pollutants do you think would cause the beaches to be closed?***

Notes

Water Travels

Logistics:
Class grade/age: 4th – 5th Grade
Class size: Approximately 30 students
Instructional Time: 180 minutes
Location: Classroom
Safety: No safety issues in this lesson.

Curriculum Objectives and Need to Know Items

The students will:

- How do pollutants move from land to water?
- Where is the water going with the pollutants?
- Is there a connection between how water cycles through the environment and pollutants?

Standards:

NGSS: 3-LS4-4, 4-ESS1-2, SEP1, SEP2, SEP3, SEP5, SEP7, SEP8
Math: 4.NF.A.2, 4.NF.B.3.D, MP3, MP4
ELA: 4.RI.3, 4.SL.1, 5.SL.1, 5.RI.4

Introduction:

A watershed is defined as an area of land that is drained by a river or stream. Precipitation or groundwater drains of the land through small tributaries (rivers or streams) which lead into larger streams and rivers. These larger bodies of water eventually drain in to basins, often large lakes or oceans.

Due to the unique properties of water, it can adhere to many substances. As water drains from one area of land to another area, it carries with the substances, such as soil, nutrients or pollution. Since watersheds drain into multiple water sources, attempting to determine the source of pollution within a body of water can be difficult.

In this activity, students will build a model of a watershed, and then mimic precipitation to determine how their watershed drains. Next, students will strategically place pollution within the watershed, predict how the pollution will spread, and proceed to test their prediction.

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Materials:

Per Student:

- Student Notes
- Pen or Pencil

Per Group of 2 Students:

- Shallow Tub
- 4 Cups of Water
- 2L Capacity Container
- 5 Plastic cups
- 2 Disposable Pipettes
- 1 Small Plastic Container
- 4 Cups of Playground Sand (or other course sand)
- 2 Cups of Gravel
- 2 Plastic Spoons
- 1 Measuring Cup
- Food Coloring
- 40 Red Pony Beads
- 150 Blue Pony Beads

Activity 1: *Building a 'Shed*

Estimated Time: 60 minutes

Procedure:

Begin by reviewing the **Needs to Know** items that still need to be addressed. Refer specifically to the items that can be addressed by the activities in this particular unit.

Inform the students that they will be exploring watersheds. Ask the students if they know what a watershed is. Coach the students to the understanding that watersheds are areas of land that drain water into small rivers or streams.

Ask the students where that water drains, or where is the final destination for the water. Allow students to report their answers without judgement or correction. At this point, all answers should be considered possibilities to explore.

Notes

At this point, inform the students that they will be making model watersheds, mimicking the action of precipitation, and determining how water can flow in a watershed.

Pair the students and distribute the student pages to the pairs. Show the students where the materials are located, and allow the students time to work through the activity. Reconvene after approximately 30-40 minutes to discuss the activity.

Conclusion:

Once the students have completed the activity, ask the students to discuss how the water moved through the watershed. The students were instructed to divide their land into at least 2 different states, and 5 different towns or cities (and map how the water flows through these cities and states). Ask the students to postulate how pollution might spread from one city or state to the next. Be sure to link these concepts to the appropriate **Need to Know** items.

Activity 2: *Where's It Flow?*

Estimated Time: 60 minutes

Procedure:

Inform the students that they will continue exploring the watersheds. With the pairs from the prior activity, have the students collect their watershed from the prior activity. Allow them time to make any repairs or alterations to their 'sheds before beginning the activity.

Refer the students to their **Need to Know** items. Review the items understood from the prior watershed activity and coach the students to the understanding that, using the watershed, they may be able to answer some **Need to Know** items regarding how pollutants move from land to the lake.

At this point, inform the students that they will be intentionally polluting their watershed. Distribute the rest of the materials and the student pages. Instruct the students to read through the student pages. Make sure they are pre-planning their starting point of pollution before placement of the dye. **Instructor approval of this plan is required.**

As they plan, walk around and observe where the student pairs are planning to start the pollution. If there is too much similarity amongst the choices in the class, suggest alternate

areas to start the pollution. Ultimately, it is desired that different points of pollution are observed among the class. Suggested placements include on the surface land near small rivers, directly in a river, deeper within the ground near a river or lake, or varying placements near or far to the lake itself. Students are to predict what route the pollution will take, and how far it will travel.

Allow the students to collect their materials and work through the activity. After approximately 20-30 minutes, reconvene as a large group to discuss the activity

Conclusion:

To wrap up this activity, allow the students to do a gallery walk and explore their classmates' watersheds and pollution routes. The student groups should have their watersheds – along with a drawn and labeled map of the route of pollution – available for viewing.

Ask the students to discuss what they learned about the watersheds and pollution. Link the concepts back to the **Need to Know** items. You may also choose to extend the discussion by asking the students how the pollution might impact biological life within the areas along the route.

Activity 3: Evaporation and Concentration

Estimated Time: 60 minutes

Procedure:

Ask the students if they water cycles on the Earth. If students are unfamiliar with the water cycle, ask them what happens to water when it heats up? Ask them what happens on a glass shower door as steam builds up in a shower? Ask them what happens when water droplets build up on a window? Coach the students to an understanding of the processes of evaporation, condensation and precipitation.

Next, inform the students that they will be focusing on one aspect of the cycle that may impact fresh water lakes: evaporation. Pair the students and distribute the student pages and materials to each pair.

Read through the directions with the students and instruct the student to label the cups "A", "B", and "C".

Notes

Next, instruct the students to place the appropriate amount of red beads into each cup (5 in "A", 10 in "B", and 25 in "C".)

Instruct the student to place the appropriate starting amount of blue beads into the cups (50 in "A", "B" and "C"). Inform the students that they should enter their data for "Round 1". Their data is the quantities and ratios (in ratio and in fraction form) of each type of bead in each cup.

As they move through the next three rounds, the students will remove a specified amount of blue beads from each cup. Inform the students to begin each new round and enter data as each round ends.

After the final round, see if the students can simplify their fractions. If not, ask the student groups to report each ratio for each cup in the 4 rounds, and work through simplifying the fractions as a large group.

The resulting data should indicate that as the blue beads are removed from the cups, the ratio of red beads/ blue beads becomes smaller. In the last round, all cups should have a ratio of 1:2, or ½.

Inform the students that the blue beads represent lake water and the red beads represent pollution. Ask the students what removing the blue beads represents (evaporation). Ask the students if cup "C" went through the process of evaporation (no). Have the students discuss how the levels of pollution changed within the cups as each round proceeded. Remind them that the amount of pollution did not change in the cups (although the level of pollution increased in cups "A" and "B"). Ask them to explain how this is possible. Coach them to an understanding of **concentration**.

Conclusion:

Once this discussion is complete, ask the students to link their new knowledge back to the **Need to Know** items.

Water Properties

Logistics:
Class grade/age: 4th – 5th Grade
Class size: Approximately 30 students
Instructional Time: 120 minutes
Location: Classroom
Safety: No safety issues in this lesson.

Curriculum Objectives and Need to Know Items Addressed

The students will:

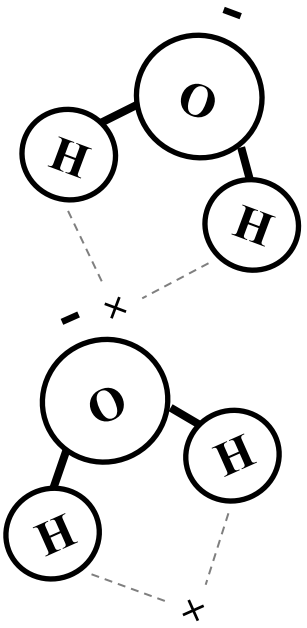
- What is water and how does water behave?
- What is it about water that makes it behave as it does?

Standards:

NGSS: 5-PS1-3, SEP1, SEP2, SEP3, SEP6, SEP7, SEP8
Math: MP2, MP4
ELA: 4.RI.7, 4.RI.4, 4.SL.1, 5.SL.1, 5.RI.4

Introduction:

Water, required by all living things, has properties or characteristics that make it a very unique substance. The properties of water distinguish it from all other substances.



The chemical formula for water is H_2O. This means that one atom of oxygen and two atoms of hydrogen are bonded together to form one molecule of water as shown in the figure provided. Water exhibits polarity due to the nature of its structure, where a negative charge resides near the oxygen and a positive charge near the two hydrogen atoms.

Since opposite electrical charges attract, water molecules tend to attract to each other, making water kind of "sticky" or cohesive. As the figure provided shows, the side with the hydrogen atoms (positive charge) attracts the oxygen side (negative charge) of another water molecule.

Notes

All these water molecules attracting each other make them tend to clump together. In other words, water is sticky and elastic, and tends to hold together in drops on many surfaces rather than spreading out in a thin film. This also accounts for the fact that water has a very high surface tension. Surface tension is responsible for capillary action, which allows water (and its dissolved substances) to move through the roots of plants and through the tiny blood vessels in our bodies.

Cohesion (water's attraction to water) and adhesion (water's attraction to other materials) are properties of water that are a result of water molecules' polarity. Water's high surface tension is the result of molecular polarity as well. In this lesson, we will note the lack of adhesive force between water and a transparency sheet. For further information on water properties refer to the following website: http://www.enotes.com//science-experiments-projects/properties-water/adhesion-cohesion-everyday-life

Another property of water is that it is often called the "universal solvent" because it dissolves more substances than any other liquid. This means that wherever water goes, whether through the ground or through our bodies, it can take along a variety of dissolved substances.

