WATER RESOURCES EDUCATION CENTER - STUDENT WATERSHED MONITORING NETWORK
FIELD INVESTIGATIONS

Alignment of Investigations to Washington State Learning Standards

An important element of the project undertaken for the Department of Ecology was to demonstrate how the investigations meet or match Washington State's Learning Standards. It is important for teachers and administrators to be able to explain how work being undertaken by students in the classroom aligns with these standards. The following two pages provide this alignment for the twelve investigations.

The vast majority of students participating in the Watershed Monitoring Network are in grades 4 through 8. Of the 102 classes monitoring in the 2014-15 school year, only 10 do not fall in the grades 4 through 8 range. Therefore, the investigations were written to primarily target those students in grades 4 through 8 with the suggestion that teachers can pick and choose among the investigations and make any modifications need to tailor the content for their particular grade level/classes. Most investigations can also be easily used with general high school science classes.

Existing or previous essential academic learning requirements (EALRS) and grade level expectations (GLEs) have been tied to assessment in different grades for different content areas. The new Common Core standards have just been fully implemented in the 2014-2015 school year to assess reading, writing and math in grades 4 and 7 and high school. Other assessments, such as the EOC (End of Course) for high school mathematics and biology is only done in grade 10.

The twelve investigations developed by the Watershed Monitoring Network team are aligned in two separate documents: Grades 4-5 and grades 6-8. Each investigation was aligned with current Washington State K-12 learning standards, with math and language arts (ELA) Common Core and with the adopted but not yet implemented Next Generation Science Standards (NGSS). Please note: The Washington State 2009 K-12 Science Learning Standards are being phased out as the State transitions to the newly adopted Washington State 2013 K-12 Science Learning Standards (Next Generation Science Standards). The new standards describe what students should know and be able to do at each grade level.

Developed by Vancouver Water Resources Education Center with funding from the WA Department of Ecology

Elementary School (grades 4-5) Standards Alignment	Site Survey		Soil				Plant		Water Quality			
	Initial Site Assessment and Observations	Photo-point Monitoring	Soil Cores: Color, Texture and Moisture	Soil Temperature, Moisture and pH	Soil Permeability	Erosion Sources and Soil Compaction	Riparian Zone Vegetation Survey	Riparian Zone Tree Survey	Temperature, pH and Dissolved Oxygen	Nitrate and Phosphate	Turbidity and Stream Measurements	Macro-Invertebrate
Current WA State K-12 Learning Standards	INQA-D ES2C,F LS2A-F	INQA-D APPA ES2C,F LS2A-F	INQA-D APPA ES2A,C-F	INQA-D APPA ES2A,C,D LS2D-F	INQA-D APPA ES2A,C,E LS2D-F	INQA-D APPA ES2A,C LS2D-F	INQA-D APPA ES2F LS1A-D LS2A-F	INQA-D APPA ES2F LS1A-D LS2A-F	INQA-D APPA PS2C LS2A-F	INQA-D APPA LS2A-F	INQA-D ES2B-D LS2A-F	INQA-D LS1A-D LS2A-F LS3A,C
NGSS – *Science and Engineering Practices*												
Asking Questions and Defining Problems	•	•	•	•	•	•	•	•	•	•	•	•
Developing and Using Models	•	•	•	•	•	•	•	•	•	•	•	•
Planning and Carrying Out Investigations	•	•	•	•	•	•	•	•	•	•	•	•
Analyzing and Interpreting Data	•	•	•	•	•	•	•	•	•	•	•	•
Using Mathematics and Computational Thinking	•	•	•	•	•	•	•	•	•	•	•	•
Constructing Explanations and Designing Solutions	•	•	•	•	•	•	•	•	•	•	•	•
Engaging in Argument from Evidence	•	•	•	•	•	•	•	•	•	•	•	•
Obtaining, Evaluating and Communicating Information	•	•	•	•	•	•	•	•	•	•	•	•
NGSS - *Disciplinary Core Ideas*	ESS2.A-B,E ESS3.C	ESS2.A-B,E ESS3.C	ESS2.A LS2.B	ESS2.A LS2.B	ESS2.A	ESS2.A ESS3.C	ESS2.E ESS3.C LS1.A-C LS4.C-D	ESS2.E ESS3.C LS1.A-C LS4.C-D	PS1.A	PS1.B	ESS2.A	ESS2.A LS1.A-D LS2.A-C LS4.C-D
NGSS - *Cross-Cutting Concepts*												
Patterns	•	•	•	•	•	•	•	•	•	•	•	•
Cause and Effect	•	•	•	•	•	•	•	•	•	•	•	•
Scale, Proportion, Quantity	•	•	•	•	•	•	•	•	•	•	•	•
Systems and System Models			•	•	•	•	•	•	•	•	•	•
Energy and Matter			•	•	•	•	•	•	•	•	•	•
Structure and Function			•	•	•	•	•	•	•	•	•	•
Stability and Change	•	•	•	•	•	•	•	•	•	•	•	•
Common Core – *Math*	4.MD.A.2 MP.4	MP.2	MP.4	MP2	MP4	MP.4	MP2	MP.4	MP.2	MP.4	MP.2	MP.4
Common Core – *ELA/Literacy*	RI.4-5.7	W4-5.7	RI.4-5.7	W4-5.8	W4-5.8	W4-5.8	W4-5.8	W4-5.8	W4-5.7	W4-9.9	RI.4-5.7	W4-5.8

Middle School Standards Alignment	Site Survey		Soil				Plant		Water Quality			
	Initial Site Assessment and Observations	Photo-point Monitoring	Soil Cores: Color, Texture and Moisture	Soil Temperature, Moisture and pH	Soil Permeability	Erosion Sources and Soil Compaction	Riparian Zone Vegetation Survey	Riparian Zone Tree Survey	Temperature, pH and Dissolved Oxygen	Nitrate and Phosphate	Turbidity and Stream Measurements	Macro-Invertebrate
Current WA State K-12 Learning Standards	INQC LS2E	INQA APPC LS2D-E	INQA-C APPE ES2G LS2E	INQA-C LS2D-E	INQA-C APPE ES2C LS2E	INQA-C APPE PS1B LS2E	INQA-C APPE LS2D LS2E	INQA-C APPC LS2A,E	PS2B ES2D LS2E	INQA-C PS2C LS2E	PS1A ES2G LS2E	INQA-C LS2A,E LS3E
NGSS – *Science and Engineering Practices*												
Asking Questions and Defining Problems	●	●	●	●	●	●	●	●	●	●	●	●
Developing and Using Models	●	●	●	●	●	●	●	●	●	●	●	●
Planning and Carrying Out Investigations	●	●	●	●	●	●	●	●	●	●	●	●
Analyzing and Interpreting Data	●	●	●	●	●	●	●	●	●	●	●	●
Using Mathematics and Computational Thinking	●	●	●	●	●	●	●	●	●	●	●	●
Constructing Explanations and Designing Solutions	●	●	●	●	●	●	●	●	●	●	●	●
Engaging in Argument from Evidence	●	●	●	●	●	●	●	●	●	●	●	●
Obtaining, Evaluating and Communicating Information	●	●	●	●	●	●	●	●	●	●	●	●
NGSS - *Disciplinary Core Ideas*	ESS2.C	ESS2.C	ESS2.C LS2.A	LS2.A	ESS3.A LS2.B	ESS3.C LS2.C	ESS2.C LS2.A	ESS3.C	LS2.A	LS2.A PS1.B	ESS2.C	LS2.A,B
NGSS - *Cross-Cutting Concepts*												
Patterns	●	●	●	●	●	●	●	●	●	●	●	●
Cause and Effect	●	●	●	●	●	●	●	●	●	●	●	●
Scale, Proportion, Quantity	●	●	●	●	●	●	●	●	●	●	●	●
Systems and System Models			●	●	●	●	●	●	●	●	●	●
Energy and Matter			●	●	●	●	●	●	●	●	●	●
Structure and Function			●	●	●	●	●	●	●	●	●	●
Stability and Change	●	●	●	●	●	●	●	●	●	●	●	●
Common Core – Math	MP.2	RP.A.2	MP.4	SP.B.5	6.SP.B.5	MP.4	7.RP.A.2	6.RP.A.1	6.SP.B.5	6.SP.B.5	MP.2	6.RP.A.3
Common Core – ELA/Literacy	RST.6-8.9 WHST.6-8.7	RST.6-8.1 WHST.6-8.2	RST.6-8.7 WHST.6-8.2	RST.6-8.9 WHST.6-8.2	RST.6-8.1 WHST.6-8.2	RST.6-8.7 WHST.6-8.7	RST.6-8.1 WHST.6-8.2	RST.6-8.9 WHST.6-8.2	RST.6-8.7 WHST.6-8.7	RST.6-8.1 WHST.6-8.2	RST.6-8.9 WHST.6-8.7	RST.6-8.1 WHST.6-8.2

Initial Site Assessment and Observations

In this investigation, students will make and record observations of the site they will be monitoring. This will familiarize them with the site and serve as baseline data to compare with future visits.

Time: *45 minutes*

When: *First visit to monitoring site*

Suggestions: *Be sure to refer back to this assessment before each trip to the site.*

Learning Objectives:

Students will demonstrate the ability to:

- *know the difference between observation and inference.*
- *make observations using their senses.*
- *use a map to identify and record key features of the site.*

Materials: *Scavenger Hunt sheet, Initial Site Assessment Data sheet, pencils, map, markers*

Standards:

NGSS (DCI):

- *Elementary: ESS2.A-B,E ESS3.C*
- *Middle: ESS2.C*

Refer to standards matrix *for complete grade-level listing of all current and common core standards*

Why are observations important?

We all live in a watershed, an area of land in which water drains to the lowest point - ponds, streams, lakes and rivers. What we do on the land affects the water quality of those bodies of water. However, many students may not spend much time outdoors. Ponds, streams, lakes and rivers may be unfamiliar places about which students have thought very little. The best way to begin to know a place is to make observations.

Observations, using as many senses as possible, help students focus on the environment around them. Observations train them to detect patterns, changes, similarities and differences. They become more aware and awareness leads to questions which lead to inquiry. Observations are the first step to thinking scientifically.

The first time out to a new location can be overwhelming. Students may not yet have a context for what they are observing and don't know how or what to observe. This activity guides students in their examination of the field site and collection of initial observations which will be used during the whole monitoring experience. This initial investigation will be the reference point for the year's monitoring. Prompts like water level, leaves, stream speed, substrate and visibility of the water body bottom will build on seasonal changes.

