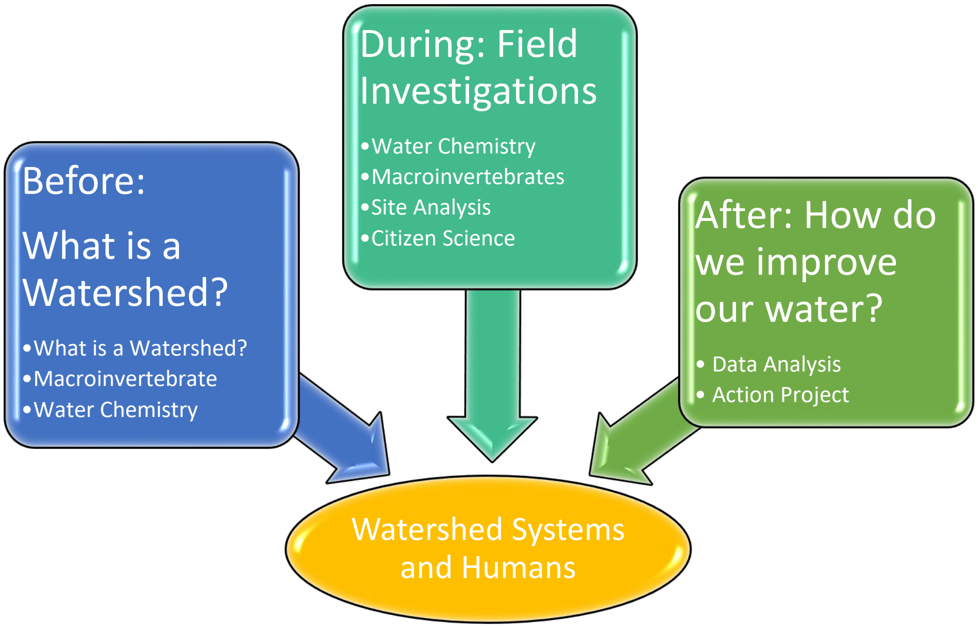
WATERSHED INVESTIGATIONS



Your students will be visiting Blandy to engage in a field investigation focused on watershed systems and human impacts on these systems. This cluster of lessons is designed to thoroughly address Virginia Science Standard 6.8, meet all elements of a **Meaningful Watershed Educational Experience (MWEE)** as defined by the Chesapeake Bay Program, and build **Environmentally Literate** citizens. Additional Virginia Standards of Learning addressed are listed at the beginning of each lesson.
To enhance classroom connections, we have developed this lesson cluster. Field investigations are more meaningful to students when they are integrated into their curriculum. This lesson cluster can be used to: introduce watershed systems, increase depth of knowledge by synthesizing a variety of components in a systems approach, review and reflect on concepts, and develop student collaboration and cooperation with an action project. Before-visit activities increase student awareness of the process of science and understanding of watersheds. With the after-visit activities, students synthesize data and concepts gathered in the field as they plan and execute watershed improvement.

BEFORE 1: What is a Watershed?

Before your visit to help students understand the concept of watershed and their place in one through modeling strategies and map reading.

VA Standards Addressed
Science (2018): 6.1e
History & Social Science (2023): VS.1b

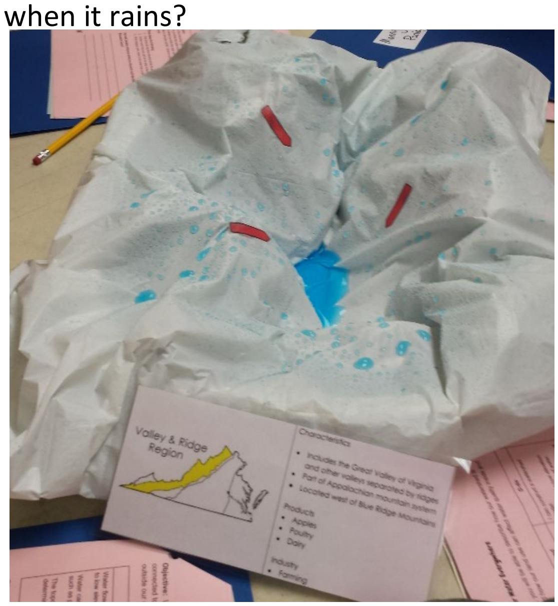
Materials (per group)