Materials:

Per Student:

- Student Notes

Per Group of 2 Students:

- Paper race tracks (laminated or placed in transparent sheet protectors)
- 1 Pipette
- 1 Stop watch (per pair)
- 1 Plastic coffee stir stick
- 1 Plastic cup of tap water filled ½ way
- Student pages
- 1 Roll of scotch tape
- Paper towels for clean up
- String
- Meter Stick or 18 inch ruler
- Scissors
- 1 Plastic cup of tap water filled ½ way
- 2 Beakers

Activity 1: *Polarity Pull and Droplet Drag Race*

Estimated Time: 60 minutes

Procedure:
Introduce this activity by discussing the meaning of the word: **property**.

What does a property mean? (It is a characteristic of an object/substance that can be sensed or measured.)

Ask the students to name properties that would be specific to themselves - that would identify them and not another person. You might want to list these on the chalk board or an overhead. Some examples are attributes such as braces, glasses, and freckles.

Next, ask the students to list as many properties of water as they can that sets it apart from other substances. List these on the board asking students to elaborate on their ideas.

Explain to the students that, through several activities, they will be exploring various properties of water. This is a good time to address the goal of the activities: to answer the **Need to Know** questions.

Group the students into pairs and distribute the student pages to each pair of students. These pages contain the directions to this activity. Be sure to also distribute the laminated or sheet protected Polarity Pull Track and Droplet Drag Race Track pages to each pair.

Each team sets up a Polarity Pull Race track. They are instructed to place place 5 drops of water all together into one big drop on the starting circle. You may choose to demonstrate the water droplet observation angle which is at eye level from the side. Ask the students to observe the drop, as demonstrated, and then draw what it looks like. Finally they should describe the shape in words. Discuss this observation before proceeding to the actual activity by asking the students why the droplet of water looks as it does. (Cohesion causes the water droplets to be attracted to each other.)

Students should follow worksheet directions to complete the activity. Ask the students to record each trial in the Polarity Pull data table and circle their best score.

When they complete the Polarity Pull, be sure the students proceed to the Droplet Drag Race. You may choose to read through, and demonstrate the directions with the students prior to conducting this part of the activity.

Notes

Once the students have completed these two "races", and then have collected and recorded

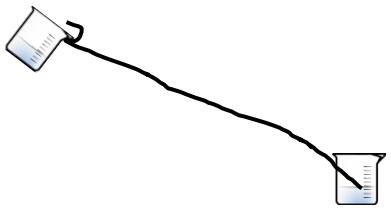
their data and answered questions on the student pages, have a short discussion of their responses. Remember to link the activity to the **Need to Know** questions.

Activity 2: *String Theory*

Estimated Time: 60 minutes

Procedure:

Review what property they discovered from the prior activity (cohesion). Inform the students that they are continuing to explore properties of water.
Ask the students to predict what would happen if they took one cup of water and poured the water into another cup – not directly, but by pouring the water down a string. Have them justify their answers. (It may help to refer to the figure below for an explanation of the set up.)



Explain to the students that their task will be to discover if their predictions are correct. Pair the students and distribute the student pages and materials for this activity. The directions are on the student pages. You may choose to read through the directions with your students prior to starting the activity.

As the students work through the activity, encourage your students to "push the limits" of the string length for the explorative part of the activity, when they get to choose their own string lengths to try. Provide an ample amount of string for each pair. Remind the students to record their observations.

Conclusion:

Once the activity is completed, allow the students to discuss and compare their findings with the entire class. Ask the students to explain why the water could travel along the string and into the cup. Ask them if their findings were as originally predicted. Finally, link the findings back to the **Need to Know** questions.

Solubility

Logistics:
Class grade/age: 4th – 5th Grade
Class size: Approximately 30 students
Instructional Time: 120 minutes
Location: Classroom
Safety: No safety issues in this lesson.

Curriculum Objectives and Need to Know Items Addressed

The students will:

- How do pollutants exist or mix in the water?
- What do these pollutants do to the properties of water?

Standards:

NGSS:
5-PS1-3., 5-ESS2-1., 4-ESS2-1., 5-PS1-3

Math: MP4

ELA:
4.RI.4., 4.RI.7., 5.RI.4.,

Introduction:

Due to the polarity of water molecules, these molecules tend to attract to other substances that exhibit a charge. Common table salt is made up of positively charged sodium and negatively charged chloride atoms. When placed in water, the polar ends of water molecules attract to the charges, separating the sodium from the chlorine. As a result, the table salt is dissolved in the water – or rather, the salt is ***soluble*** in water.

Solubility is defined as the property, or ability, of a substance to dissolve into another substance (forming a **solution**). Therefore, a solution consists of a **solute** (that which has been dissolved) within a **solvent** (the substance within which the dissolving took place). While it does not dissolve every type of substance, water can dissolve the most types of different solutes than any other solvent. Therefore, water is considered to be a **universal solvent**.

Notes

Substances that do not dissolve in water tend to be non-polar or not charged. Many biological materials have charged or polar portions. Oil or fats, substances containing lipids, do not carry charges and do not dissolve in water. These substances form layers in the water depending on their density.

Water molecules adhere to other water molecules (**cohesion**). This property lends a unique movement to watery substances. Substances that are dissolved in water may travel along with it. This is important when considering the movement of soluble pollutants. Different substances have different densities. **Density** is defined as the degree of compactness of a substance. The more material pack in a small space, the denser that material is. Density is equal to the mass of a substance divided by its volume. Water has a density of 1 gram per cubic centimeter (or 1 gram per 1 ml). Vegetable oil has a density of approximately 0.9 g per cubic centimeter. Therefore, oil is less dense than water, and it floats when placed in water. The density of water will change as substances are added to it. Salt will create a more dense watery solution. Substances that may float in fresh water lakes may, therefore, not float in salt water oceans. Pollutants will have varying densities. Some may float in the freshwater lakes, and some may sink. Likewise, organisms that inhabit the freshwater ecosystems will thrive at certain levels in the lake, in part, due to density.

Materials:

Per Student:

- Student Notes

Per Group of 2 Students:

- Water
- Oil
- Dropper for each liquid
- Paper towels
- Masking tape (for labeling cups)
- 6 plastic cups (labeled water/salt, water/sugar, water/margarine, oil/salt, oil/sugar, and oil/margarine)
- 1 plastic cup for teacher demo
- 6 plastic spoons
- Salt
- Granulated sugar
- Margarine
- 4 plastic cups labeled (A, B, C, D)

- Pre-prepared salt water
- Plastic spoon
- 1 Fresh egg

Activity 1: *Now You See It, Now You Don't*

Estimated Time: 60 minutes

Advanced Preparation: While not necessary**,** this activity may be aided by melting the margarine prior to use. Approximately 2 tablespoons is a good amount to use.

Procedure:

Review the properties of water with your students and explain that the following activity builds upon knowledge of these properties. Then, ask your students if oil and water can mix to become one solution. Next, demonstrate the result by attempting to mix water and oil together – showing that the oil will separate from the water to form layers. Assess prior knowledge by asking your students why the two won't mix.

Inform the students that they will be exploring solubility. Ask if any of the students can explain what is meant by the term, solubility. It is not necessary that your students define the term, the purpose of asking the question is to assess for prior knowledge. Your students may understand something about mixtures and solutions. You can follow up the question regarding solubility by asking to define mixtures and solutions, or asking the students what happens to salt when mixed into water, and where does that solid salt go?

To begin the activity, pair the students and distribute the student pages. Review the directions with your students. They will be placing several substances into water to observe what results. Provide the materials for your students' use, and allow the students time to work through the activity. Be sure to encourage the students to record their results on their student pages.

Prepare a table on the board to record student results. Below is an example of an appropriate design for this table:

Notes

Example Table Design:

Water & Salt	Water & Sugar	Water & Margarine	Oil and Salt	Oil and Sugar	Oil and Margarine
				Dissolved	Dissolved

When the students have completed their activity, instruct the students to place whether or the substances dissolved in the water and in the oil. Compare the results with all the students. Ask the students to explain why the results occurred as they did. If necessary, coach them to think about the properties of water.

Essentially, the salt and sugar should dissolve in water and not as well in the oil. Oil is non-polar (not charged) and salt and the atoms within salt and sugar will not be attracted to the fats of oil. Margarine is oil based. As such, it will not dissolve in water but should, to a good extent, in oil.

Conclusion:

Coach your students to apply this knowledge to the **Need to Know** items.

Activity 2: *Density of Water*

Estimated Time: 60 minutes

Procedure:
Advanced Preparation: To prepare the salt water, dissolve ½ cup of salt to every 1 cup of water needed for this activity (a classroom of 20 students will require at least 15 cups of salt water).

Procedure:

Ask the students if they understand why oil floated instead of sinking when placed in the water. Be sure to coach them away from the understanding that one is polar and one is not charged (which explains the separation, but not the floating, of the oil). If students understand and use the term, density, ask them to define it. An immediate understanding of the term is not necessary.