Vocabulary: watershed, observation, inference, riparian zone, canopy, invasive species, erosion, substrate, discharge, meandering, channelized, residential, commercial

Developed by Vancouver Water Resources Education Center with funding from the WA Department of Ecology

Engage *(classroom, pre-field)*

1. Observe a photograph: Practice observing by showing students a photograph. The photograph can be of almost anything but one of the monitoring location or other body of water is appropriate. Include some action in the photo – students, wind, animals, etc. Ask the students to give you their observations, not their inferences; just what they see, not what they think is happening. For example, the trees along a stream have no leaves (observation). The trees are dead (inference).
2. Observe with other senses. Bring in rocks, leaves, flowers etc. Have students "observe" with their eyes closed.
3. Brainstorm: What do you think your monitoring site might look like? Will there be plants? Garbage? Wildlife? Footpaths? Drainage pipes? Fish?
4. Project WET * Activity : Blue River

Explore *(field activity)*

Materials:

- Scavenger Hunt sheet
- Data sheet
- Pencils
- Markers

1. As students approach the monitoring site, request that they cease talking and walk quietly, listening.
2. Initial Observations: At the site, allow students to spread out (arm's length apart) and make initial observations without talking to one another. Ask them to close their eyes for 30 seconds and listen. What do they hear? Ask them to keep their eyes closed and take a deep breath. What do they smell? Now have them open their eyes and ask, "What do you feel?" and let them feel the water, the air, the soil and the plants (avoiding plants such as poison oak or stinging nettles!).
3. Scavenger Hunt: Let students pair up with a buddy and give them a copy of the Scavenger Hunt page. Feel free to adapt it to your site. The object is to focus their observations as they explore the site. Set distance and time boundaries for their exploration. Discuss their findings.
4. Data Sheet: As a large group or as groups of 4-5 students (if chaperones or student leaders are available), continue with observations by filling out the Initial Site Assessment Data Sheet. Most of the observations on this sheet will not change substantially during the course of your monitoring and can be referenced before each trip to the site. Make sure students understand what they are observing.
5. Map: Have students draw a map of the site. Include the body of water, human landmarks such as bridges and paths, vegetation and landforms such as rocks and ledges. Label each feature and indicate the direction of water flow, if appropriate, and compass directions. If students have difficulty creating maps, a template may be created in the classroom with the outline of the stream and a few key features. This template can be reproduced for each pair of students. Students can then fill in the details as above and label them. The template sheets can be laminated and reused if the students use erasable markers.

Explain *(post-field, classroom)*

1. Direct instruction of background information
2. Discussion of results
3. Develop a claim based on evidence – for example:
   - What do our results tell us about the health of the riparian zone?
   - Based on our observations, what is the potential for significant erosion at our site?

Evaluate *(field or classroom)*

1. How is the land being used by people around your body of water? How might that affect the water quality?
2. Was there evidence of pollution? From where might it be coming?
3. What questions do you have for the next site visit?
4. What key features and patterns did you observe? Are they natural or human-made?

Extend *(post-field, classroom)*

1. Students could examine topographic maps of their watershed. They could calculate the watershed area, total stream length or lake area, and determine gradient.
2. Based on their experience, students could develop the scavenger hunt for next year's class.
3. Project WET * Activity: Color Me a Watershed

Resources

- http://www.mswildlife.org/media/AASStreamsidesurveyform.pdf
- http://nwnature.net/cam/science/wq/docs/wq_data.pdf
- http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm
- Mark K. Mitchell, William B. Stapp, 2008, Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools, 13th Edition, Kendall Hunt Publishing
- Riparian and Aquatic Ecosystem Monitoring: A Manual of Field and Lab Procedures, 4th Edition, 2003, Student Watershed Research Project, Portland State University

*See "Guidelines to Investigations" for Project WET activities information

Watershed Monitoring Network Initial Site Assessment Data Sheet

Watershed: ________________________ Names: ________________________

Location: ________________________ Class: ________________________

Site: ________________________ Date: ____________ Time: ________

1. Land Use:

___ Forest ___ Wetlands ___ Park ___ School
___ Crops ___ Pasture/fields ___ Residential ___ Commercial
Other/Comments: ________________________
a) Discharge pipes: ___ No evidence ___ Residential ___ City ___ Industrial
b) Other discharges: ________________________
c) Litter: ___Yes ___ No Type: ________________________

2. Riparian Zone:

a) Width: ___ <20 ft. ___ 20 – 40 ft. ___ 40 – 60 ft. ___ >60 ft.
b) Canopy cover: ___ Open (< 60% cover) ___ Closed (> 60% cover)
c) Bank cover: ___ Grasses ___Forbs ___ Shrubs ___ Blackberry ___ Trees ___ No plants
d) Invasive species: ___ Present ___ Absent Type: ________________________

3. Bank Stability and Erosion:

a) Bank material: ___ Clay ___ Rocks ___ Stones ___ Dirt ___ Mud
b) Bank slope: ___ Steep ___ Moderate ___ Slight
c) Bank condition: ___ Undercut ___ Slightly eroded ___ Moderately eroded
___ Severely eroded ___Riprap ___ Concrete ___ Natural
d) Evidence of erosion control: ___ No ___ Yes – type: ________________________

4. Stream Channel:

a) Condition: ___ Meandering (curvy) ___ Channelized (straight)
b) Estimated width: ___ <10 ft. ___ 10 – 25 ft. ___ 25 – 50 ft. ___ > 50ft.
c) Estimated depth: ___ < 6 in. ___ 6 – 12 in. ___ 13 – 24 in. ___ 25 – 36 in.
___ 36 – 72 in. ___ > 72 in.
d) Estimated speed: ____________
e) Estimated percent: Riffle: _______ Glide: _______ Pool: ________

5. Lake or Pond:

a) Condition: ___ Dredged ___ Silted-in ___ Natural ___ Dam present
b) Estimated width: ____________
c) Estimated depth: ____________

6. Substrate (Water body bottom): Rank 1 (the most) to 4 (the least)

a) Inorganic material: ___ Boulders (>12 in.) ___ Cobble (3-12 in) ___ Gravel (.25-3 in.)
___ Sand/Silt (<.25 in.)
b) Compacted: ___ Yes ___ No
c) Organic substrate: ___ Muck ___ Detritus ___ Leaves ___ Branches ___ Logs, root wads
d) Living substrate: ___ Aquatic submerged plants ___ Aquatic emerged plants
___ Algae: ___ Floating mats or globs ___ Attached ___ Suspended

7. Water:

a) Odor: ___ None ___ Fishy ___ Sewage ___ Chlorine ___ Rotten eggs ___ Chemical
b) Color: ___ Clear ___ Brownish ___ Greenish ___ Milky ___ Orange ___ Gray
c) Clarity: ___ Clear ___ Slightly turbid ___ Turbid ___ Opaque

8. Weather:

a) Rain in the last two days: ___ None ___ Trace ___ Light ___ Moderate ___ Heavy
b) Wind: ___ None ___ Light breeze ___ Breezy ___ Windy
c) Cloud cover: ___ Clear ___ Partly cloudy ___ Mostly cloudy ___ Overcast

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Watershed Monitoring Network Initial Site Assessment Data Sheet (metric)

Watershed: ___________________________________ Names: ______________________________

Location: ______________________________________ Class: _______________________________

Site: ____ Date: _________________ Time: _________

1. Land Use:

___ Forest ___ Wetlands ___ Park ___ School
___ Crops ___ Pasture/fields ___ Residential ___ Commercial
Other/Comments: ____
a) Discharge pipes: ___ No evidence ___ Residential ___ City ___ Industrial
b) Other discharges: ____
c) Litter: ___Yes ___ No Type: ____

2. Riparian Zone:

a) Width: ___ < 6 m ___ 6 – 12 m ___ 12– 18 m ___ > 18 m
b) Canopy cover: ___ Open (< 60% cover) ___ Closed (> 60% cover)
c) Bank cover: ___ Grasses ___Forbs ___ Shrubs ___ Blackberry ___ Trees ___ No plants
d) Invasive species: ___ Present ___ Absent Type: __________________________________

3. Bank Stability and Erosion:

a) Bank material: ___ Clay ___ Rocks ___ Stones ___ Dirt ___ Mud
b) Bank slope: ___ Steep ___ Moderate ___ Slight
c) Bank condition: ___ Undercut ___ Slightly eroded ___ Moderately eroded
___ Severely eroded ___Riprap ___ Concrete ___ Natural
d) Evidence of erosion control: ___ No ___ Yes – type: ________________________________

4. Stream Channel:

a) Condition: ___ Meandering (curvy) ___ Channelized (straight)
b) Estimated width: ___ < 3 m ___ 3 – 6 m ___ 6 - 10 m ___ > 10 m
c) Estimated depth: ___ <15 cm ___ 16 – 30 cm ___ 31 – 60 cm ___ 61 – 90 cm.
___ 91 – 182 cm ___ > 182 cm
d) Estimated speed: ___________________
e) Estimated percent: Riffle: _______ Glide: _______ Pool: _________

5. Lake or Pond:

a) Condition: ___ Dredged ___ Silted-in ___ Natural ___ Dam present
b) Estimated width: ______________
c) Estimated depth: ______________

6. Substrate (Water body bottom): Rank 1 (the most) to 4 (the least)

a) Inorganic material: ___ Boulders (>30 cm) ___ Cobble (7 - 30 cm) ___ Gravel (.5 - 7 cm)
___ Sand/Silt (<.5 cm)
b) Compacted: ___ Yes ___ No
c) Organic substrate: ___ Muck ___ Detritus ___ Leaves ___ Branches ___ Logs, root wads
d) Living substrate: ___ Aquatic submerged plants ___ Aquatic emerged plants
___ Algae: ___ Floating mats or globs ___ Attached ___ Suspended

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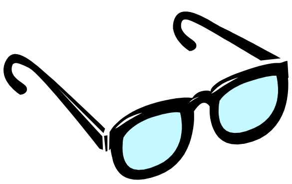
SCAVENGER HUNT

Use your senses (Feel, Listen, See, Smell)

- ☐ Something cool
- ☐ Something warm
- ☐ Something rough
- ☐ Something smooth

- ☐ A bird singing
- ☐ Water flowing over rocks
- ☐ Traffic
- ☐ Construction
- ☐ Leaf blower or lawn mower
- ☐ Wind
- ☐ Insect noise



- ☐ Toothed leaf
- ☐ Scat (animal waste)
- ☐ Tree taller than a streetlight
- ☐ Plant with thorns
- ☐ Animal tracks
- ☐ Plant in the water

- ☐ Earthy dirt
- ☐ Odorless water
- ☐ Fragrant flower
- ☐ Cars or traffic

3 signs of humans:

1. ______________________________
2. ______________________________
3. ______________________________

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Time: *45 minutes*

When: *First visit to monitoring site*

Suggestions: *Be sure to refer back to this assessment before each trip to the site.*

Learning Objectives:

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Materials: *Scavenger Hunt sheet, Initial Site Assessment Data sheet, pencils, map, markers*