- Aluminum pan (turkey roasting pan)
- Plastic table cloths
- Squirt bottles with water and food coloring

- Newspaper/recycled paper
- Sticky Post-It arrows
- Pepper shakers filled with pepper
- Towels for clean up
- Virginia Relief Map (optional)- https://energy.virginia.gov/commerce/ProductDetails.aspx?ProductID=2536
- Virginia's Geographic Regions Cards (one region per group)
- Map of the school area and waterways (digital or physical)
- Poster or other large paper
- Markers and other map-drawing supplies

Instructional Strategy:

1. Inquiry Engagement, Part 1: Ask students some of the following questions: How does water get to your house? Where does the water go after you use it? Where does water go after it falls on land?
2. Inquiry Engagement Part 2: Once students are thinking about water and how it gets to different places, inquire: What is a watershed? Describe a watershed. Do you know your watershed address (i.e., Do you know what watershed you live in)? Definition: A watershed is an area of land over which water flows to a single collection place. Ask students for examples of watersheds.
3. Explore (investigation instruction): Instruct students that they are to build a landscape using the materials found on their tables (see the materials list). Model the following process:
    a. Quickly describe a landscape for the students, such as the Rockies or the Himalayas or a desert valley. Ask students to describe how that landscape will look.
    b. Place crumpled paper in a turkey pan to lay the foundation for mountains and valleys.
    c. Form the landscape by placing the plastic tablecloth over the paper form (tuck in the sides so the water stays inside the tray).
    d. Tell students to use the post-it arrows to predict the ways water will move over the landscape, i.e., what direction will the water flow when it rains?
    e. Once the landscapes are built, students use the spray bottles to simulate rain on their landscapes. They observe how the water moves over their landscapes to determine if their predictions about water flow were accurate. After students have made their initial observations and have evaluated their predictions about water flow, they can sprinkle pepper on their landscapes to model erosion of soils and/or rocks. When the students use the spray bottles again to create "rain", they can explore the process of erosion and how slope (steepness) affects erosion.



    f. As students work in their teams, go to each group and ask:

i. Where are the high and low elevation points?
ii. Where are the steepest slopes? The gentler slopes?
iii. What determines where the water will go?
iv. How would you describe some of the water resources? (Are there lakes, rivers, a bay? An ocean?)
v. Did the water move as you predicted?

g. Tell student teams that at the end of the activity, they will share their model with the rest of the class and answer the above questions during a gallery walk.

4. <u>Gallery Walk/ Explain</u>: Instruct students to put down spray bottles. Remind students that they will share the above details with the rest of the class during the gallery walk. Ask the class to hover over the table while each of the student teams describe and SHOW how water moves (using the spray bottle).
5. <u>Mapping a Watershed</u>
   a. Using a map that includes both the school and local bodies of water, instruct students to identify the nearest flowing water and trace its pathway both back to the origin (headwaters) and out to an ocean. Working in groups, students draw and label their own poster-map of the water's path, labeling water and town names, and any other key features.
   b. Groups share their maps, describing why they included each feature. Create a master map. Using features identified by the students, make a list of possible human impact events to affect the flow of the watershed model. For example, farms could introduce nitrogen or phosphates by allowing livestock in the river or not using Best Management Practices (BMPs) when applying fertilizer. Construction of a new bridge between towns could allow sediment into the water.
6. <u>Clean up:</u> While students are working on their paragraph (if you choose to do the extension activity), ask your instructional helpers to bring the entire model to a designated place to empty the water and either discard or save for future models the recycled papers. The plastic tablecloths should be taken outside and shaken to remove as much water as possible. At the end of the instructional day, hang the tablecloths outside to dry, if possible. If no instructional helpers, you can designate roles in the student teams.