Every Drop Counts

Explain that they will be focusing on the concept that some substances float in waters, while others sink. Pair up the students and distribute the student pages. Read through the student pages

Allow the student pairs time to collect their materials. The procedure calls for the student pairs to acquire one cup of salt water, and compare how a pollutant (an egg) floats in the initial salt water solution, compared to when that concentration is halved, and halved two more times. Students should then relate these results back to the ***Evaporation and Concentration*** activity – and how pollutants may be located in different parts of the lake depending on the varied environmental conditions.

Allow time for the students to view the eggs in these cups, and to make comparisons. Then, reconvene as a large group for discussion.

In the discussion, be sure to ask the students why the egg floated in some types of water but sank in others. At this point, do refer to density. Ask the students if the density of the egg changed from when it is placed in one type of water to another ***(the answer is no, it is the watery solutions that differ in density).***

Have the students link the concept of density to how pollutants make interact with water, and within water ecosystems. Be sure students apply this knowledge to the appropriate **Need to Know** items

Notes

Habitats

Logistics:
Class grade/age: 4th – 5th grade
Class size: Approximately 30 students
Instructional Time: 210 minutes
Location: Classroom and Computer Lab (or other location that allows for use of technology with internet access)
Safety: No safety issues in this lesson.

Curriculum Objectives and Need to Know Items Addressed:

The students will:

- What organisms are affected by the pollution?
- What lives in the lake or relies upon the lake water?
- How can we prevent movement of these pollutants into the habitats?

Standards:

NGSS: 4-ESS2-2, SEP2, SEP6, SEP8
Math: 4.MD.A.1, 4.MD.A.2, MP1, MP2, MP4, MP5, MP6, MP7
ELA: 4.RI.4, 4.RI.7, 5.RI.4, 5.RI.7

Introduction:

A habitat is defined as a natural environment for an organism, where an organism can live, grow and interact with other organisms as well as non-living components in its environment. There are many different habitats. Of particular interest to our problem are the freshwater and coastal habitats.

Freshwater habitats exist in water that contains a low salt content. These consist of lakes, streams, rivers, ponds, or streams. Animals and plants that exist in these habitats must be adapted to thrive in the low salt waters. In rivers or streams, animal and plant life must be able to live in a continually changing environment, and deal with the constant movement of water at varying rates. Levels of light diminish with increased water depth, affecting the ability of photosynthetic life to exist in certain regions of the habitat.

Land habitats interact with the freshwater habitats they surround. Animal life and plant life abounds at various shorelines, feasting or being feasted upon by freshwater organisms. Nonliving factors such as soil, sand or rock can filter pollutants from running into the water. These factors can also change the environment of the waters through erosion.

Notes

Every Drop Counts

Although nautical charts are typically utilized for boating navigation, they are a reliable resource for determining features of a body of water. A scientist may be interested in locating landforms within a given area of water, measuring the depth of the aquatic floor, or studying patterns or trends in the **topographic** features of the area. Similar to a **bathymetric map**, a nautical chart provides information regarding the land formations of a body of water. In this activity, students will interpret a nautical chart and use the information to gain a better understanding of the lake's aquatic habitats.

A nautical chart features several pieces of information:

- **Numerical Values** – these numbers, represented as **fathoms**, represent the depth of the lake. 1 fathom is the equivalence of 6 feet, or approximately 1.8 meters. Depths are generally measured at the lowest tide of the cycle.

- **Contour Lines** – these lines "outline" depth ranges, and are similar to the lines that would be located on a topographical map, or bathymetric map.

- **Colored Areas –** The tan sections of the map represent land, white the light blue and white portions of the water represent differences in depth.

- **Tear-Drop Symbol** – represents the location of a lighthouse. Typically, these symbols include two measurements: the height of the lighthouse and the distance (in miles) from which it can be seen. For example, a lighthouse with indications "20ft 3M" would represent a lighthouse that is 20 feet tall and can be seen from 3 miles away.

Topographical information also allows scientists to collect information regarding the natural habitats within a region. Freshwater lakes are typically comprised of several "Lake Zones", including the **littoral zone, benthic zone, limnetic zone,** and **euphotic zone**. Each of these zones includes specific environments to provide for biological communities. Of course, the water quality naturally impacts these lake zones, and in turn, the health and sustainability of aquatic life within such locations.

Notes

Materials:

Per Student:

- Copy of Student Pages

Per Group of 2 Students:

- 1 copy of "Lake Michigan Beach Nautical Chart"
- Computer with Internet Access
- Colored Pencils
- Thin Black Marker
- Habitat Sheets
- Shallow Tub
- Water
- Index Cards
- 2-4 Cups of Coarse Sand
- 1 Cup of Gravel
- 1 Measuring Cup
- Lake Habitats from *Where's It At?*
- Toilet Paper
- Cotton Balls
- Pipe Cleaners
- Craft Sticks
- String
- Liquid Detergent
- Dixie Cups
- 3 tbps of Vegetable Oil in a Plastic Cup

Activity 1: *Where's It At?*

Estimated Time: 60 minutes

Objectives:

- Identify information presented in a nautical chart.
- Use nautical charts to generate general statements regarding topographic features.
- Identify distinct zones of biological communities and predict their location in Lake Michigan based on information from a nautical chart.

Every Drop Counts

Procedure:

Explain to students that they will be investigating features of Lake Michigan by looking a **nautical chart**. For this activity, students will work in groups of two.

Provide each student with the first student page and each group with a copy of the "Lake Michigan Beach Nautical Chart." Explain to the students that they will use this map to understand the **topographical** features of the Lake Michigan beach. Provide the students with approximately ten to fifteen minutes to make general observations about the nautical chart and its characteristics.

During this time, you may pose the following questions to guide student thinking:

- **What do you think the numbers represent?**
- **What do you think the light blue section represents? What about the white section? The tan section?**
- **What do you think the curved lines represent?**
- **What do you think this map could be used for?**

Allow time for students to share their observations. Next, explain to the students that the purpose of the nautical chart is to identify the topographic features of the shoreline and aquatic floor.

First, students should understand that water depth is represented in **fathoms**. Provide students with the second student page. Then, provide students with adequate time to complete the procedure outlined on their student page. This will include completing the table (converting fathoms to feet), using colored pencils to shade in portions of the lake with similar ranges of depth, and identifying several other features of the nautical map.

Next, students will navigate to: http://www.lakeaccess.org/ecology/lakeecologyprim9.html. Provide each student with the third student page. Ask them to record important information regarding the **littoral zone, benthic zone, euphotic zone, and limnetic zone**. Next, students will attempt to estimate the locations of these zones on their nautical chart. Explain to the students that it is difficult to locate the exact location of these zones because their position depends upon the temperature, depth, and clarity of the water.

Notes

Conclusion:

- **What information does a nautical chart represent?**
- **What could a nautical chart be used for?**
- **Why might a scientist interested in water quality need to be able to read a nautical chart?**

Activity 2: *Are You Shore, Habitat?*

Estimated Time: 90 minutes

Procedure:

Ask the students to describe their environment. If need be, center the discussion around their homes. Inquire about what needs are provided in their environment for their survival, what factors with which they interact (living and nonliving). Coach the students to the concept that they live in a specific habitat.

Inform the students they will now make a model of a lake, including a shoreline. Show the students the materials and explain that they are to use the directions on their student pages to complete the model. Once the model is complete, instruct the students to use the two index cards to create waves within their lake. Be sure that the students record their observations of changes along the shoreline and in the lake due to the wave action.

Allow the wave observations to take place for approximately 5-10 minutes and then reconvene as a large group to discuss their observations.

Conclusion:

Ask the students to focus on the changes they observed upon the shore and in the lake. Have them relate these changes to how they may affect the aquatic life within the lake. Lastly, allow the students time to relate this information to their **Need to Know Items**.

Activity 3: *Save the Shore*

Estimated Time: 60 minutes

Procedure:

Explain to the students that they will now return to their lake habitats. Split the students into pairs. Allow the students pairs time to fix their habitat, specifically the shoreline. Provide the student pages to the students and inform them that they will be polluting the waters and creating waves, while trying to protect the shoreline from the pollution.

Display the materials that are available for the students to use in saving the shoreline. Allow the pairs approximately 10 minutes to design and plan how the will save the shoreline from the pollution. They will also need to predict how the pollution (oil) will react with the water in their lake.

Instruct the students to collect their materials and pollute the model lakes, as well as begin to try and save the shoreline. Next, instruct the students to create small waves using their index cards to see what happens to the shoreline. Be sure the students record their results on their student pages.

Conclusion:

Once all groups have completed the activity, have the students report their course of action, and their observations to the class. Be sure to discuss how each material used may have worked to save their shoreline. Relate the activity to how pollution that may enter the lake can have effects upon other parts of the habitat. Link this information to the appropriate **Need to Know** items.

Notes

Aquatic Life

Logistics:
Class grade/age: 4th – 5th Grade
Class size: Approximately 30 students
Instructional Time: 60 minutes
Location: Classroom
Safety: No safety issues in this lesson.

Curriculum Objectives and Need to Know Items Addressed

The students will:

- How can we monitor the aquatic life in Lake Michigan?
- Is all aquatic life essential, or beneficial?
- How does water quality affect aquatic life?