Standards:

NGSS (DCI):

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Refer to standards matrix *for complete grade-level listing of all current and common core standards*

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Vocabulary: watershed, observation, inference, riparian zone, canopy, invasive species, erosion, substrate, discharge, meandering, channelized, residential, commercial

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Resources

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- http://nwnature.net/cam/science/wq/docs/wq_data.pdf
- http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm
- Mark K. Mitchell, William B. Stapp, 2008, Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools, 13th Edition, Kendall Hunt Publishing
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Other/Comments: ____
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b) Other discharges: ____
c) Litter: ___Yes ___ No Type: ____

2. Riparian Zone:

a) Width: ___ <20 ft. ___ 20 – 40 ft. ___ 40 – 60 ft. ___ >60 ft.
b) Canopy cover: ___ Open (< 60% cover) ___ Closed (> 60% cover)
c) Bank cover: ___ Grasses ___Forbs ___ Shrubs ___ Blackberry ___ Trees ___ No plants
d) Invasive species: ___ Present ___ Absent Type: ______________________________

3. Bank Stability and Erosion:

a) Bank material: ___ Clay ___ Rocks ___ Stones ___ Dirt ___ Mud
b) Bank slope: ___ Steep ___ Moderate ___ Slight
c) Bank condition: ___ Undercut ___ Slightly eroded ___ Moderately eroded
___ Severely eroded ___Riprap ___ Concrete ___ Natural
d) Evidence of erosion control: ___ No ___ Yes – type: ______________________________

4. Stream Channel:

a) Condition: ___ Meandering (curvy) ___ Channelized (straight)
b) Estimated width: ___ <10 ft. ___ 10 – 25 ft. ___ 25 – 50 ft. ___ > 50ft.
c) Estimated depth: ___ < 6 in. ___ 6 – 12 in. ___ 13 – 24 in. ___ 25 – 36 in.
___ 36 – 72 in. ___ > 72 in.
d) Estimated speed: ________________
e) Estimated percent: Riffle: _______ Glide: _______ Pool: _________

5. Lake or Pond:

a) Condition: ___ Dredged ___ Silted-in ___ Natural ___ Dam present
b) Estimated width: ______________
c) Estimated depth: ______________

6. Substrate (Water body bottom): Rank 1 (the most) to 4 (the least)

a) Inorganic material: ___ Boulders (>12 in.) ___ Cobble (3-12 in) ___ Gravel (.25-3 in.)
___ Sand/Silt (<.25 in.)
b) Compacted: ___ Yes ___ No
c) Organic substrate: ___ Muck ___ Detritus ___ Leaves ___ Branches ___ Logs, root wads
d) Living substrate: ___ Aquatic submerged plants ___ Aquatic emerged plants
___ Algae: ___ Floating mats or globs ___ Attached ___ Suspended

7. Water:

a) Odor: ___ None ___ Fishy ___ Sewage ___ Chlorine ___ Rotten eggs ___ Chemical
b) Color: ___ Clear ___ Brownish ___ Greenish ___ Milky ___ Orange ___ Gray
c) Clarity: ___ Clear ___ Slightly turbid ___ Turbid ___ Opaque

8. Weather:

a) Rain in the last two days: ___ None ___ Trace ___ Light ___ Moderate ___ Heavy
b) Wind: ___ None ___ Light breeze ___ Breezy ___ Windy
c) Cloud cover: ___ Clear ___ Partly cloudy ___ Mostly cloudy ___ Overcast

Watershed Monitoring Network Initial Site Assessment Data Sheet (metric)

Watershed: ___________________________________ Names: ______________________________

Location: ______________________________________ Class: _______________________________

Site: ____ Date: _________________ Time: _________

1. Land Use:

___ Forest ___ Wetlands ___ Park ___ School
___ Crops ___ Pasture/fields ___ Residential ___ Commercial
Other/Comments: ____
a) Discharge pipes: ___ No evidence ___ Residential ___ City ___ Industrial
b) Other discharges: ____
c) Litter: ___Yes ___ No Type: ____

2. Riparian Zone:

a) Width: ___ < 6 m ___ 6 – 12 m ___ 12– 18 m ___ > 18 m
b) Canopy cover: ___ Open (< 60% cover) ___ Closed (> 60% cover)
c) Bank cover: ___ Grasses ___Forbs ___ Shrubs ___ Blackberry ___ Trees ___ No plants
d) Invasive species: ___ Present ___ Absent Type: __________________________________

3. Bank Stability and Erosion:

a) Bank material: ___ Clay ___ Rocks ___ Stones ___ Dirt ___ Mud
b) Bank slope: ___ Steep ___ Moderate ___ Slight
c) Bank condition: ___ Undercut ___ Slightly eroded ___ Moderately eroded
___ Severely eroded ___Riprap ___ Concrete ___ Natural
d) Evidence of erosion control: ___ No ___ Yes – type: ____________________________________

4. Stream Channel:

a) Condition: ___ Meandering (curvy) ___ Channelized (straight)
b) Estimated width: ___ < 3 m ___ 3 – 6 m ___ 6 - 10 m ___ > 10 m
c) Estimated depth: ___ <15 cm ___ 16 – 30 cm ___ 31 – 60 cm ___ 61 – 90 cm.
___ 91 – 182 cm ___ > 182 cm
d) Estimated speed: ___________________
e) Estimated percent: Riffle: _______ Glide: _______ Pool: _________

5. Lake or Pond:

a) Condition: ___ Dredged ___ Silted-in ___ Natural ___ Dam present
b) Estimated width: ______________
c) Estimated depth: ______________

6. Substrate (Water body bottom): Rank 1 (the most) to 4 (the least)

a) Inorganic material: ___ Boulders (>30 cm) ___ Cobble (7 - 30 cm) ___ Gravel (.5 - 7 cm)
___ Sand/Silt (<.5 cm)
b) Compacted: ___ Yes ___ No
c) Organic substrate: ___ Muck ___ Detritus ___ Leaves ___ Branches ___ Logs, root wads
d) Living substrate: ___ Aquatic submerged plants ___ Aquatic emerged plants
___ Algae: ___ Floating mats or globs ___ Attached ___ Suspended

7. Water:

a) Odor: ___ None ___ Fishy ___ Sewage ___ Chlorine ___ Rotten eggs ___ Chemical
b) Color: ___ Clear ___ Brownish ___ Greenish ___ Milky ___ Orange ___ Gray
c) Clarity: ___ Clear ___ Slightly turbid ___ Turbid ___ Opaque

8. Weather:

a) Rain in the last two days: ___ None ___ Trace ___ Light ___ Moderate ___ Heavy
b) Wind: ___ None ___ Light breeze ___ Breezy ___ Windy
c) Cloud cover: ___ Clear ___ Partly cloudy ___ Mostly cloudy ___ Overcast

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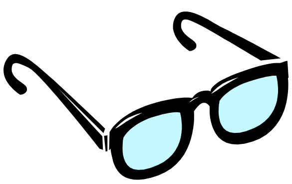
SCAVENGER HUNT

Use your senses (Feel, Listen, See, Smell)

- ☐ Something cool
- ☐ Something warm
- ☐ Something rough
- ☐ Something smooth

- ☐ A bird singing
- ☐ Water flowing over rocks
- ☐ Traffic
- ☐ Construction
- ☐ Leaf blower or lawn mower
- ☐ Wind
- ☐ Insect noise



- ☐ Toothed leaf
- ☐ Scat (animal waste)
- ☐ Tree taller than a streetlight
- ☐ Plant with thorns
- ☐ Animal tracks
- ☐ Plant in the water

- ☐ Earthy dirt
- ☐ Odorless water
- ☐ Fragrant flower
- ☐ Cars or traffic

3 signs of humans:

1. ______________________
2. ______________________
3. ______________________

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Photo Point Monitoring

In this investigation, students will learn how to create photo points at their monitoring site to track changes over time. Permanent photo points can be established during the initial site visit and used on subsequent visits. These photos will show how the site changes seasonally and yearly.

Time: *45 minutes to set up the photo points; 15-20 minutes subsequent visits*

When: *Every visit to site*

Suggestions: *IPads are useful to use in this investigation.*
Take your general site map and photos with you at each visit.

Learning Objectives:

Students will demonstrate the ability to:

- *problem solve to determine the best location for photo points.*
- *take a compass bearing.*
- *take consecutive photographs of the site from the same location.*
- *accurately track changes over time.*

Materials: *Data sheets, pencils, tape measure, camera, GPS, compass, photo identification labels, one-meter stake (optional), stakes (optional)*

Standards:

NGSS (DCI):

- *Elementary: ESS2.A-B,E*
- *Middle: ESS2.C*

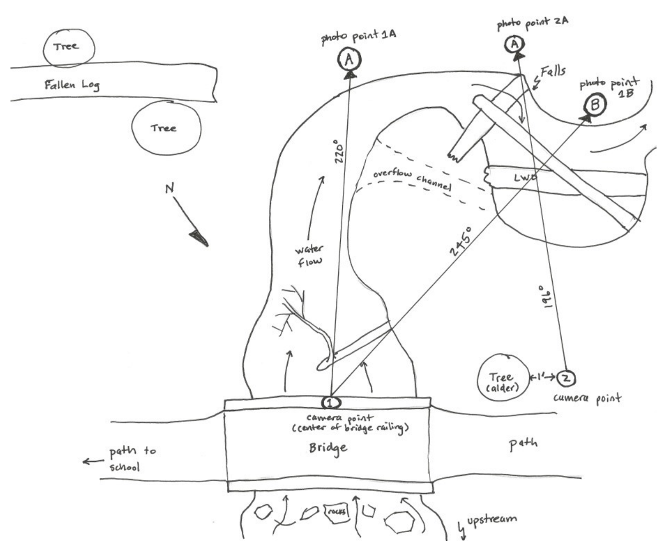
Refer to standards matrix *for complete grade-level listing of all current and common core standards*

Why use photo point monitoring?

Photo point monitoring is a way to visually document changes at the monitoring site over time. It is a useful tool to accurately recall what the site looked like on previous visits. Changes in water flow and depth, bank stability, erosion and riparian vegetation can be recorded at different seasons and over the years.

This procedure focuses on photographing changes around specific objects, or features, at the monitoring site such as stream banks, large woody debris or man-made structures. Changes in stream profiles can be tracked with upstream and downstream photos. This can also be used to take "before" and "after" pictures to document restoration projects.

Camera points, where the camera is set, are established so that the desired features can be photographed. These are permanent landmarks such as trees, buildings, fences, landforms or steel stakes. Photo points are where the camera lens is pointing. A camera point can have several photo points. It is important to make an accurate sketch of the area showing the location of the camera and photo points so they can be relocated on the next visit.