Extensions:

a) After the gallery walk, ask students to provide details on what they learned about watersheds from this modeling activity. Ask them for responses to "What is a watershed?" They can use the key words and concepts they generate to write an explanatory paragraph to help develop skills in writing.
b) Students research most problematic pollutants at the terminus of their watershed (for example, the Chesapeake Bay Buoy System or the Chesapeake Bay Program Water Quality Data), and prepare an infographic or other display of the sources and impacts of those pollutants.
c) Invite experts/professionals in careers associated with some of the pollution sources to share the Best Management Practices (BMPs) their field uses to mitigate the effects of pollution. Have students prepare interview questions in advance.

BEFORE 2: Introduction to Macroinvertebrates

Before the field investigation, Students learn about the connections between water chemistry and macroinvertebrate health, and how to identify macroinvertebrates.

VA Standards Addressed: Science (2018)**:** 6.1f, 6.8

Materials

- Copies of Headwaters Science Institute Lesson (whether online or printed)
- Devices with internet access, one per student or pair

Instructional Strategy: https://leafpacknetwork.org/virtual-stream-study/

1. Use the Headwaters Science Institute Lesson to introduce macroinvertebrates to the students. Discussion Questions:
   - Break down the term “benthic macroinvertebrate”.
   - Describe two different roles (or niches) that macroinvertebrates have in a watershed.
   - Describe or draw a benthic macroinvertebrate life cycle.

2. Practice using a Macroinvertebrate dicot key. https://www.macroinvertebrates.org/key/ This key is very similar to the one they will use while at Blandy. Practice identifying some macroinvertebrates. Students can draw macroinvertebrates and note distinguishing features.
3. Try a virtual stream study at **https://leafpacknetwork.org/virtual-stream-study/**
4. Close: Why do we observe macroinvertebrates to understand watershed health?

Extension: Each student creates a “trading card” about an aquatic macroinvertebrate. The card should include an image of the organism, information about its pollution tolerance (including specific tolerance ranges if available), and a diagram of the life cycle.

BEFORE 3: Introduction to Water Chemistry

Before the field investigation, Students learn about the connections between water chemistry and macroinvertebrate health.

VA Standards Addressed: Science (2018) 6.1, 6.8, 6.9

Lesson Preparation: Teachers will use this file to make the datasheet and cards for this inquiry. Using card stock and laminating the materials works best for multiple uses. If students cannot go to a stream, the teacher should collect bucket(s) of water for the class on the day of the lab. While at the stream, the teacher should take the water temperature and the dissolved oxygen readings. Students can compare their results to the teacher’s or use the teacher’s results for those two properties.

Materials (for each group):

- Enough copies of https://www.potomacriver.org/wp-content/uploads/2017/09/Waterways-Chemistry-Inquiry-for-MS.pdf for student groups.
    - A set of pictures of pollution sources
    - An information card about the chemical property assigned to the team (6 tests: dissolved oxygen, nitrogen, phosphorus, pH, turbidity, temperature, alkalinity.)
- A graph relating the levels of various chemical properties to fish health. https://drive.google.com/file/d/1nfmFxDtEbAeQ66wezr2ur_MQay49kmwQ/view?usp=sharing
- A test kit https://www.monitorwater.org/order-kits
- A water sample

Instructional Strategy:
https://www.potomacriver.org/wp-content/uploads/2017/09/Water-Chemistry-Inquire-Teacher-Instructions.pdf
1. Teachers show students a map (satellite image) of where the water was collected. The class discusses the land uses and land cover in vicinity of the stream. If the class has learned about pollution sources and the relationships of land uses to water quality, they can make a class hypothesis about whether water chemistry will be suitable for aquatic life. (Resource: Opening Presentation: Watersheds, Land Use, and Sustainable Practices (Presentation: PDF/PowerPoint)
2. The activity and labs are done in teams. Each team is assigned one of the chemical properties. The student worksheet will guide the students (and teachers) through the activity. The team will: read and learn about that property from the information cards and identify possible pollution sources using the pollution cards.
3. Student then conduct the chemistry test for their property and report their findings to the class.
4. The class determines whether water chemistry is conducive to aquatic life and states factors that contribute to their conclusion.
Note: Lesson from Interstate Commission on the Potomac River Basin www.potomacriver.org

DURING: Field Investigation

VA Standards Addressed: Science (2018) 6.1, 6.8, 6.9

During your field investigation at Blandy, your students will engage in several indoor and outdoor lessons where they explore watershed concepts as watershed scientists, water quality technicians, and citizen scientists do.