Standards:

NGSS: 3-LS3-2, 3-LS4-3, 3-LS4-4, 5-LS1-1, 5-ESS2-1, SEP 1, SEP2, SEP3, SEP4, SEP5, SEP6, SEP7, SEP8
Math: 4.NBT.B.4, 4.NBT.B.5, 5.NBT.B.6, 5.NBT.B.7, MP1, MP2, MP4, MP7
ELA: 4.RL.1, 4.RI.1, 4.RI.2, 4.RI.7, 4.SL.2, 5.RL.1, 5.SL.2

Introduction:

Regardless of the source, pollution decreases water quality and poses a variety of negative impacts on aquatic life. For example, fertilizers and pesticides from agricultural resources, along with runoff from urban locations and sewage seepage ultimately cause increased levels of phosphates, nitrates and heavy metals, which are in turn absorbed by aquatic life. Because many of these pollutants cannot be dissolved in water, they remain available to be absorbed by fish and other aquatic organisms. Unnatural and harmful, these pollutants make it difficult to sustain life.

There are a variety of ways in which scientists monitor trends in aquatic life. Of course, having an understanding of population is required to study how organisms, such as fish, survive within their environment. Scientists known as fishery biologists work extremely hard to monitor the fish populace, using a method called **tagging.** Tagging fish allows biologists to gather a wealth of information. For instance, fishery biologists are able to understand fish movement, migration patterns, population and natural mortality rates. One of the most common ways to tag a fish is through body cavity tagging.

Notes

Every Drop Counts

Another aquatic organism that has recently become a threat to water quality includes **harmful algal blooms**. These toxic organisms are characterized by the rapid and explosive growth of freshwater algae. Commonly recognized by its green, slimy appearance and tendency to emit a foul smell and tasted, algal blooms pose a serious threat to aquatic and human health. Spreading across the surface of the water, the thick algae prohibit sunlight to reach the aquatic floor, ultimately cutting off the food source for many plants and animals.

Most recently, the rapid growth of algal blooms has largely impacted a neighboring Great Lake, Lake Michigan. Previously, the cause of algal blooms was tied to sewage overflow. However, recent findings have determined that run off containing high levels of nitrates and phosphates from agricultural fertilizer, animal waste and recreational activities have impacted algal bloom growth.

Materials:

Per Student:

- Copy of Student Pages
- 1 Copy of *Fish Cannot Smell in Polluted Waters* Article

Per Group of 2 Students:

- 1 Paper Bag
- 1 Plastic Cup
- Goldfish Crackers (approximately 40-50 per group)
- Pretzel Goldfish Crackers (approximately 20-30 per group)
- Paper Towels
- Calculators

Per Group of 3 or 4 Students:

- 100 Skittles of one color
- 100 Skittles of a second color
- 1 Tray
- 1 Plastic Cup

For the Teacher:

- Computer with Internet Access and sound capabilities
- Projector

Notes

Activity 1: ***Tag, You're It!***

Estimated Time: 60-75 minutes

Procedure:

Open a discussion into how a scientist may determine the population of fish, or other aquatic species, may exist in a body of water.

You may choose the pose the following questions to engage students:

- **If you were asked to determine the number of fish in a lake, how could you do this?**
- **How could scientists determine the population of fish in a large body of water, such as Lake Michigan?**
- **Why might scientists that are interested in water quality want to know the population of fish in a given area?**

Explain to the students that they will be investigation how to tag fish. This is a strategy used by scientists to determine the population of fish within a given area to study population, movement and migration patterns, etc. In this activity, students will simulate the process of tagging.

Navigate to: https://www.youtube.com/watch?v=yTONL-DPXBg. Allow time to view the video and encourage students to ask questions about the process of tagging fish. Answer all questions.

Next, pass out the student pages to each student. Arrange students into groups of 2, and provide each group with the necessary materials. Explain to the student that they will follow the recorded procedures to tag their fish and ultimately determine the total population of fish that are in their paper bag. You may wish to model the first several rounds with the students.

Once students have collected their information and are ready to estimate the total number of fish in their bag, you may need to assist with the calculations (based on the mathematics level of your students):

- **First**, students will determine the **mean** (average) number of tagged fish recaptured in all trials. To calculate this, students will find the sum of the tagged fish recaptured in all ten trials, and then divide the sum by 10.
- **Second**, students will determine the **mean** (average) amount of fish captured in all trials. To calculate this, students will find the sum of the fish captured in all ten

trials, and then divide the sum by 10.

- **Finally**, students will need assistance in solving the proportion. Although this task is commonly addressed in middle school, students should be familiar with making equivalent fractions.

An example of solving a proportion is below:

$$\frac{T}{N} = \frac{t}{n} \quad or \quad \frac{20}{x} = \frac{12}{35}$$

n (**Mean** Number of Fish Captured) = *35*
t (**Mean** Number of Tagged Fish Recaptured) = *12*
T (Number of Tagged Fish) = *20*
N (Total Fish Population) = *x*

To solve, cross multiply.
So, (20*35) = (12**x*).
Therefore, 700=12*x*
To solve for *x*, divide both sides of the equation by 12.
x is equal to 58.3, or approximately 58 fish.

Conclusion:

Have students share their results. How did their estimates turn out? Did tagging increase or decrease their accuracy? What ideas do they have to share?

Then, ask students to brainstorm reasons why surveying the population of fish would be valuable for scientists that are studying water quality. After all student predictions have been shared, provide each student with a copy of the article titled, "*Fish Cannot Smell in Polluted Waters.*" Allow students adequate time to read through the information.

Article Link: **http://www.scientificamerican.com/article/fish-cannot-smell-in-polluted-waters/**

Pose the following questions to evaluate student understanding:

- **Why is it important for fish to be able to smell?**
- **What is causing fish to lose their sense of smell?**
- **Why might scientists tag fish in their study of pollution and water quality?**

Notes

Activity 2: ***Algal Blooms: A Big Problem***

Estimated Time: 60-75 minutes

Procedure:

Explain to students that they will be investigating an organism that has recently threatened Lake Michigan, called **algal blooms**. Students may recognize this organism as a slimy, green, plant-like substance that is often found in lakes. Explain to the students that recently, another one of the Great Lakes, Lake Erie, has suffered from an abundance of algal blooms.

For the first part of this activity, students will work individually. Provide each student with the first student page of this lesson. Explain to the students that they will watch a video about algal blooms, and are responsible for listening and recording information as directed on their student pages. **Note: You may choose to show portions of this video.**

Navigate to the following link and cue up the attached video for students to view: https://www.youtube.com/watch?v=gMwQaHtK904. Following the video, spend several minutes discussing the questions outlined on the student pages.

Next, arrange students in groups of three or four to complete the algal bloom growth simulation. Provide all student groups with the necessary information. Students will follow the procedure outlined in their student pages. During the activity, verify that all groups are correctly recording their data. After each group has completed the simulation, ask them to organize their data by constructing a line graph on the provided graph paper.

Conclusion:

When all student groups have completed their work, reconvene as a whole class and discuss the following questions:

- **Describe what happened to your population of algal blooms during the simulation.**
- **How would you describe the water quality of your "lake" as you completed the simulation?**
- **If you were to present the negative impacts that algal blooms have on water quality and aquatic life, what would you say?**
- **How do you think scientists could decrease the growth of algal blooms?**

Every Drop Counts

Solution

Logistics:
Class grade/age: 4th – 5th Grade
Class size: Approximately 30 students
Instructional Time: 60 minutes
Location: Classroom
Safety: No safety issues in this lesson.

Curriculum Objectives and Need to Know Items Addressed

The students will:

- What are current solutions to the problem?
- How can we help to decrease the pollution that affects Lake Michigan?

Standards:

NGSS: 3-LS4-4, 5-ESS1-2, SEP1, SEP3, SEP7, SEP8
ELA: 4.RL.1, 4.RI.3, 4.RI.7, 5.RI.7, 4.SL.1, 5.SL.1, 4.W.2.B, 5.W.2, 4.RF.4, 5.RF.4

Introduction:

Water quality, aquatic life, and the overall health of Lake Michigan are heavily influenced by pollution. The sources of the pollutants and impact the lake are both man-made and natural. Although we will never be able to completely eliminate the contamination of pollutants into the lake, there are several proactive steps that can be taken in an effort to be more environmentally friendly.

In the **home**, citizens can refrain from pouring items into storm drains, minimizing the use of toxic chemicals and cleaning solutions, and properly maintain their septic systems on a regular basis. In the area of **agriculture**, citizens can properly dispose of chemically-based pesticides and fertilizers properly and contain animals within a fence and away from streams. **Transportation**, known for its use of motor oil and gasoline, can maintain vehicle emissions standards and perform regular maintenance on vehicles. **Industry**, a broad category, may include the construction of buildings, maintenance of landscaping, and/or other related fields. Finally, as citizens enjoy a variety of **recreational** activities, they can monitor their disposal of trash, care of animal waste, proper use of boating protocols in relation to chemical leakage, and other pollutant-preventative actions.

Notes

Materials:

Per Student:

- Copy of Student Pages

Per Group of 3 or 4 Students:

- 1 Piece of Chart Paper
- Chart Markers (or other writing materials)

Activity 1: *What Are Your Suggestions?*

Estimated Time: 60-75 minutes

Objectives:

- Identify common sources of pollution.
- Brainstorm methods to decrease the amount of pollution.
- Evaluate which methods to decreasing the amount of pollution would be most impactful in increasing environmental health and water quality.

Procedure:

Explain to the students that prior to creating their "best fit solution" for the problem statement, they will organize their ideas by considering common sources of pollution that may affect the lake and water quality, and then suggesting ways to decrease the occurrence of these issues.