Vocabulary: *camera point, photo point, compass bearing, GPS, permanent landmark, true north, magnetic north*

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Engage *(classroom, pre-field)*

1. Show students "before" and "after" photographs. They can be of anything that shows change (hair cuts, home improvement projects, etc.) Have students make observations to identify the changes. Then show students "before" and "after" photographs of a restoration project. Talk about the goals of such a project and ask students to provide evidence from the photos to support the claim that the project was successful. Make sure students provide written explanations that support their claims.
2. Allow students to take pictures of a designated area with their cell phones. See if two or more can duplicate the same photo. They will have to determine where the first photo was taken, the height of the camera from the ground, the distance to the area photographed and the angle of the camera.
3. Practice using a compass. There are activities such as this one available on the web: www.brighthubeducation.com/lesson-plans-grades-3-5/96243-teaching-students-how-to-use-a-compass/

Explore *(field activity)*

Materials:

- Camera
- GPS
- Compass
- Photo identification labels
- Data sheets
- Clipboard
- One-meter stake (optimal)
- Permanent stakes (optional)

1. Enter information onto the first page of the Photo Point Permanent Record data sheet. Taking good notes and providing details now will make it easier to find and use the photo points next time. Include a sketch of the site showing the location and direction of the camera and photo points as you establish them.
2. Choose the features that are to be photographed. Find a permanent landmark for the camera point – from where photos will always be taken – that includes the features. Make sure that vegetation growth will not obscure the photo area in the future. If a permanent landmark is not available, a stake may be placed (with permission from the landowner, city or county). Take a compass bearing between the camera and the center of the photo point and record. Be sure to indicate if the bearing is based on true north or magnetic north .
3. Take a GPS reading and record on the Photo Log.
4. Fill out the Photo Identification Label. One can be made for each shot or the label can be laminated, filled out with a dry erase marker, wiped clean and reused. Bright blue paper is recommended for the label as it photographs better than white in many lighting conditions. Use numbers to designate the camera point and letters to designate the photo points.
5. Place the label on the clip board and place it in a lower corner of the shot. The writing should be clearly legible. Another student may hold the label in the frame instead. A one-meter stake (one meter tall, 6 to 8 inches wide, marked and numbered in 10 cm intervals) may be used as a height reference for the photo. Place it 5 to 10 meters from the camera near the center of the photo area.
6. Take the photo.
7. Measure the height of the camera and record on the Photo Log.
8. Measure the distance from the camera to the photo point and record on the Photo Log.
9. Repeat with the next photo point. At a minimum, choose one camera point and three photo points.

10. Transfer the Data from the Photo Log onto General Site map. See example on page 1.

Explain *(post-field, classroom)*

1. Direct instruction of background information.
2. Print the photographs and assemble them in a binder in page protectors. Include the Photo Point Permanent Record Data Sheet and Photo Log. Take this binder the next time the site is visited and use as a reference to accurately set up subsequent photographs.
3. Compare the latest photographs with previous ones and record any changes.
4. Develop a claim based on evidence – for example:
   - How has the site changed since the last visit?
   - How has the site changed since this time last year?

Evaluate *(field or classroom)*

1. Have students draw a sketch of their own photo point locations in the classroom, then exchange sketches to see if others can find their photo points from the sketch.
2. Have students demonstrate their ability to use a compass in a scavenger hunt.
3. What is the difference between true north and magnetic north?

Extend *(post-field, classroom)*

1. Students may assemble a portfolio of historical pictures showing change over time in their watershed.
2. Students may choose a feature around their home and photograph it over time to show changes.
3. Students can use Google maps to see photos taken at different years for some places.

Resources

- Hall, Fredrick C. 2001. Photo point monitoring handbook; www.fs.fed.us/pnw/pubs/gtr526/
- OWEB Guide to Photo Point Monitoring: http://www.oregon.gov/OWEB/docs/pubs/PhotoPoint_Monitoring_Doc_July2007.pdf
- Stream Webs; www.streamwebs.org/resources/data-sheets
- Student Watershed Research Project; www.swrp.esr.pdx.edu/publications/manual/manual_main.htm

Photo Point Permanent Record Data Sheet

Site: ______________________________ Established by: _______________________ Date:_______

Site Description:
____

____

____

Goals for Photo Point Monitoring: ____

Photo Frequency: __ Every visit __ Fall __ Winter __ Spring __ Summer __ Once per year: __________

General Site Map: Draw a bird's eye view of the site. Include a north arrow and landmarks. Enter the camera points and photo points as they are established by their number. Add an arrow showing the direction from the camera to the photo point.

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Photo Log

Camera Point # ____

Photo Point # _____ Compass Bearing ____________________ true N magnetic N (circle one)

GPS Coordinates: ______________________ Notes:

Camera height: _______________________

Distance: __________________________

Camera Point # ____

Photo Point # _____ Compass Bearing ____________________ true N magnetic N (circle one)

GPS Coordinates: ______________________ Notes:

Camera height: _______________________

Distance: __________________________

Camera Point # ____

Photo Point # ______ Compass Bearing ____________________ true N magnetic N (circle one)

GPS Coordinates: ______________________ Notes:

Camera height: _______________________

Distance: __________________________

Camera Point # ____

Photo Point # _____ Compass Bearing ____________________ true N magnetic N (circle one)

GPS Coordinates: ______________________ Notes:

Camera height: _______________________

Distance: __________________________

Camera Point # ____

Photo Point # _____ Compass Bearing ____________________ true N magnetic N (circle one)

GPS Coordinates: ______________________ Notes:

Camera height: _______________________

Distance: __________________________

DATE:________ TIME:___________

SITE:____________________________

CAMERA: 1 2 3 4 5

PHOTO: A B C D E

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Water Quality: Temperature, pH and Dissolved Oxygen

In this investigation, students will measure the air temperature, and the temperature, pH and dissolved oxygen of the water at their monitoring site.

Time: *15-20 minutes*

When: *Every visit to site*

Suggestions: *This activity uses CHEMetrics kits. Other kits are available from Hach and LaMotte with different directions.*

Learning Objectives:

Students will demonstrate the ability to:

- *describe the impact of temperature, pH and dissolved oxygen on aquatic organisms.*
- *measure temperature, pH and dissolved oxygen.*
- *develop a claim based on evidence.*

Materials: *thermometer, pH meter or color comparator, dissolved oxygen test kit, goggles, rinse water, Water Quality data sheet, waste container*

Note: *Use the same Water Quality data sheet for all water quality tests*

Standards:

NGSS (DCI):

- *Elementary: PS1.A*
- *Middle: LS2.A*

Refer to standards matrix *for complete grade-level listing of all current and common core standards*

Why is temperature, pH, and dissolved oxygen important to water quality?

Temperature – Temperature affects aquatic organisms in a variety of ways. The body temperature of most aquatic organisms is the same as the surrounding water and fluctuates with the water temperature. Most aquatic organisms are adapted to live in a narrow temperature range and they die when the temperature becomes too low or too high. Temperature affects their metabolism, reproduction and emergence. Temperature also affects the rate of photosynthesis of aquatic plants, the base of the aquatic food web. Pollutants can become more toxic at higher temperatures. The amount of dissolved oxygen becomes lower as the water becomes warmer. Temperature is measured in degrees Fahrenheit or Celsius (Centigrade).

pH – pH is the measure of hydrogen ions, or acidity, in the water. Water has hydrogen ions and hydroxyl ions. When there are equal numbers of both, the water is neutral. As the hydrogen ions increase, the water becomes more acidic; as the hydroxyl ions increase, the water becomes more basic. pH is measured on a logarithmic scale of 0 – 14: 7 is neutral; below 7 is acidic; above 7 is basic. Most aquatic organisms have a narrow pH tolerance range of 6.5 – 8.5. Acidic waters can cause toxic heavy metals to be released into the water. Acid rain and mining operations can lower the pH of water bodies.

Dissolved Oxygen – Most aquatic organisms need oxygen to survive. Dissolved oxygen is the oxygen present in water available to aquatic organisms. It is not the oxygen that is part of the water molecule but rather oxygen gas. Oxygen enters the water from the air through rain, turbulence and wind, and through the photosynthesis of aquatic plants. Organisms absorb the oxygen through structures such as gills or their skin. Waters with higher dissolved oxygen have ecosystems that are generally more diverse and stable. Decomposition of organic material is a major cause of low dissolved oxygen resulting in fewer species. Dissolved oxygen is measured in parts per million (ppm) or milligrams per liter (mg/L).

Vocabulary: temperature, pH, dissolved oxygen, acid, base, parts per million, milligrams per liter

Engage *(classroom, pre-field)*

1. Temperature:
   a. Set up an experiment to compare air temperature and water temperature change over time (water changes temperature more slowly than air).
   b. Set up an experiment showing the effect of temperature on dissolving substances (such as sugar or salt) in water. (More salt or sugar can dissolve at higher temperatures).
2. pH: Test the pH of various liquids, such as lemon juice, vinegar, milk and ammonia, using litmus paper.
3. Dissolved oxygen: Have students participate in a demonstration or experiment of how gas dissolves in water and how colder water can hold more gas than warm (http://www.middleschoolchemistry.com/lessonplans/chapter5/lesson8)

Explore *(field activity)*

Temperature

Materials:

- Dial or digital thermometer
- Water Quality data sheet

Dial Thermometer:

1. Remove thermometer from its protective cover. Push the end of the thermometer through the loop or hole in the side of the cover. This turns the cover into a handle – do not hold the thermometer rod itself. Hold with dial facing up so you can read it.
2. Air temperature: hold the thermometer by the handle away from your body above the water. Wait at least 1 minute. Read the temperature (each line is 2° C).
3. Water temperature: hold the thermometer by the handle and place the end in the water. Wait 1 minute. Read the temperature (each line is 2° C). Repeat 2 more times.

Digital Thermometer:

1. Remove the protective cover from the end of the thermometer. Turn the thermometer on.
2. Air temperature: hold the thermometer by the handle away from your body above the water. Wait 1 minute. Read the temperature.
3. Water temperature: hold the thermometer by the handle and place the other end in the water. Do not submerge the entire thermometer. Wait 1 minute. Read the temperature. Repeat 2 more times.

pH

Materials:

- pH meter
- Water Quality data sheet

or

- pH color comparison test kit
- Goggles
- Waste container
- Rinse water (distilled)
- Water Quality data sheet

pH meter:

1. Remove cap from narrow end of meter.
2. Turn meter on.
3. Place narrow end of meter in water to be tested (about two inches on the meter).
4. Wait at least 2 minutes for the meter to read the pH. The numbers on the screen should stop moving.
5. Record the pH.
6. Repeat 2 more times

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Explore *(field activity)*

pH

Color comparator

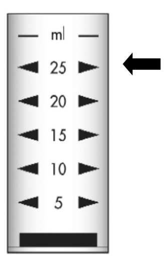
1. Put on goggles.
2. Fill the tube to the 5 mL mark with sample water.
3. Add 10 drops of wide range indicator solution.
4. Cap and shake to mix.
5. Place tube in the comparator and match its color with the closest color in the comparator.
6. Record the pH from the closest color.
7. Pour the treated sample into waste container. Rinse the sample tube with distilled water and pour into waste container.