Below is an overview of the “standard” program activities to assist you with integrating the field experience into the classroom experiences. Field investigations may change due to weather, volume of students, or through communication with Blandy educators. Typically, each class of up to 28 students is divided into 5 groups. Each group collects their own data. This structure informs the way that data will be analyzed back in the classroom.

* **Water Chemistry:** In small research groups, students conduct a series of tests to measure the health of the watershed. They communicate their findings and use evidence and reasoning to support their conclusions.
* **Macroinvertebrate:** Students use microscopes and tools to identify and count aquatic organisms. They use a diversity index to calculate water health.
* **Site Analysis**: How does human use of land affect water health? Using various resources, students examine the habitat and area surrounding the water body to determine how human usage affects ecosystem health.
* **Citizen Science:** Student water quality data is uploaded into our database and made available for analysis in the classroom.

AFTER 1: Data Analysis

After your field investigation, students analyze their findings to determine the quality of water tested during their field investigation. Chemical indicators and biological indicators are compared. Depending on the goal of the teacher, students can either practice finding measures of center and creating graphs to represent their data, or they can use a program to generate these visuals.

Background: Biological indicators provide a glimpse of water quality over time. For example, some dragonflies spend months, even years as aquatic nymphs. If one is present, and almost ready to metamorphose into its adult stage, the quality of the water was able to sustain it up to that point. Biological indicators can fluctuate seasonally and may be affected by changes in weather.
Chemical indicators provide a measure of water quality at that moment, and can change rapidly due to weather changes, environmental changes, or human activity.

Measuring both biological and chemical factors creates a more nuanced and complete picture of the health of the aquatic system. Ideally, multiple assessments can be compared over time.
In both measures of water quality, the skill of the monitor can affect the results.

VA Standards Addressed: Science (2018) 6.1c, d, f, 6.8. Mathematics: 6.5c, 6.10, 6.11 (if conversion to fractions is used, 6.2). Language Arts 6.1, 6.7, 6.8

Materials:

- Access to student data from Blandy field investigation
- Student data sheets
- Supplies for graphing and writing (paper, pencils, rulers, markers, templates OR access to workbook and writing apps)
- Calculators (optional)

Lesson Preparation:
Student water quality data should be entered into a shared workbook. This may happen during the field experience, look for a link in the follow-up email. If not accomplished at Blandy, a template is available in Google Sheets. **This is a force copy so you will be prompted to save a copy to your Drive.** If you conduct your field experience somewhere other than Blandy, keeping track of these data will

help when submitting the information required by Virginia's Department of Wildlife Resources scientific collection permit.
We recommend executing the mathematical analysis in math class, then interpreting the findings in science class to integrate these two connected subjects.

Instructional Strategy:

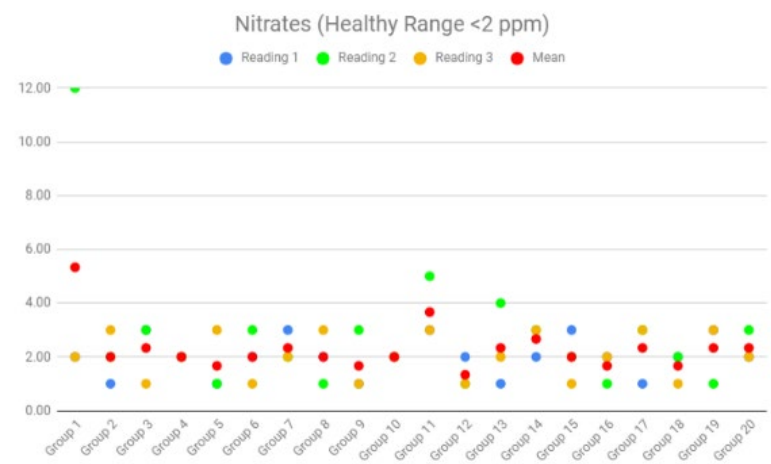
Mathematical Data Analysis

1. Aquatic macroinvertebrate pollution tolerance index calculation:
    a. Using the combined findings of all student datasheets, complete the Pollution Tolerance Index protocols on the Macroinvertebrate Data Sheet II (one side of the datasheet they received during their Blandy field investigation).
        i. Check each group of organisms found (the number of individuals is irrelevant at this point)
        ii. Multiply by the modifier for that group (4 for Group 1, 3 for Group 2…)
        iii. Add all group scores to determine the total score.
        iv. Compare to the water quality assessment chart.
    b. Optional extension: additional data which can be used for comparison is available on the Virginia Save Our Streams page.
2. Aquatic macroinvertebrates biodiversity calculation and circle graph: These calculations can be completed using spreadsheet software like Google Sheets or Excel. Students can also generate circle graphs in these applications. This can be a differentiation tool or a way for students to check their work and learn to use these programs. The Google Sheet template includes automatic calculation and graph generation. (This is a force copy document.)
    a. This can be completed with individual data (biodiversity of the group's sample) or class data. Calculating at both levels of and comparing the biodiversity may provide evidence that multiple trials yield more accurate results. It is not recommended that the entire school's data be compared since organisms are released back into the sample and may be counted more than once by a subsequent class.
    b. Biodiversity Calculation:
        i. On Macroinvertebrate Data Sheet I, calculate the total number of organisms.
        ii. Label the empty column on the table "Biodiversity percent"
        iii. Using the instructions and formula on Macroinvertebrate Data Sheet II, calculate and record the percent that each group of organisms is of all the organisms collected.
        iv. Students should check their math by adding up all the percentages. The total should be close to 100.
    c. Circle Graph: Students convert their numeric data into a visual representation.
        i. Depending on your students' familiarity with creating circle graphs, you may wish to scaffold by modeling the process of creating a circle graph or providing a template with percentages already marked.
        ii. Optional extension to incorporate fractions: Percentages can be rounded to the nearest whole number, then converted to fractions, and simplified. By placing these fractions on a number line, students can round them to the nearest

workable fraction, and then create a circle graph based on fractions instead of percentages.

3. Water chemistry mean calculation and scatter graph: As with the Macros biodiversity and circle graph, calculations and graph generation can be completed automatically in the [Google Sheets template](). While at Blandy, the students are divided into groups. Each group conducts all tests and enters their data.

   a. Divide the class into 6 groups. Each group works with a different test.
   b. Students calculate the mean value for each group's water chemistry trials by adding together all trial results and then dividing them by the number of trials.
   c. The group then determines the range of the data and uses it to create a graph like the one to the right. As with the circle graph, this process may need to be modeled or a template provided to support student abilities.



<u>Scientific Analysis and Communication</u>:
Prerequisites: At a minimum, student groups need to have calculated the mean of their water chemistry tests and have completed the macroinvertebrate pollution tolerance index. The graphs may help build understanding but are not necessary.

4. Interpreting the findings – The following can be done as a class discussion, or by having each group talk through the questions and then share their thoughts. Keep a list of variables that could have influenced findings and use a t-chart to sort evidence into healthy/not healthy. These notes can be done as a whole class on the board/smartboard/or flip chart, or in individual student groups.
   a. Ask students to look at their macroinvertebrate data. Based on this assessment, is the aquatic system healthy or not? What are some factors that could have contributed to our results? Points to discuss include the role of seasonality (some organisms may not be present), changes in weather (rain can wash them away, or a dry spell make it harder to survive), rigor of the sampling method, and expertise of the aquatic biologists (students) conducting the identification.
      i. If the biodiversity circle graph was completed, bring it into the conversation. The organisms that were counted in the pollution tolerance index were selected because their tolerances are known, but having healthy populations of many different species is also important for ecosystem balance. Review the circle graphs. Do they represent many species or only a few? Do just a few species take up most of the chart or are the percentages more evenly distributed? A healthy system will have lots of species and no one species will dominate. Remind students that they may have introduced bias by targeting specific organisms. How does this skew the results?

b. Ask students to look at their water chemistry data. Based on this assessment, is the aquatic system healthy or not? What are some factors that could have contributed to our results? Points to discuss include changes in weather (rain can dilute, increase turbidity, wash in pollutants, increase dissolved oxygen, etc. Sun can warm the water, reducing oxygen), technological errors, and expertise of the chemists (students) conducting the tests. This is a good opportunity to note outliers in the data.
c. Compare the findings.
    i. Have students look at their group's data and compare that to the overall findings (data from entire grade levels can be used). What happened as data from more trials were added? (Students should observe that the results became more accurate).
    ii. Compare the macroinvertebrate index and the results of the chemistry tests. Do those tests agree about the health of the aquatic system? If there is a discrepancy between test results, why do they think that is the case? How could they test it? Did they make any other observations during the field investigation that could be added to that information?