Arrange students in small groups of three to four. Assign each group one of the following categories. Some groups may have the same category:

- **Home** – spraying toxic chemicals (such as pesticides and fertilizers) onto plants, dish detergent, cleaning chemicals, no recycling, bacteria from sewage
- **Agriculture** – pesticides and fertilizers are distributed amongst the crops and leak into the groundwater, animal waste
- **Transportation** – car oil, cleaning chemicals, leaking fluids,
- **Industry** – loose soil from construction sites, chemical dumping, air pollution
- **Recreation** – boating oil, disposal of trash

Every Drop Counts

Students will then be responsible for identifying pollutants that are produced within their category, and suggesting solutions to remediate the problem. Students will need access to a computer with the internet to research their category.

As students collect information and determine solutions, they will create an illustration that is associated with the source of pollution. Provide students with plenty of time to complete their research and illustration.
Once all groups have completed their work, post all student illustrations on the wall. Students will then do a gallery walk and **draw a star** next to the solutions that they feel will be most impactful in increasing environmental health and water quality.

Conclusion:

Once students have completed their gallery walk, combine all posters in the front of the room and discuss the solutions that the students have identified. Pose the following debrief questions:

- **What did you consider in choosing which solutions would impact environmental health and water quality?**
- **What did you learn about how pollution behaves in water during this PBL unit?**
- **What solutions could you immediately implement?**
- **What solutions would be more difficult to implement?**

Notes

Generate Solutions

Class age/size: 4th-5th Grade/whole class

Materials:

- K/NK Charts
- Final Problem Statement
- Generating Solutions sheets or post-it notes
- Information from activities and research

Time: 20 minutes

Objectives/Standards:

- *Students brainstorm solutions to the problem.*
  - **NGSS: SEP1, SEP2, SEP3, SEP4, SEP5, SEP6, SEP7**
  - **Math: MP1, MP3, MP4, MP5, MP7**
  - **ELA: 4.RL.1, 4.RI.2, 4.RI.4, 5.RI.4, 4.W.2.B, 5.W.2**

Introduction:

Brainstorming solutions is the next step towards developing the ultimate solutions to the problem. At this stage, students should not be trying to choose solutions, the goals is to generate a large list of solutions for students to consider in the next lesson.

Activity/Activities:

The students will brainstorm ideas for the ultimate solution to the problem by writing them on either the Generating Solutions handouts or post-it notes. They will then hang their solutions on the wall. As a class, or as small groups, the students will categorize the solutions according to common themes.

Coaching Questions:

- Have you investigated all of the areas of the Problem Statement?
- Do you have enough information?
- Have you investigated all of the Need to Know items?
- What options are you considering?

Every Drop Counts

Assessment:

- Do the proposed solutions address the overall task and factors to consider in the Problem Statement?
- Do the proposed solutions show evidence of sufficient content knowledge to support the learners' case?
- Do they actively consider a broad range of solution elements?
- Do they offer valid support for their solution elements?
- Do all learners participate?

Notes

Best Fit

Class age/size: 4th-5th Grade/whole class

Materials:

- K/NK Charts
- Final Problem Statement
- Generating Solutions sheets or post-it notes
- Information from activities and research
- Decision matrix or similar (if desired)

Time: 20 minutes

Location: Classroom

Objectives/Standards:

- *Students will determine the best solution to the problem.*
  - **NGSS: SEP1, SEP2, SEP3, SEP4, SEP5, SEP6, SEP7**
  - **Math: MP1, MP3, MP4, MP5, MP7**
  - **ELA: 4.RL.1, 4.RI.2, 4.RI.4, 5.RI.4, 4.W.2.B, 5.W.2**

Introduction:

The students will develop criteria for evaluating which solutions best fit the problem, and determine which solution(s) are a best fit. The key understanding is that there is seldom a perfect solution for a messy problem, just solutions that are a better or worse fit. The students may come up with one solution for the class, a solution with several components, or several solutions.

Activity/Activities:

By referring to the Meet the Problem letter and the Problem Statement, the students will develop a list of criteria to judge the proposed solutions. Teachers may have the students use a decision matrix, SWOT analysis, or other methods for evaluating the solutions.

Coaching Questions:

- What is at stake in the problem? Have you considered all of the stakeholders/factors?
- What are the pros and cons of each possible solution?

- What solutions or combination of solutions seems most reasonable? Why or why not?
- What is the best-fit solution? How do you know?
- What are the potential consequences of this solution?
- What is the hardest question that you might be asked when you present this solution?
- Have you reached consensus?
- Is the solution realistic?

Assessment:

- Does the solution incorporate the information and content that learners have gained throughout this problem?
- Does the best-fit solution address all the factors in the problem statement?
- Do the learners work cooperatively to reach consensus on their shared vision?
- Do they set criteria for establishing priorities?
- Do they analyze the factors by means such as: feasibility, ethics/morals, cost benefit and risk analysis, consequences?
- Do they consider the consequences of their decisions?

Notes

Present the Solution

Class age/size: 4-6th grade/whole class

Materials:

- K/NK Charts
- Final Problem Statement
- Generating Solutions sheets or post-it notes
- Information from activities and research
- Decision matrix or similar (if desired)

Time: 2 hours (1 hour for preparation, 1 hour for presentations)

Location: Classroom

Objectives/Standards:

- *Students will design a presentation of their solution and give the presentation to poser of the problem.*
    - **NGSS: SEP1, SEP2, SEP4, SEP5, SEP6, SEP7, SEP8**
    - **Math: MP2, MP3, MP4, MP5, MP6, MP7**
    - **ELA: 4.RL.1, 4.RI.2, 4.RI.4, 5.RI.4, 4.W.2.B, 5.W.2**

Introduction/Activity/Activities:

The students will develop presentations of the solution(s) to the problem. There may be multiple solutions within the class, or one solution with multiple parts presented by different groups. This is an especially powerful experience if the students are able to present their solutions to the problem poser.

Every Drop Counts

Coaching Questions:

- Do you know what your role in the presentation is?
- Are your presentation materials ready?
- Have you considered and prepared for questions from the audience?

Assessment:

- Do the presentations communicate learners' solutions effectively, accurately, and clearly?
- Do learners ask appropriate questions of other presenters?
- Do learners engage with all of the presentations?

Notes

Final Debrief

Class age/size: 4-6th grade/whole class

Materials:

- Chart Paper
- Markers

Time: 30 minutes

Location: Classroom

Objectives/Standards:

- *Students will reflect on what the learned from the presentations and from the problem as a whole.*
    - **NGSS: SEP6, SEP7, SEP8**
    - **Math: MP3, MP7**
    - **ELA: 4.W.3, 5.W.3, 4.SL.1, 5.SL.1**

Introduction and Activity/Activities:

The learners will reflect upon their learning through journaling small group discussion, whole class discussion, or any combination of these activities. Students sometimes don't realize how much they have learned until they are asked to reflect and make connections.

Coaching Questions:

- Guide learners to critically analyze their groups' presentation and those of other groups for effectiveness and completeness of the solution.
    - What elements worked and what didn't? How did you know?
    - What did you see in other presentation that was different from yours?
    - What content did other teams find that your team did not?
    - What would you exclude or add to your presentation if you were to do it again?
    - What would be the best solution to the problem?

- Guide learners to critically analyze their processing and group skills.
    - What skills worked for you as you gathered information, and what did not?

  - How effective did you think you were in solving the problem?
  - How effective did you think your group was in solving the problem?
  - How would you change your research tactics for another problem?
  - What helped you most to understand the problem?
- Guide learners to critically analyze their learning throughout the problem.
  - What new content knowledge did you gain through this problem?
  - How did that content knowledge help you to understand the problem?
  - What questions do you still have about the content of this problem?
  - Did your beliefs change after listening to others?
  - How did your thinking change during this problem?

Assessment:

- Can learners articulate the problem and solution in an individual journal entry?
- Do learners engage in whole group sharing about the presentation, the process, and the learning?

Every Drop Counts 

Date:

Dear students,

I am ***(place personal information here).***

I have heard that you are studying water and habitats in your classes, and I would like your help with a related issue that affects the Chicago region. Beach closures due to low water quality have been a long-standing problem in Illinois. In 2012, a reported 33 out of 40 beaches that were monitored had instances of beach actions (either contamination advisories or closures). During the swim season, these closures and advisories affect the general economy. Summer beach activity generates approximately $35 a day per individual, which has been estimated to result in an economic loss of approximately $37,000 a day.

While the economic side is important to the city, the environmental state of the lake is the larger concern. Water conditions are currently monitored by assessing various water quality measurements, such as the levels of E.Coli bacteria, clarity, pH levels, etc. Several water quality pollutants can cause health issues. Also, bacterial growth can be impacted by other pollutants and can affect not only the human population, but also the organisms that live in and depend upon the water in this Great Lake.

There may be multiple reasons for the increase of harmful pollutants in this water habitat, but we have yet to identify the exact source or sources of pollution. We are curious to understand the conditions that lead to the pollution of the lake.

As we currently are struggling to identify the sources of pollution to the water habitat, we are at a loss as to how to prevent it from reoccurring. We need help in determining from where the pollution might arise. Finding appropriate solutions to prevent, or decrease, the effects of this pollution on our lake and beach habitats is important, as well. Any help that you and your classmates can offer with this obstacle is greatly appreciated. I will be available to see and hear your assessments and solutions on ***(enter date of completion and presentation here)***.