Dissolved Oxygen

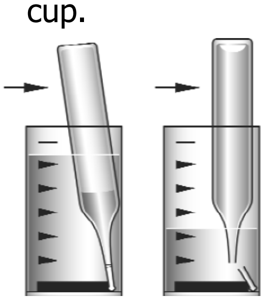
Materials:

- CHEMetrics dissolved Oxygen kit (K-7152)
- Goggles
- Waste container
- Rinse water (distilled)
- Thermometer
- Water Quality data sheet

1. Put on goggles.
2. Fill the sample cup to the 25 mL mark with the water to be tested.



3. Place the ampoule in the sample cup. Snap the tip by pressing the ampoule against the side of the cup. The ampoule will fill, leaving a small bubble. Remove the ampoule from the cup.



4. Mix the contents of the ampoule by turning it several times, allowing the bubble to travel from end to end. **Wait 2 minutes for color development.**
5. Hold the comparator with the colored tubes in a vertical position while standing directly beneath a source of light. Place the ampoule between the color standards moving it from left to right along the comparator until the best color match is found. If the color of the ampoule is between two color standards, a concentration estimate can be made. Record your result.
6. Place the ampoule and water sample in the waste container. Rinse the sample cup with distilled water and pour into waste container.
7. Measure the water temperature with the thermometer and record your result.

Explain *(post-field, classroom)*

1. Dissolved oxygen – Calculate the percent saturation:
   - Use the following table to determine 100 percent DO saturation at the water temperature you measured.
   - Divide the measured DO by the DO from the table and multiply by 100 to get the percent saturation.

Temperature (degrees C)	**DO (mg/L)**	**Temperature (degrees C)**	**DO (mg/L)**
0	14.60	23	8.56
1	14.19	24	8.40
2	13.81	25	8.24
3	13.44	26	8.09
4	13.09	27	7.95
5	12.75	28	7.81
6	12.43	29	7.67
7	12.12	30	7.54
8	11.83	31	7.41
9	11.55	32	7.28
10	11.27	33	7.16
11	11.01	34	7.05
12	10.76	35	6.93
13	10.52	36	6.82
14	10.29	37	6.71
15	10.07	38	6.61
16	9.85	39	6.51
17	9.65	40	6.41
18	9.45	41	6.31
19	9.26	42	6.22
20	9.07	43	6.13
21	8.90	44	6.04
22	8.72	45	5.95

2. Review background information on temperature, pH and dissolved oxygen.
3. Compare results with previous data, if available. Make a graph of the results and previous data.
4. Compare results with water quality standards. Washington State Surface water quality standards can be found at: www.ecg.wa.gov/programs/wq/swqs
5. Develop a claim based on evidence, for example:
   - What do our results tell us about the health of our water body?
   - Based on our results, do you think salmon could live here?

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Evaluate *(field or classroom)*

1. What are some ways that human activities affect the temperature of water bodies? How can we restore or maintain good water temperatures?
2. Draw the pH scale and show where the pH of lemon juice, milk and ammonia lie. Then show the best range for aquatic life, the pH of normal rain and the pH of acid rain. Finally, show the pH where salmon do well, where reproduction is affected and where they die.
3. Draw a picture of water molecules and oxygen molecules at cold temperature and one of the molecules at hot temperature. Discuss the difference between the two pictures.

Extend *(post-field, classroom)*

1. Research the effect of dams on river water temperature and dissolved oxygen both upstream and downstream of the dam.
2. Choose a geographical location that has experienced acid rain. Research the sources, the impact and the steps being taken or that should be taken to reduce the impact.
3. Conduct a biochemical oxygen demand experiment on water collected from the monitoring site (http://water.epa.gov/type/rsl/monitoring/vms52.cfm).

Resources

- Mark K. Mitchell, William B. Stapp, 2008, Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools, 13th Edition, Kendall Hunt Publishing
- Riparian and Aquatic Ecosystem Monitoring: A Manual of Field and Lab Procedures, 4th Edition, 2003, Student Watershed Research Project, Portland State University
- The Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods, 5th edition, 2001, Tom Murdoch; Martha Cheo; Kate O'Laughlin; Adopt-A-Stream Foundation.

- There are many websites available with more background information and procedures.

Watershed Monitoring Network Water Quality Data Sheet

1. Weather:

a) Rain in the last two days: ___ None ___ Trace ___ Light ___ Moderate ___ Heavy

b) Wind: ___ None ___ Light breeze ___ Breezy ___ Windy

c) Cloud cover: ___ Clear ___ Partly cloudy ___ Mostly cloudy ___ Overcast

2. Water:

a) Odor: ___ None ___ Fishy ___ Sewage ___ Chlorine ___ Rotten eggs ___ Chemical

b) Color: ___ Clear ___ Brownish ___ Greenish ___ Milky ___ Orange ___ Gray

c) Clarity: ___ Clear ___ Slightly turbid ___ Turbid ___ Opaque

3. Canopy cover: ___ Open (< 60% cover) ___ Closed (> 60% cover)

4. Has anything <u>changed</u> in the following categories?

- Land use: ____
- Riparian zone: ____
- Bank stability and erosion: ______________________________________
- Stream Channel: ____
- Substrate (Water body bottom): ____________________________________

5. Water Quality Data

Test	Trial #1	Trial #2	Trial #3	Average
Air Temperature (°C)				
Water Temperature (°C)				
pH				
Turbidity (cm)				
Dissolved Oxygen (mg/L)				
Nitrate (mg/L)				
Phosphate (mg/L)				

6. Stream Measurements **7. Stream Flow**

Tape Mark	Width (m)	Depth #1 (cm)	Depth #2 (cm)	Depth #3 (cm)	Average Depth		Trial	Time (sec)
0 m							1	
5 m							2	
10 m							3	
Average		- - - -	- - - -	- - - -				

Average width X average depth = area (m^2): ______________

(10m ÷ average time) X 0.8 = velocity (m/sec): ____________ area X velocity = flow (m^3/sec):___________

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Water Quality: Nitrate and Phosphate

In this investigation, students will measure the nitrate and phosphate concentrations in the water at their monitoring site.

Time: *15-20 minutes*

When: *Every visit to site*

Suggestions: *This activity uses CHEMetrics kits. Other kits are available from Hach and LaMotte with different directions.*

Learning Objectives:

Students will demonstrate the ability to:

- *describe the impact of nitrate and phosphate on aquatic organisms.*
- *measure nitrate and phosphate.*
- *develop a claim based on evidence.*

Materials: *nitrate test kit, phosphate test kit, goggles, rinse water, waste container, Water Quality data sheet*

Note: *Use the same Water Quality data sheet for all water quality tests*

Standards:

NGSS (DCI):

- *Elementary: PS1.B*
- *Middle: LS2.A*
  PS1.B

Refer to standards matrix *for complete grade-level listing of all current and common core standards*

Why are nitrate and phosphate important to water quality?

Nitrogen and phosphorus are essential elements for all living organisms. They are used in DNA and chemical processes in the body. Most nitrogen is found in the air and most phosphorus is bound up in rocks and sediments, making them unavailable to organisms. This makes them "limiting factors" – they can limit the amount of growth, particularly of plants. When nitrogen and phosphorus are readily available in a form plants can use, such as nitrate and phosphate, plant growth can explode.

Too much plant growth in the water can have negative effects on aquatic systems. Algae can grow in such numbers as to create a "bloom" that completely covers a lake. Some algal species produce toxins harmful to other organisms. Submerged vegetation can choke off a waterway, preventing boat access or swimming. When all this vegetation dies, it sinks to the bottom and decomposes. The decomposition process depletes the dissolved oxygen in the water making it unfit for aquatic life and leading to the death of macroinvertebrates and fish. This degradation is known as "eutrophication."

Small amounts of nitrate and phosphate occur naturally. Most eutrophication is the result of human activities. Major sources of nitrate and phosphate are fertilizer, sewage and runoff from animal farms. Phosphate also comes from the erosion of phosphate-bearing soil and sediment during human land-altering activities such as construction and mining.

Vocabulary: nitrate, phosphate, dissolved oxygen, limiting factor, eutrophication, organic, parts per million, milligrams per liter, ampoule

Engage *(classroom, pre-field)*

1. Discuss the nitrogen and phosphorus cycles with students.
2. Test water from the tap or an aquarium and discuss the results.
3. Show a video on the effects of eutrophication.

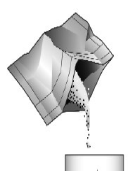
Explore *(field activity)*

Nitrate

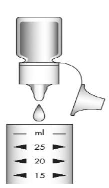
Materials:

- CHEMetrics nitrate test kit (zinc) – K-6905
- Goggles
- Rinse water (distilled)
- Waste container
- Water Quality data sheet

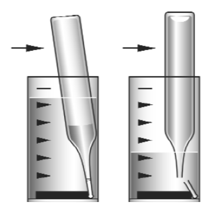
1. Put on goggles.
2. Fill the reaction tube (<u>plastic container with cone-shaped bottom and green cap</u>) to the 15 mL mark with the water sample.
3. Cut open and empty the contents of one zinc foil pack into the reaction tube.



4. Screw the green cap on to the reaction tube and shake it vigorously for exactly 2 minutes.
5. Add 10 drops of the Acidifier Solution to the empty 25 mL sample cup.



6. Pour treated sample from reaction tube into the sample cup, being careful not to get any of the zinc into the sample cup.
7. Place the ampoule in the sample cup. Snap the tip by pressing the ampoule against the side of the cup. The ampoule will fill, leaving a small bubble. Remove the ampoule from the cup.



8. Mix the contents of the ampoule by turning it several times, allowing the bubble to travel from end to end. <u>Wait 10 minutes for color development.</u>
9. Hold the comparator with the colored tubes in a vertical position while standing directly beneath a source of light. Place the ampoule between the color standards moving it from left to right along the comparator until the best color match is found. If the color of the ampoule is between two color standards, a concentration estimate can be made. Record your result.
10. Place the ampoule and water sample in the waste container. Rinse the sample cup with distilled water into waste container.

Developed by Vancouver Water Resources Education Center with funding from the WA Department of Ecology

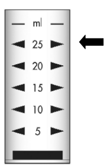
Explore *(field activity)*

Phosphate

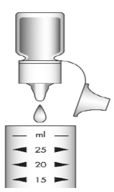
Materials:

- CHEMetrics phosphate kit (K-8510)
- Goggles
- Waste container
- Rinse water (distilled)

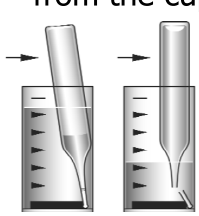
1. Put on goggles.
2. Fill the sample cup to the 25 mL mark with the water to be tested.