5. Writing a conclusion: Students make a claim about the health of the aquatic ecosystem based on their field investigation and support it with evidence from their tests and observations.
    a. This can take the form of a basic 5-sentence paragraph or up to a 5-paragraph paper.
    b. Regardless of length, it should include a claim, three pieces of evidence from their water quality tests or the discussion, and a conclusion that restates the claim and includes analysis of the evidence as reasoning.
    c. The writing and editing of this report could be transitioned to the language arts class to further integrate curriculum.

Extension: Work with the art teacher to have the students turn their data into emotionally engaging works of art. Science Friday has lesson suggestions on their website.

AFTER 2: Action Project

After your visit to give students the opportunity to apply their learning by taking action within the community to improve water quality in their watershed.

VA Standards Addressed: Due to the open nature of this lesson, many additional standards may be addressed.

Science: (2018) 6.1c, d, f, 6.8, 6.9

Language Arts: 6.1, 6.2, 6.9

Lesson Preparation: (minimum of two 50-minute class periods, not including extension)

Instructional Strategy:

1. Identify a problem or area of improvement: Students go online to access water quality data, find monitoring sites, and use what they have learned about water quality to identify areas in need of improvement.
2. They then use Google maps with a satellite layer to visualize potential sources of point and non-point pollution and brainstorm intervention/improvement opportunities. This is a key area to integrate student choice while keeping the action project achievable and assessable. Possibilities include:
    - Drafting a letter to a business owner to inquire about what strategies are in place to reduce pollution.
    - Creating a public service announcement (radio or TV spot, advertisement in a newspaper on online media, informative pamphlet…) to highlight potential problems, possible solutions, and resources for landowners.
    - Creating a visual or performance art piece (play, art show, public mural) to share potential problems, possible solutions, and resources for landowners with the community.
    - Researching and proposing land use changes that could improve water quality (rain garden, silt fencing, riparian buffer…) to an organization of power (school board, town council, local environmental organization).
    - Assessing their schoolyard to identify land use problem areas and propose improvements to the school maintenance department.
    - Planning a community cleanup day or awareness fair.
3. Students (as a class, in groups, or individuals) select a course of action and prepare their product. As the teacher, you may choose to limit brainstorming options for student selection. Some products (visual or performance art, for example) may need accompanying information to demonstrate the depth of student understanding. The key to this assessment/action project is that the student(s) engage an audience outside of the classroom while demonstrating their learning. The following is a simple rubric that can be adapted to guide development and assessment of the projects.

WATERSHED INVESTIGATIONS

	Great (4)	Good (3)	Getting There (2)	Needs work (1)	0
So what?	Defines a watershed, identifies the local watershed, describes why healthy water is important for humans and other parts of the ecosystem.	Defines the local watershed, describes why healthy water is important for humans or the ecosystem	Defines a watershed, says that healthy water is important.	Defines a watershed	Not present
Uses data to define problem	Includes a graph of current water quality, describes effect of pollutants present, identifies possible source of pollutants	Includes a graph of current water quality, describes effect of pollutants	Includes a graph of current water quality	Includes current water quality data	Not present
Identifying solutions	Two or more possible solutions are described, a plan or resources for enacting the solutions is included	A solution is described, a plan or resources for enacting the solution is included	A solution is described	A solution is identified	Not present
Recognizing challenges	Multiple barriers (cost, time, resources, safety…) are described and solutions proposed	A barrier (cost, time, resources, safety…) is described and a solution proposed	A barrier(s) is described	A barrier(s) is identified	Not present
Audience	Language/visuals are appropriate and help engage audience	Language/visuals are appropriate for the audience	Language/visuals need editing to be appropriate for the audience	Work needs editing	Major errors