Thanks for your help with this problem.

Sincerely,

(Place personal information here.)

Every Drop Counts 

Name_____ Date_____

Know	*Need to Know*	*Need to Do*

Every Drop Counts 

Name_____ Team _____ Date _____

Problem Statement

	Here's what I think…	Here's what we (pair) think…	Here's what our group thinks…
Overall Task			
Factors to Consider			

How can we . . .

in such a way that we consider…

Water Travels: *Build A Shed*

Problem:

You are instructed to build a model of a watershed. A watershed is an area of land that drains water into a large body of water; such as, a lake or an ocean. Water draining from the land can span several states before reaching its destination. Before creating your model, think about how water flows. You will use sand, as well as gravel to create your landscape. Below are the materials you may use:

Materials:

Per Group of 2 Students:

- Shallow Tub
- Approximately 4 Cups of Water, and 1 plastic cup for "rain" water
- 1 Plastic cup, with small holes poked in the bottom
- 4 Cups of Playground Sand (or other course sand)
- 2 Cups of Gravel
- 2 Plastic Spoons
- 2 Index cards

Procedure:

When creating the landscape, adhere to the following rules below:

- The landscape must span at least 2 states and 5 cities.
- There must be various gradations in your landscape (make mountains and valleys.)
- You must create several small rivers, streams, lakes of various sizes.
- Recall: the land and various waterways drain into larger areas.
- In the space provided on the next page, draw out a detailed map of your watershed, including boundaries of your cities and states.

Build A Shed

Example watershed:

http://hawp.org/what-is-a-watershed/

Create a detailed map of your landscape below:

- When building your watershed, be sure to use the spoons to pack down the land so that it maintains it shape. Once the model is built, fill your streams, rivers, lakes and ocean with water. Do not submerge your landscape. Small streams may remain waterless.

- Obtain a cup of "rain" water and one cup with holes on the bottom. Use these materials to create precipitation on your landscape by holding the cup with holes over the watershed and pouring the rain water into the cup.

QUESTIONS

After creating precipitation, draw and describe how the water travels in your watershed:

Does the water travel as you thought it would? Why/ why not?

Water Travels: *Where's It Flow?*

Problem: You will be continuing your exploration into how watersheds work, while discovering how pollutants may move through the watershed you built.

Materials:
Per Group of 2 Students:

- Model watersheds from prior activity
- Water for shed and "rainwater" in cup
- Plastic cup with holes in bottom
- Disposable pipette – 1
- Food dye – 1 bottle

Procedure:

You will be using the food dye to model the pollution. You will be charting how the color moves through the watershed during precipitation.

- Choose a location on your watershed (it does not have to be directly on the land or directly in the water). Be sure your teacher approves where you are placing the pollution.
- Plan to place approximately 5-10 drops of dye if placed directly into water, and 15-20 drops of dye if placed onto – or into – land. You can adjust the quantity of drops as needed.
- On the map created for the prior activity, mark the area you will place your pollution. You choose the amount of pollution – but do not use more than 20 drops of food coloring.

Predict where your pollutant will travel along the watershed and record your answer below:

Where's It Flow?

Once you receive instructor approval for your placement of the pollution and have predicted its course, place the pollution in the appropriate spot of the watershed.

- Use the water and the cup with holes at the bottom to create precipitation on your watershed and observe what occurs with regards to the pollutant.

Draw and describe how your pollutant traveled below:

Did the pollutant travel as predicted? _____

Below, explain why you believe the pollutant travelled as it did:

Water Travels: *Evaporation and Concentration*

Problem: Water cycles through the planet in a very specific manner (evaporation, condensation and precipitation). How can we better understand how pollution interacts with water in a lake as it cycles through the environment?

Materials:

Per Group of 2 Students:

- **3 Plastic Cups labeled "A", "B" and "C"**
- **40 Red beads (representing pollution)**
- **150 Blue beads (representing water)**

Procedure:

Each cup represents a lake, with the blue beads representing the water. The red beads represent pollution.

Round 1:

In cup "A", place 5 red beads and 50 blue beads.
In cup "B", place 10 red beads and 50 blue beads.
In cup "C", place 25 red beads and 50 blue beads.

Compare the pollution in the three cups. Enter the quantities, fractions and ratios of red to blue beads in the table below:

Cup	# Red Beads	# Blue Beads	Fraction Red Beads / Blue Beads	Ratio Red Beads : Blue Beads
A				
B				
C				

Looking at the cups and at the number, which cup do you think is more polluted?

Explain your answer below:

Round 2:

From cup "A", remove 15 Blue beads.
From cup "B", remove 10 Blue beads.
From cup "C", do not remove any beads.

Compare the pollution in the three cups. Enter the quantities, fractions and ratios of red to blue beads in the table below:

Cup	# Red Beads	# Blue Beads	Fraction Red Beads / Blue Beads	Ratio Red Beads : Blue Beads
A				
B				
C				

Looking at the cups and at the number, which cup do you think is more polluted?

Explain your answer below:

Round 3:

From cup "A", remove 15 Blue beads.
From cup "B", remove 10 Blue beads.
From cup "C", do not remove any beads.

Compare the pollution in the three cups. Enter the quantities, fractions and ratios of red to blue beads in the table below:

Cup	# Red Beads	# Blue Beads	Fraction Red Beads / Blue Beads	Ratio Red Beads : Blue Beads
A				
B				
C				

Looking at the cups and at the number, which cup do you think is more polluted?

Explain your answer below:

Round 4:

From cup "A", remove 10 Blue beads.
From cup "B", remove 10 Blue beads.
From cup "C", do not remove any beads.

Compare the pollution in the three cups. Enter the quantities, fractions and ratios of red to blue beads in the table below:

Cup	# Red Beads	# Blue Beads	Fraction Red Beads / Blue Beads	Ratio Red Beads : Blue Beads
A				
B				
C				

Looking at the cups and at the number, which cup do you think is more polluted?

Explain your answer below:

If the act of removing the Blue beads represents water evaporation, explain how and extended period of dry conditions and hot temperatures affects the lake, with regards to pollution.

Water Properties: *Drag Race and Polarity Pull*

Drag Race - Page 1 of 4

Problem: Working to understand how water behaves, such that we can gain an understanding of the pollution problem in Lake Michigan.

Materials:
Per Group of 2 Students:

- Droplet Drag Race Track (laminated or in plastic transparent sheet protector)
- Tape
- 1 pipette (dropper)
- 1 plastic cup ½ filled with water
- 1 plastic coffee stirrer

Procedure:

1. Work with your partner taking turns being the drag racer.
2. Place the **Droplet Drag Race Track** on a flat surface and tape the corners of the transparency sheet to the race track.
3. Place 5 drops of water from the pipette all together in the start circle.
4. Look at the drop of water at eye level from the side and draw what you see in the box.

Describe what it looks like:

Drag Race

5. Using a plastic coffee stirrer, stretch the spherical water droplet from the start circle to the farthest distance on the track without breaking the drop in to droplets. You must pull the droplet only one direction (not back and forth) along the track and part of the drop must remain in the starting circle.
6. Record three distance trials in the Droplet Drag Race data table and find the average distance traveled (add all of the distances and divide the sum by 3)
7. Remember: DISTANCES RECORDED MUST HAVE A CONTINUOUS BOND!
8. Do the same as above for 3 trials with 10 drops of water; and then with 15 drops of water. Record the distances in the Droplet Drag Race data table, circling your greatest distance for each set of data.

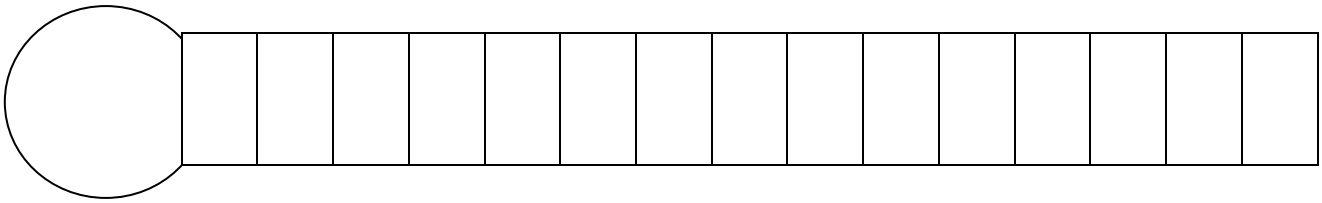
TRIAL	**DISTANCE in cm**		
	5 DROPS	**10 DROPS**	**15 DROPS**
1			
2			
3			
AVERAGE			

1. Was there a difference in the AVERAGE distance you could drag 5 drops, 10 drops and 15 drops. Why do you think this is so?

2. Work with your partner to discuss what you think the property or quality of water is that caused it to behave the way it did in this activity.

3. Write what you and your partner talked about.

DRAG RACE COURSE



Polarity Pull

Problem: Working to understand how water behaves, such that we can gain an understanding of the pollution problem in Lake Michigan.