3. Add 2 drops of Activator Solution to the sample cup.



4. Place black cap on sample cup and shake it to mix the contents well.
5. Remove cap and place the ampoule in the sample cup. Snap tip by pressing ampoule against the side of the cup. The ampoule will fill leaving a small bubble. Remove ampoule from the cup.



6. Mix contents of ampoule by turning it several times, allowing the bubble to travel from end to end. Wait 2 minutes for color development.

7. Use the appropriate comparator to determine the level of phosphate in sample:

a. Low Range Comparator**:** Place ampoule, flat end downward into the center tube of the round comparator. Direct the top of the comparator up toward a source of light while viewing from the bottom. Rotate comparator until the color standard below the ampoule shows the closest match.

b. High Range Comparator**:** Hold the comparator with the colored tubes in a vertical position while standing directly beneath a source of light. Place the ampoule between the color standards moving it from left to right along the comparator until the best color match is found. Record your result

8. Place the ampoule and water sample in the waste container. Rinse the sample cup with distilled water into the waste container.

Developed by Vancouver Water Resources Education Center with funding from the WA Department of Ecology

Explain *(post-field, classroom)*

1. Review background information on nitrate and phosphate.
2. Compare results with previous data, if available. Make a graph of the results and previous data.
3. Compare results with water quality standards. Washington State surface water quality standards can be found at: www.ecy.wa.gov/programs/wq/swqs
4. Develop a claim based on evidence, for example:
   - What do our results tell us about the health of our water body?
   - Based on our results, do you think salmon could live here?

Evaluate *(field or classroom)*

1. What are some ways that human activities affect the eutrophication of water bodies? How can we restore or maintain good water quality?
2. Draw a picture of the nitrogen cycle and the phosphorus cycle.

Extend *(post-field, classroom)*

1. Set up several aquatic ecosystem tubs or bottles with different amounts of nitrate and/or phosphate. Have students observe them over several weeks and note changes.
2. Test the effect of different amounts of fertilizer on seedling rate of growth.
3. Research the major sources of nitrate and phosphate pollution in your watershed. What can be done to control their input into rivers, lakes and streams?

Resources

- Mark K. Mitchell, William B. Stapp, 2008, Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools, 13th Edition, Kendall Hunt Publishing
- Riparian and Aquatic Ecosystem Monitoring: A Manual of Field and Lab Procedures, 4th Edition, 2003, Student Watershed Research Project, Portland State University
- The Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods, 5th edition, 2001, Tom Murdoch; Martha Cheo; Kate O'Laughlin; Adopt-A-Stream Foundation.
- http://water.usgs.gov/edu/nitrogen.html
- http://enviroliteracy.org/article.php/479.html

- There are many websites available with more background information and procedures.

Watershed Monitoring Network Water Quality Data Sheet

1. Weather:

a) Rain in the last two days: ___ None ___ Trace ___ Light ___ Moderate ___ Heavy

b) Wind: ___ None ___ Light breeze ___ Breezy ___ Windy

c) Cloud cover: ___ Clear ___ Partly cloudy ___ Mostly cloudy ___ Overcast

2. Water:

a) Odor: ___ None ___ Fishy ___ Sewage ___ Chlorine ___ Rotten eggs ___ Chemical

b) Color: ___ Clear ___ Brownish ___ Greenish ___ Milky ___ Orange ___ Gray

c) Clarity: ___ Clear ___ Slightly turbid ___ Turbid ___ Opaque

3. Canopy cover: ___ Open (< 60% cover) ___ Closed (> 60% cover)

4. Has anything changed in the following categories?

- Land use: ____
- Riparian zone: ____
- Bank stability and erosion: ____
- Stream Channel: ____
- Substrate (Water body bottom): ____

5. Water Quality Data

Test	Trial #1	Trial #2	Trial #3	Average
Air Temperature (°C)				
Water Temperature (°C)				
pH				
Turbidity (cm)				
Dissolved Oxygen (mg/L)				
Nitrate (mg/L)				
Phosphate (mg/L)				

6. Stream Measurements

Tape Mark	Width (m)	Depth #1 (cm)	Depth #2 (cm)	Depth #3 (cm)	Average Depth
0 m					
5 m					
10 m					
Average		- - - -	- - - -	- - - -	

7. Stream Flow

Trial	Time (sec)
1	
2	
3	

Average width X average depth = area (m^2): _____________

(10m ÷ average time) X 0.8 = velocity (m/sec): ___________ area X velocity = flow (m^3/sec):__________

Developed by Vancouver Water Resources Education Center with funding from the WA Department of Ecology

Water Quality: Turbidity and Stream Measurements

In this investigation, students will measure the turbidity of the water at their monitoring site. They will also measure stream depth, width and flow.

Time: *Turbidity - 15 minutes*
Stream measurements - 20 minutes

When: *Every visit to site*

Suggestions: *Do turbidity before or upstream of the other tests so the water is not stirred up.*

Learning Objectives:

Students will demonstrate the ability to:

- *measure turbidity and describe its impact on aquatic organisms.*
- *measure depth, width, and flow and describe the impacts that changes in stream measurements have on aquatic organisms.*
- *develop a claim based on evidence.*

Materials: *turbidity tube, tape measures, meter stick, stop watch, Water Quality data sheet*

Standards:

NGSS (DCI):

- *Elementary: ESS2.A*
- *Middle: ESS2.C*

Refer to standards matrix *for complete grade-level listing of all current and common core standards*

How does turbidity impact water quality? What effect do changes in stream depth, width and flow have on water quality?

Turbidity – Turbidity is the measure of the cloudiness of the water. It is caused by particles, such as dirt and algae, suspended in the water. These particles block sunlight and reduce water clarity. The force of moving water suspends the particles. When the water stops moving, the particles sink to the bottom.

Suspended particles can make it difficult for organisms with gills to breathe. When the particles sink, the stream bottom can be covered with a layer of silt which can suffocate fish eggs and macroinvertebrates. The particles reflect sunlight, decreasing the amount available for photosynthesis. The particles also make it difficult for visual predators, such as salmon and trout, to hunt.

Stream measurements – Rivers and streams are dynamic systems. They carry different volumes of water at different seasons and move around within and over their banks, sometimes changing channels. This is referred to as "meandering".

Rainfall, snowmelt and runoff increase stream depth. They also increase stream flow. As the stream fills, the width of the stream may increase. Moving water is a powerful force and can move rocks and large woody debris, reshaping the contours of the stream and depositing gravel, sand and silt.

These changes in stream measurements occur naturally; however human activities can alter the magnitude of the change. Stream channelization may help drain the surrounding land more quickly but often leads to increased flooding downstream. Stormwater runoff through storm drains increase the amount of water entering the stream during a rain event leading to big fluctuations in flow rate and increased erosion. Dams alter water flow and increase the width and depth above the dam.

Vocabulary: turbidity, clarity, particle, suspended, depth, width, stream flow, meander, stream channelization, stormwater runoff, velocity

Developed by Vancouver Water Resources Education Center with funding from the WA Department of Ecology

Engage *(classroom, pre-field)*

1. Turbidity
   a. Use the "Turbidity or Not Turbidity" lesson from Project Wet's "Healthy Water, Healthy People."
   b. Use this lesson from the Smithsonian: http://nationalzoo.si.edu/Education/ClassroomScience/Turbidity/Teacher/default.cfm
2. Stream measurements
   a. Use a stream table to demonstrate how streams change and meander.
   b. Look at historical photos that document changes in stream channels http://andrewsforest.oregonstate.edu/pubs/pdf/pub1990.pdf
   c. Practice using a tape measure and meter stick by measuring different heights and distances in the classroom.

Explore *(field activity)*

Turbidity

Materials:
- Turbidity tube
- Water Quality data sheet

1. Check the clamp at the bottom of the tube to make sure it is closed.
2. Wade into the stream. Lay the tube in the water with the open mouth of the tube facing upstream.
3. Slowly push the tube under the water, keeping the end with the stopper slightly lower than the mouth. Be careful not to touch the bottom of the stream or sediment will get into the tube.
4. When the tube is full, swing the open end up out of the water. Bring it full to the stream bank.
5. Look through the open end of the tube toward the bottom of the tube. Can you see the black and white disk at the bottom of the tube? If you can, record the water height in centimeters.
6. If you cannot see the black and white disk at the bottom of the tube, have one team member release the clamp and allow water to drain out. Another member of the team should look through the open end of the tube toward the bottom and watch until the black and white disk becomes visible. At that point, stop the water draining from the tube and record the water height in the tube in centimeters.
7. Repeat 2 more times

Explore *(field activity)*

Stream Measurements

Materials:

- Two tape measures, at least 10 meters long but as ong as the Stream width.
- Meter stick
- Stop watch
- Water Quality data sheet
- Three sticks the same size

<u>Width and Depth</u>

1. Take one tape measure and stretch it out along the bank for 10 meters. Lay it on the bank out of the water.
2. At the "0" meter mark on the tape measure on the ground, take the other tape measure and stretch it across the stream to measure the width. Measure from water's edge on one side of the stream to water's edge on the other side. Record the width.
3. Use the meter stick to measure how deep the stream is in 3 places across the stream at the "0" meter mark on the tape measure on the ground. Record the depths.
4. Repeat step 2 and 3 at the 5 meter mark and 10 meter mark (on the tape measure on the ground).

<u>Stream Flow</u>

1. Find 3 sticks, each about the size of a magic marker, which will float and are lighter in color than the water.
2. One person stands at the downstream end of the tape measure on the ground. One person stands in the middle with the stop watch. One person takes the sticks and stands at the upstream end of the tape measure.
3. When everyone is ready, the upstream person drops ONE stick into the water and shouts "GO!" as it passes the end of the tape measure. The person with the stop watch immediately starts the stop watch. Watch the stick as it floats down the stream.
4. When the stick floats past the end of the tape measure, the downstream person shouts "Stop!" and the stop watch is stopped. Record the time. Reset the stop watch.
5. Repeat steps 3 and 4 with the remaining sticks. Record your results. Wind up the tape measure.

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Explain *(post-field, classroom)*

1. Review background information on turbidity and stream measurements.
2. Calculate the flow rate: Multiply the average depth by the average width to get the area (square meters). Divide the distance traveled by the sticks (10 m) by the average time and multiple by 0.8 (to account for the roughness of the stream bed) to get the velocity (meters/second). Multiply the area by the velocity to get the flow in cubic meters/ second. See formula at the bottom of the Water Quality data sheet
3. Compare results with previous data, if available. Make a graph of the results and previous data.
4. Compare results with water quality standards. Washington State Surface water quality standards can be found at: www.ecg.wa.gov/ programs/wq/swqs
5. Develop a claim based on evidence, for example:
   - What do our results tell us about the health of our water body?
   - Based on our results, do you think salmon could live here?