Materials:
Per Group of 2 Students:

- Polarity Pull Track (laminated or in plastic transparent sheet protector)
- Tape
- 1 pipette (dropper)
- 1 plastic cup ½ filled with water
- 1 plastic coffee stirrer
- Stopwatch

Procedure:

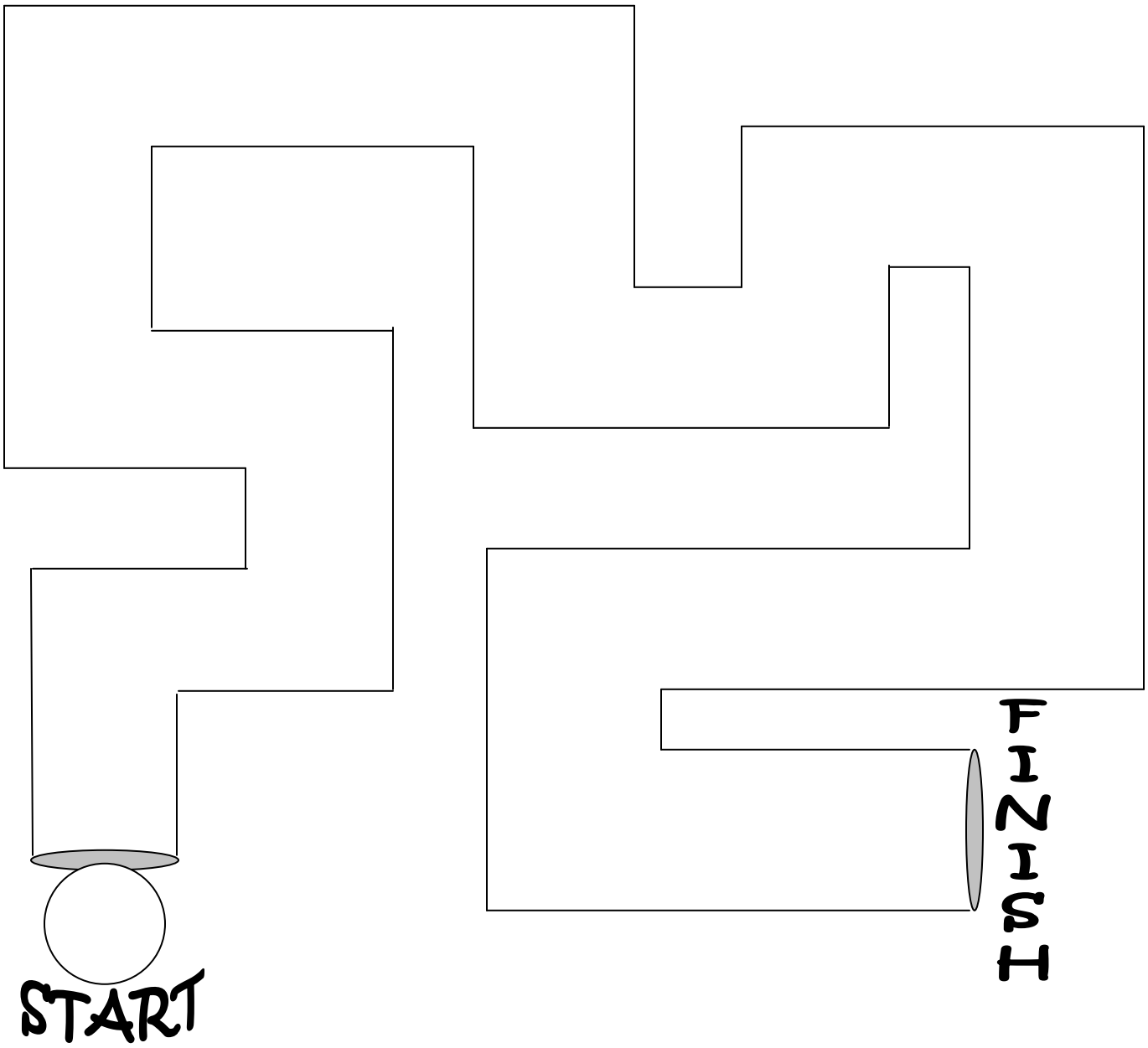
1. Work with your partner alternating between the task of timer and racer.
2. Place the **Polarity Pull Race Track** on a flat surface and tape the corners of the transparency sheet to the race track.
3. Place 5 drops of water from the pipette (all in one big drop) on the start circle.
4. Using a plastic coffee stirrer, move the water drop around the maze to the finish line while your partner times using the stopwatch.
5. Record time trials in the **Polarity Pull** data table and **circle your best score**.
6. If you lose any droplets from the large drop you must move the large drop back through the maze to collect the random tiny drops.
7. Clean up by using a piece of paper towel to wipe up all of the water drops on the Track sheet and on your work surface.

Polarity Pull

POLARITY PULL RACE TRACK

Reminder:

- Place on flat surface;
- Tape transparency sheet over track.
- Place 5 drops of water on starting circle.



Polarity Pull

POLARITY PULL Data Table:

Record time trials in seconds and circle best score-

	TIME
Trial 1	
Trial 2	
Trial 3	

1. Which was your best trial? How do you explain that?

2. Describe what you observed happening to the water drop as you "pulled" it around the track.

3. Discuss as a group other situations you have observed when water behaves this way. Record your ideas.

Water Properties: *String Theory*

Problem: Working to understand how water behaves, such that we can gain an understanding of the pollution problem in Lake Michigan.

Materials:
Per Group of 2 Students:

- Paper towel for clean-up
- String
- Meter stick or 18 in ruler
- Scissors
- 2 beakers
- 1 plastic cup ½ filled with water

Procedure:

1. Measure and cut a length of string 40 cm. long. Soak the string in a beaker containing water for 30 seconds.
2. Put one end of the string into the beaker so that the end of the string is submerged in the water. Have 1 team member hold the string so it stays submerged in water.
3. Put the other end of string into another beaker. Have 1 team member hold the string so that it stays in the beaker.
4. Lift the first beaker up so that it's above the second beaker. Position the beaker so that the string is taut.
5. **SLOWLY** pour the water down the string into the other beaker.
6. Repeat the procedure with 2 different lengths of your choice. Make sure to record the lengths in your chart.
7. Throw strings away.

String Theory

Length of String	Observation
40 cm	
Your choice:	
Your choice:	

Solubility: *Now You See It, Now You Don't*

Problem: What happens to the level of liquids when you dissolve materials into them?

Materials:
Per Group of 2 Students:

- Water
- Oil
- Paper towels
- 6 plastic cups (labeled water/salt, water/sugar, water/margarine, oil/salt, oil/sugar, and oil/margarine)
- 6 plastic spoons
- Salt
- Granulated sugar
- Margarine

Procedure:

1. Fill 3 plastic cups 1/3 full with water. Fill 3 plastic cups 1/3 full with oil. Mark the level of the liquid.
2. Put about a ½ teaspoon of salt into the proper water cup and another ½ teaspoon of salt into the proper oil cup.
3. Stir each for about 20 seconds or until dissolved (whichever occurs first).
4. Record your observations in the table.
5. Mark the level of the liquid again. Compare with the original.
6. Repeat the procedure with sugar.
7. Repeat the procedure with a small dollop of margarine.
8. Record your observations

Now You See It Now You Don't

Cup Contents	Observation
Water + Salt	
Oil + Salt	
Water + Sugar	
Oil + Sugar	
Water + Margarine	
Oil + Margarine	

Solubility: *Density of Water*

Problem: Lakewater is considered fresh water because it contains a much smaller concentration of salt than marine (salt) water. With that said, the actual concentration of salt will vary among different lakes, and among environmental conditions (think back to evaporation). Does the salt concentration of a lake effect where a pollutant interacts with the water?

Materials:
Per Group of 2 Students:

- 4 plastic cups labeled (A, B, C, D)
- Pre-prepared salt water
- Plastic spoon
- 1 Fresh egg
- Tap water

Procedure:

- Obtain your cups, and fill cup "A" with the pre-prepared salt water (1/2 cup salt per 1 cup of water). Predict whether the egg will float or sink.
- Place the egg in cup "A". Observe and record the results in the table below.
- Remove the egg and pour half the contents of cup "A" into cup "B". Fill the rest of cup "B" with tap water, mix with spoon, and predict whether the egg will float or sink.
- Place the egg in cup "B". Observe and record the results in the table.
- Remove the egg and pour half the contents of cup "B" into cup "C". Fill the rest of the cup "C" with tap water, mix with spoon, and predict whether the egg will float or sink.
- Place the egg in cup "C". Observe and record the results in the table.
- Lastly, remove the egg and pour half the contents of cup "C" into cup "D". Fill the rest of cup "D" with tap water, mix with spoon, and predict whether the egg will float or sink.
- Place the egg in cup "D". Observe and record the results in the table.

Density Table

Cup	Prediction (sink or float)	Observations
Cup A		
Cup B		
Cup C		
Cup D		

Which cup best simulated a lake that is in a hot, dry region? Explain why.

Which cup best simulated environmental a lake that is in a cooler, wet region? Explain why.

How did the pollution (the egg) behave differently depending on which lake (cup) it was in? Explain your answer.

Habitats: *Where's It At?*

Problem: How can I use a nautical chart to identify topographical characteristics of the lake?

Materials:

Per Student:

- Copy of Student Pages

Per Group of 2 Students:

- 1 copy of "Lake Michigan Beach Nautical Chart"
- Computer with Internet Access
- Colored Pencils
- Thin Black Marker

Procedure:

In this activity, you will be investigating features of Lake Michigan by reading a **nautical chart**. With a partner, collect a copy of the "Lake Michigan Beach Nautical Chart." In the space below, record your observations.

Habitats: *Where's It At?*

BACKGROUND INFORMATION

Although nautical charts are typically utilized for boating navigation, they are a reliable resource for determining features of a body of water. A scientist may be interested in locating landforms within a given area of water, measuring the depth of the aquatic floor, or studying patterns or trends in the **topographical** features of the area. The "Lake Michigan Beach Nautical Chart" features characteristics about Lake Michigan and the surrounding beaches.

1.) Investigate the **depth** of the lake at various points. A nautical chart typically represents the depth of the aquatic floor in **fathoms**. Using the information below, complete the chart:

Fathom	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Feet			18		30				54	

Complete the following questions regarding this measurement. Show all work:

A. One fathom is equal to how many feet?

B. What would be the depth, in feet, of 20 fathoms?

C. What would be the depth, in feet, of 27 fathoms?

D. What would be the depth, in feet of 31 fathoms?

Habitats: *Where's It At?*

2.) What do you notice about the curvy lines on the nautical map? These are called **contour lines**. What do you think these lines represent?

3.) If you were to create "sections" based on the depth of the water, how many "sections" would you create? Using a colored pencil, shade in each "section" with a different color. Then, write the depth range, in feet, of each section.

4.) Now that you have a better understanding of the nautical chart, what do you think the **tan**, **blue** and **white** portions of the map represent?

Habitats: *Where's It At?*

Next, you will collect important information regarding what scientists refer to as: **lake zones.**

1.) With a partner, navigate to the following website: http://www.lakeaccess.org/ecology/lakeecologyprim9.html

2.) Using this website, collect and record information regarding the following **lake zones**. *Your teacher may also advise you to use additional websites.*

Littoral Zone

Benthic Zone

Limnetic Zone

Euphotic Zone

3.) Using a thin black marker and the information above, predict the location of each of these **lake zones** on your map. Write where you believe each zone would be located.

Habitats*: Are You Shore, Habitat?*

Problem: How do waves impact the shoreline a lake?

Materials:
Per Group of 2 Students:

- Shallow tub
- Water
- Index cards - 2
- Sand– approx. 2-4 cups
- Plastic spoon, 2
- Gravel – 1-2 cups
- Plastic cups (for sand and gravel)

Procedure:

- Observe the materials available for use. You will be creating a model shoreline using the available materials.
- Discuss with your partner how you will design your shoreline and record your plan in the space below:

Are You Shore Habitat?

- Once your plan is set, build the shoreline. Be sure to pack the sand and or gravel.
- Slowly add water to your model to create an ocean associated with the shoreline land you created.
- Use the index cards provided to create small waves. For approximately 5 minutes, observe how the small waves affect the shoreline. Record any observations below:

- To mimic stronger waves, put a little more force into the wave action (but don't get messy!)
- Record any observations of the shoreline below:

When cleaning up the materials, do not destroy your model – it will be used in another activity.

Habitats: *Save the Shore*

Problem: How can you save the shoreline from oil-based pollution?

Materials:
Per Group of 2 Students:

- Shoreline model from prior activity
- Water
- Index cards - 2
- Vegetable oil
- Dixie cups
- Toilet Paper
- Cotton Balls
- Pipe Cleaners
- Craft Sticks
- String
- Liquid Detergent
- 3 tbsp of Vegetable Oil in a Plastic Cup

Procedure:

Use your shoreline from the prior activity for this lesson. Collect the materials available and survey what is available for use in saving the shoreline from an oil-based pollutant. How do you think each material can be used to save the shoreline?

Save the Shore!

Place the oil into the lake and use the index cards to create small waves. Use the materials available to save the shoreline from the oil!

Which materials did you use? Why?

Was your plan to save the shoreline successful? Why / Why not?

Where did the oil sit in the water? How did it interact with the land?

Aquatic Life: *Tag, You're It!*

Problem: How can you calculate the population of fish, or other aquatic life, within a given area?

Materials:

Per Student:

- 1 Copy of *Fish Cannot Smell in Polluted Waters* Article

Per Group of 2 Students:

- 1 Paper Bag
- 1 Plastic Cup
- Goldfish Crackers (approximately 40-50 per group)
- Pretzel Goldfish Crackers (approximately 20-30 per group)
- Paper Towels
- Calculators (optional)

Procedure:

1. Open your bag of Goldfish Crackers and place them into the paper bag. These items represent your **total fish population** and **lake.**

2. You will now simulate the process of tagging fish and completing calculations to determine the total population of fish within your lake.

3. Using your plastic cup, scoop out some of your fish and pour them on to the paper towel. Count the number of fish, and place them to the side (you will no longer use these crackers). Count out the same number of Pretzel Goldfish Crackers. These Pretzel Goldfish Crackers will represent your **total number of tagged fish**.

   Record the **total number of tagged fish** here: _____

4. Place the newly tagged fish back into the lake and gently shake your bag.

5. Using your plastic cup, scoop out a sample of fish and pour them onto your paper towel.

6. Count the **total number of fish captured** and record this information in your data table for the appropriate trial number.

Aquatic Life: *Tag, You're It!*

7. Separate the regular fish from the tagged fish. Count the **number of tagged fish recaptured** and record this information in your data table for the appropriate trial number.

8. Collect all the fish and place them back into the lake. Gently shake your bag.

9. Repeat Steps #5-8 to complete all ten trials.

Trial	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
n *= Total Number of Fish Captured*										
t *= Number of Tagged Fish Recaptured*										

10. To calculate the **total fish population** of your lake, you will first determine the *mean* amount of **total number of fish captured (*n*)** and *mean* amount of **number of tagged fish recaptured (*t*).** Your teacher may assist you with these calculations:

Mean amount of **total number of fish captured:**

Mean amount of **number of tagged fish recaptured:**

Aquatic Life: *Tag, You're It!*

11. You will now use the following equation to determine the **total fish population (N).** Your teacher may assist you with the calculations.

    T (total number of tagged fish) = _____

    N (total fish population) = ____*x*_____

    ***t* (Mean Amount of Fish Captured)** = _____

    ***n* (Mean Amount of Tagged Fish Recaptured)** = _____

$$\frac{T}{N} = \frac{t}{n}$$

12. Based on your calculations, the **total fish population** of your lake is: _____

13. Open your lake and pour your fish onto your paper towel. Count the actual number of fish within your lake. Record the number below:

    Actual fish population: _____

14. How close was your estimate to the actual?

Aquatic Life: *Algal Blooms: A Big Problem*

Problem: How do toxic pollutants impact the growth of algal blooms, and ultimately, lake habitats?

Materials:

Per Group of 3 or 4 Students:

- 100 Skittles of one color
- 100 Skittles of a second color
- 1 Tray
- 1 Plastic Cup

Background Information:

Complete the following questions while watching *Battling the Bloom: Lake Erie*:

What causes algal blooms to grow?

What does water containing algal blooms look like?

Aquatic Life: *Algal Blooms: A Big Problem*

How do algal blooms affect the health of plants, animals, and humans?

How are farms and algal blooms linked?

What are some solutions that have been used to fight algal blooms?

Aquatic Life: *Algal Blooms: A Big Problem*

Procedure:

1.) In this simulation, you will model the growth of algal blooms. Collect the following materials from your teacher:

- 100 Skittles of one color
- 100 Skittles of a second color
- 1 Tray
- 1 Plastic Cup

2.) Place 99 Skittles of the first color and 1 Skittle of the second color into the tray. In this simulation:

The **tray represents** a body of water.

The first color Skittle _____ represents a **healthy water environment.**

The second color Skittle _____ represents an **algal bloom.**

3.) Pour all Skittles into the plastic cup. Gently shake the cup and pour the Skittles back into the tray.

4.) If the **algal bloom** Skittle is touching a **healthy water environment** Skittle, it turns into an **algal bloom.**

5.) Replace the **healthy water environment** Skittles with the **algal bloom** Skittles.

6.) In the chart on the following page, record the TOTAL number of **healthy water environment** Skittles remaining. Then, record the TOTAL number of **algal bloom** Skittles remaining.

7.) Repeat Steps #3-6 for 15 rounds, or until your body of water contains all **algal bloom** Skittles.

Discussion: Describe what happened to your body of water during the simulation:

Aquatic Life: *Algal Blooms: A Big Problem*

Algal Bloom Simulation Data

Round	Number of *Healthy Water Environment* Skittles	Number of *Algal Bloom* Skittles
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Solution: *What Are Your Suggestions?*

Problem: What are common sources of pollution that may affect the lake and water quality, and how can we prevent or decrease the occurrence of this problem?

Materials:

Per Group of 3 to 4 Students:

- 1 Piece of Chart Paper
- Chart Makers (or other writing materials)

Procedure:

Your team will responsible for investigating sources of water quality pollution and suggesting solutions to remediate the problem. Each group will be assigned a category from which to research and prepare a presentation.

My group's category is: _____

1.) Using a computer with internet access and websites recommended by your teacher, research sources of pollution within your category. Also, begin brainstorming possible solutions that would help decrease the amount of pollution that could eventually affect water quality.

2.) Create a visual illustration of your research. Include pictures of the different sources of pollution and possible solutions associated with your category.

3.) When all groups are finished, you will do a gallery walk to view each group's categories. **Draw a star** next to the solutions that you feel will be most impactful in decreasing pollution and improving water quality.

Solution: *What Are Your Suggestions?*

Sources of Pollution	Possible Solutions