Evaluate *(field or classroom)*

1. What are some ways that human activities have affected the turbidity or stream measurements of your stream? How can we restore or maintain good water clarity?
2. Have students demonstrate their ability to correctly read a tape measure and meter stick.

Extend *(post-field, classroom)*

1. Research historical changes in your stream using Google Earth and other historical maps and photographs.
2. A huge storm is dumping 8 inches of rain per hour in your watershed. Construct different scenarios based on the length of the storm and predict the impacts.

References

- Mark K. Mitchell, William B. Stapp, 2008, Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools, 13th Edition, Kendall Hunt Publishing
- Riparian and Aquatic Ecosystem Monitoring: A Manual of Field and Lab Procedures, 4th Edition, 2003, Student Watershed Research Project, Portland State University
- The Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods, 5th edition, 2001, Tom Murdoch; Martha Cheo; Kate O'Laughlin; Adopt-A-Stream Foundation.
- Healthy Water, Healthy People Water Quality Educators Guide, 2003, Project Wet International Foundation
- http://water.usgs.gov/edu/turbidity.html
- There are many websites available with more background information and procedures.

Watershed Monitoring Network Water Quality Data Sheet

1. Weather:

a) Rain in the last two days: ___ None ___ Trace ___ Light ___ Moderate ___ Heavy

b) Wind: ___ None ___ Light breeze ___ Breezy ___ Windy

c) Cloud cover: ___ Clear ___ Partly cloudy ___ Mostly cloudy ___ Overcast

2. Water:

a) Odor: ___ None ___ Fishy ___ Sewage ___ Chlorine ___ Rotten eggs ___ Chemical

b) Color: ___ Clear ___ Brownish ___ Greenish ___ Milky ___ Orange ___ Gray

c) Clarity: ___ Clear ___ Slightly turbid ___ Turbid ___ Opaque

3. Canopy cover: ___ Open (< 60% cover) ___ Closed (> 60% cover)

4. Has anything <u>changed</u> in the following categories?

- Land use: ______________________________
- Riparian zone: ______________________________
- Bank stability and erosion: ______________________________
- Stream Channel: ______________________________
- Substrate (Water body bottom): ______________________________

5. Water Quality Data

Test	Trial #1	Trial #2	Trial #3	Average
Air Temperature (°C)				
Water Temperature (°C)				
pH				
Turbidity (cm)				
Dissolved Oxygen (mg/L)				
Nitrate (mg/L)				
Phosphate (mg/L)				

6. Stream Measurements **7. Stream Flow**

Tape Mark	Width (m)	Depth #1 (cm)	Depth #2 (cm)	Depth #3 (cm)	Average Depth		Trial	Time (sec)
0 m							1	
5 m							2	
10 m							3	
Average		- - - -	- - - -	- - - -				

Average width X average depth = area (m^2): ______________

(10m ÷ average time) X 0.8 = velocity (m/sec): ___________ area X velocity = flow (m^3/sec):___________

Developed by Vancouver Water Resources Education Center with funding from the WA Department of Ecology

Riparian Zone Vegetation Survey

In this investigation, students will determine the canopy cover and diversity of plant species in the riparian zone near their water monitoring site. This information will be used to predict the potential for erosion, the potential for polluted surface waters entering the stream and the presence of wildlife habitat.

What is the relationship between the riparian vegetation zone and water quality?

"Riparian" vegetation refers to the grasses, forbs, shrubs and trees that grow on the banks of a body of water. The width of the riparian vegetation zone and the diversity of the vegetation growing there play an important role in water quality and the prevention of erosion in several ways:

Bank stabilization The roots of plants and trees strengthen and stabilize the banks. Roots also provide a path for water to flow through soil which prevents the soil from becoming too saturated. As the width of the riparian vegetation zone decreases, stream banks erode and wash away. With little or no riparian vegetation, most creeks will nearly double in width and become much more shallow. Shallow waters usually have higher water temperatures. Little or no riparian vegetation also increases the likelihood of invasive plants.

Shade Overhanging trees provide shade which lowers the temperature of the water. Cooler, shaded streams are able to hold more dissolved oxygen and have less algae.

Pollution As a result of development and human activity, water running off surrounding land may contain sediment, fertilizers, animal waste, oil, and other toxic substances. The riparian vegetation acts as a buffer zone between the stream and surrounding land.

Surface water volume Without vegetation, rain runs directly over the land to a stream or water body. Less rainwater is retained in the soil and more water fills the stream to potentially cause flooding. A well-vegetated riparian zone is able to reduce the velocity of the runoff, allowing time for the sediments and pollutants to soak into the soil before runoff enters the body of water.

Wildlife habitat A well-vegetated riparian zone creates a wildlife corridor where birds and other animals can travel freely, as well as providing food, nesting and hiding places. Leaves and branches of riparian plants falling into the water provide a food source for bacteria, macroinvertebrates and fish in the stream. Over 80 percent of all wildlife species in western Washington use riparian areas during part of their life cycle.

Vocabulary: riparian, diversity, bank stability, erosion, pollutant, invasive plants, buffer zone, parallel, perpendicular, dissolved oxygen, canopy cover, forbs

Time: *30 minutes per activity (90 minutes total)*

When: *Fall and Spring*

Suggestions: *Coordinate location with soil permeability investigation.*

Learning Objectives:

Students will demonstrate the ability to:

- *describe the diversity of the riparian zone at their monitoring site.*
- *compare the riparian zone as it changes seasonally.*
- *explain how the riparian zone affects erosion, water quality and wildlife.*
- *use evidence to support a claim.*

Materials: *Data sheet (s), 1 meter x 1 meter PVC frame, two 50 meter measuring tapes, canopy cover tube (see "Guidelines to Investigations" for construction)*

Standards:

NGSS (DCI):

- *Elementary: ESS2.E, ESS3.C, LS1.A-C, LS4.C-D*
- *Middle: ESS2.C, LS2.A*

Refer to standards matrix *for complete grade-level listing of all current and common core standards*

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Engage *(classroom, pre-field)*

1. Show students' photographs of riparian zones that vary in the amount and diversity of vegetation. Have students make claims for the riparian zone that would give the most protection from erosion, have the best wildlife habitat, be most likely to have lower stream temperatures, etc. Make sure students provide written explanations that support their claims.
2. Show students the photograph of a riparian zone with very dense and diverse vegetation. Tell students to identify and count every type of vegetation that is different. Students should start to complain that this is an impossible task. Show them a second photograph that outlines one area of the photograph with a square and have them repeat the task only for the outlined area. Explain that it would be too time consuming for them to identify every plant in their riparian zone, so in the field they will use a one meter PVC frame to randomly sample three areas to develop a r representative sample.

Explore *(field activity)*

Canopy Cover

Materials:

- Tape measure
- Canopy cover tube
- Data sheet

1. See "Guidelines for Investigations" for canopy cover tube construction.
2. Take one tape measure and stretch it out 10 meters along the bank, parallel to the water. Lay it on the bank out of the water.
3. Stand at the zero meter mark (beginning) of the tape measure.
4. Using the canopy cover tube, look through the tube straight up to the sky.
5. Estimate percent canopy cover by observing how many of the four sections are covered by tree leaves and branches. One section is 25%.
6. Record your observation.
7. Move to the 5 meter mark and repeat steps 3-5.
8. Move to the 10 meter mark and repeat steps 3-5.

Plant Diversity Survey Along Water Body

Materials:

- Tape measure
- 1m x 1m PVC frame
- Data sheet

1. See "Guidelines for Investigations" for PVC frame construction.
2. Take one tape measure and stretch it out 10 meters along the bank, parallel to the water. Lay it on the bank out of the water.
3. Stand at the zero meter mark (beginning) of the tape measure.
4. Take a few steps away from the water and place the PVC frame on the ground.
5. Count the number of different types of plants (diversity) and record. Do not count the total number of plants.
6. Estimate the percent of bare soil, leaves and twigs and live plants. Record on data sheet.
7. Move to the 5 meter mark and repeat steps 3-5.
8. Move to the 10 meter mark and repeat steps 3-5.

Explore *(field activity)*

Plant Diversity Away from Water Body

Materials:
- Tape measure
- 1m x 1m PVC frame
- Data sheet

1. Take one tape measure and stretch it out 10 meters along the bank, parallel to the water. Lay it on the bank out of the water.
2. Take a second tape measure and, beginning at the 5 meter mark, stretch it 10 meters perpendicular to the first tape.
3. Stand at 0 meter mark on the second tape.
4. Take a few steps away from the water and place the PVC frame on the ground.
5. Count the number of different types of plants (diversity) and record. Do not count the total number of plants.
6. Estimate the percent of bare soil, leaves and twigs and live plants. Record on data sheet.
7. Move to the 5 meter mark on the second tape and repeat steps 4-6.
8. Move to the 10 meter mark and repeat steps 4-6.

Explain *(post-field, classroom)*

1. Direct instruction of background information
2. Discussion of results.
3. Develop a claim based on evidence – for example:
   - What does the width of our riparian zone tell us about the potential for erosion at our site?
   - How will seasonal changes like canopy cover affect the riparian zone, and how will that affect water quality?
   - How might the diversity of vegetation impact the food web/food chain at our sampling site?

Evaluate *(field or classroom)*

1. Name three ways riparian vegetation zones affect water quality.
2. Based on our results, design a solution that could improve the riparian zone at our site.
3. Using aerial photographs, compare upstream and downstream riparian vegetation with our monitoring site. Make a claim about how the water quality at your site would compare to these sites.

Extend *(post-field, classroom)*

1. Have a field biologist visit the classroom and speak to the students about their "real life" field surveys.
2. Set up a plant identification activity using dichotomous keys and plant ID resources.
3. Have the students make their own plant identification cards for plants commonly seen at their monitoring site or in southwest Washington. Could also include wildlife ID cards.
4. Project WET Activity *: Invaders!
5. Project Learning Tree *: Lesson #80 Nothing Succeeds Like Succession.
6. Project Learning Tree *: Lesson #12 Invasive Species

Resources

- Student Watershed Research Project – Riparian and Aquatic Ecosystem Monitoring: http://www.swrp.esr.pdx.edu/publications/manual/manual_main.htm
- http://www.qmdc.org.au/publications/download/1857/website-pdfs/education/riparian-assessment.pdf
- pubs.er.usgs.gov/publication/sir20045185?currow=263
- www.mswildlife.org/_media/AAS_Streamside_survey_form.pdf

* See "Guidelines to Investigations" for Project WET and Project Learning Tree activities information

Watershed Monitoring Network Riparian Vegetation Data Sheet

Watershed: ______________________________ Names: ______________________________

Location: ______________________________ Class: ______________________________

Site: ______________________________ Date: ______________ Time: __________

Canopy Cover

Tape measure mark	% Canopy cover
0 meter mark	
5 meter mark	
10 meter mark	

Comments: ____

Plant Diversity Survey Along Water Body

Tape measure mark	Number of different types of plants	% Bare soil	% Leaves & twigs	% Grasses & forbs	% Shrubs	% Trees
0 meter mark						
5 meter mark						
10 meter mark						

Comments: ____

Plant Diversity Survey Away From Water Body

Tape measure mark	Number of different types of plants	% Bare soil	% Leaves & twigs	% Grasses & forbs	% Shrubs	% Trees
0 meter mark						
5 meter mark						
10 meter mark						

Comments: ____

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Riparian Zone Tree Survey

In this investigation, students will conduct a tree survey in the riparian zone near their water monitoring site. This information will be used to predict the potential for erosion and flooding, the potential for polluted surface waters entering the stream and the value of this area for wildlife habitat.

Time: *30 minutes*

When: *Fall and Spring*

Suggestions: *Conduct this investigation at the same time as the Vegetation Survey if you have trees at your monitoring site.*

Learning Objectives:

Students will demonstrate the ability to:

- *describe how a riparian buffer zone can benefit a stream.*
- *explain how trees in riparian zones impact water quality parameters like temperature.*
- *calculate the diameter of trees using the DBH method .*

Materials: *Data sheet(s), 50 meter measuring tape, calculator, tree identification resource,1 inch PVC pipe cut to 4.5 feet (for DBH measurement), flagging, permanent marker*

Standards:

NGSS (DCI):

- *Elementary: ESS2.E, ESS3.C, LS1.A-C, LS4.C-D*
- *Middle: ESS3.C*

Refer to standards matrix *for complete grade-level listing of all current and common core standards*

What is the relationship between trees in the riparian zone and water quality?

Riparian vegetation refers to the plants, shrubs and trees that grow on the banks near a body of water. The riparian vegetation zone is referred to as a buffer zone because it protects (or buffers) the water body from the harmful effects of excessive surface runoff. The effectiveness of the riparian buffer zone increases with its size and diversity of vegetation within it.

Trees play an important role in the riparian buffer zone. All parts of a tree have a role to play. Just like an umbrella, trees protect the area under it from excessive heat and erosion from heavy rain. The leaves and bark of a tree retain a huge amount of water, allowing some of it to evaporate (transpiration) and some of it to reach the ground more slowly. When surface water is slowed down, the soil is able to absorb more water and naturally filter it before entering the groundwater system. Slowing down surface water flow also reduces the threat of downstream flooding after heavy rain. A typical medium-sized tree in the Pacific Northwest can intercept as much as 2,380 gallons of rain per year. The roots of trees stabilize the soil and control erosion by absorbing excess water in the soil. Trees also provide habitat and food for terrestrial wildlife and shade for aquatic wildlife. Macroinvertebrates, like aquatic insects, eat leaves and other vegetation that ends up in the water.

Trees that don't lose their leaves, like Douglas fir trees, are called evergreen. Trees that lose their leaves, like maple trees, are called deciduous.

Common species of trees found in riparian zones of southwest Washington include black cottonwood, red alder, western red cedar, Oregon ash and many types of willow.

Vocabulary: riparian, buffer zone, runoff, diversity, erosion, pollutant, diameter, circumference, transpiration, surface water , groundwater, dichotomous key, parameter, DBH, evergreen, deciduous

Engage *(classroom, pre-field)*

1. Show students photos of two different riparian zones – one with many trees and one with none or few trees. Have the students compare and contrast the differences they might expect in regards to the wildlife, potential for erosion and potential for pollutants entering the stream from surface runoff.
2. Take students outside to the school parking lot. Break them into groups of four, assigning each group a different light pole. Tell them they will be measuring the DBH (Diameter at breast height) of the pole, which is the diameter of the pole at a point 4.5 feet off the ground. Have students brainstorm on how to determine diameter then compare results.
3. Practice using dichotomous keys and tree identification resources. Some examples include: Common trees of the Pacific NW http://oregonstate.edu/trees/dichotomous_key.html; What Tree Is That? http://www.arborday.org/trees/whattree/

Explore *(field activity)*

Materials:

- 50 meter tape measure
- 1 inch PVC pipe cut to 4.5 feet (for DBH measurement)
- Tree Survey data sheet
- Calculator

Defining a 10 meter by 10 meter square survey area near the water monitoring site

1. Take one tape measure and stretch it out 10 meters along the bank. Lay it on the bank out of the water.
2. Have one student stand at the 0 meter mark and one student stand at the 10 meter mark. The students will be markers for two corners of the survey area.
3. From the 0 meter mark, stretch the tape measure out 10 meters perpendicular to the first tape.
4. Have another student stand at this point.
5. From the 10 meter mark determined in Step 2, stretch the tape measure out 10 meters perpendicular to the first tape.
6. Have another student stand at this point. The four students will act as the boundary points for the 100 square meter survey area.

Tree Inventory and Calculating DBH of Single and Multi-Stem Trees

1. Get an idea of how many trees you will be inventorying and measuring. You may need more than one student to help with this. To keep track of trees, tie flagging with numbers around the trees.
2. Start on one side of your survey area. Does the tree have needles or leaves? Note this on the data form.
3. Use the PVC pipe or the measuring tape to show 4.5 feet on the tree above ground.
4. With the tape measure, measure the circumference of the tree at this level on the tree.
5. Write this number in the data form.
6. If you have time in the field, calculate the diameter of each tree by dividing the circumference by 3.14. This number is called the DBH or the tree Diameter at Breast Height.
7. If the tree is multi-stemmed, then the DBH is found by squaring all of the individual DBHs found on each stem, adding them together, and then taking the square root of the total sum. (see data sheet for formula)
8. Enter this in the data form.
9. Inventory and measure all the trees in your survey area.

Explain *(post-field, classroom)*

1. Direct instruction of background information
2. Discussion of results
3. Develop a claim based on evidence – for example:
   - What might the presence or absence of trees in our riparian zone tell us about the potential for erosion at our site?
   - How might the presence or absence of trees in our riparian zone affect water quality?
   - How might the diversity of trees in our riparian zone affect water quality?

Evaluate *(field or classroom)*

1. Demonstrate the ability to calculate diameter using the DBH method.
2. Discuss erosion and how trees not only keep sediment out of the water but also stabilize the bank.
3. Explain what would happen to the stream if the banks eroded and the stream widened. Would a slower stream with less shade have a different temperature? Have them predict what would happen to the diversity of life in the stream.
4. Discuss how water quality at your site would be different if the sizes and types of trees on your site were different.

Extend *(post-field, classroom)*

1. Have students research local riparian zone restoration projects that are currently underway in the community. Invite engineers and biologists to visit the classroom to discuss the project.
2. Have students contact their municipality's Urban Forestry Department to learn about tree planting or other service learning opportunities in their community.

Resources

- City of Vancouver Urban Forestry Department – Healthy Trees, Healthy Watersheds: www.cityofvancouver.us/urbanforestry
- Arkansas Game and Fish (Lesson Plans – Imperative Riparian Zones FBCEC)
- http://www.fs.fed.us/psw/programs/uesd/uep/products/11/800TreeCityUSABulletin_55.pdf
- Arbor Day Foundation Tree - How Trees Can Retain Stormwater Runoff
- Student Watershed Research Project – Riparian and Aquatic Ecosystem Monitoring: http://www.swrp.esr.pdx.edu/publications/manual/manual_main.htm

Watershed Monitoring Network Riparian Tree Survey Data Sheet

Watershed: ______________________________ Names: ______________________________

Location: ______________________________ Class: ______________________________

Site: ______________________________ Date: ______________ Time: __________

Tree #	S (one) M (multi) stem	E (Evergreen) or D (Deciduous)	Circumfer-ence (inches)	DBH *	Tree Size (DBH) (single stem only) **			Notes (Tree species)
					Small (1-12″)	Medium (12 -20″)	Large (20″+)	
					☐	☐	☐	
					☐	☐	☐	
					☐	☐	☐	
					☐	☐	☐	
					☐	☐	☐	
					☐	☐	☐	
					☐	☐	☐	
					☐	☐	☐	
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					☐	☐	☐	
					☐	☐	☐	
					☐	☐	☐	

* DBH = circumference ÷ 3.1416

* Multi-stem DBH = $\sqrt{DBH(A)^2+DBH(B)^2+DBH(C)^2+...}$

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Soil Cores: Color, Texture and Moisture

In this investigation, students will collect site soil samples using a soil core sampler. The soil will be examined for the characteristics of soil texture, color, layers and moisture. Seasonal changes in the saturation level of the soil will also be observed.

Time: *60 minutes*

When: *Fall/Spring*

Suggestions: *Refer to soil activity: Soil Temperature, Moisture and pH*

Learning Objectives:

Students will demonstrate the ability to:

- *describe the four components of soil.*
- *determine the soil textural classification of soil.*
- *explain the relationship between soil color and texture, erosion and water quality.*
- *estimate soil moisture by making soil into a ball.*
- *develop a claim based on evidence.*

Materials: *soil corers, scraper, towel, squirt bottle, hand cleaner, laminated soil texture and moisture keys, bucket of water*

Standards:

NGSS (DCI):

- *Elementary: ESS2. A-B, E ESS3.C*
- *Middle: ESS2.C LS2.A*

Refer to standards matrix *for complete grade-level listing of all current and common core standards*

What is the relationship between soil characteristics and water quality?

Soil is made up of four components – minerals, water, air and organic material. The mineral component consists of inorganic particles - sand, silt and clay. Water and air occupy the pore spaces of the soil. The *organic* material, sometimes called humus, is made of decom-posed plants and animals.

Soil is made up of layers or horizons. Each layer has different characteristics that influence plant growth. The surface layer, or "O" horizon, is predominantly organic material, humus. The next layer is the "A" horizon. Referred to as topsoil, it is a mix of organic material and inorganic particles. The "B" horizon, or subsoil, is primarily inorganic material. There are other deeper horizons but this activity will focus on the upper layers that students can collect.

Soils in cities are different from those in less disturbed areas. Urban soils have been constantly mixed, moved and disturbed. Distinct soil horizons are less obvious if present at all. If you have watched any building or street construction, you may recall it all starts with a big hole. Soil is dug out, moved and often replaced with another kind of soil from somewhere else.

Soil color provides clues to the types of minerals found in soil and can be an indicator of prolonged soil wetness and *soil moisture*. The color in soil is mainly due to two factors – organic content and the chemical nature of iron compounds found in the soil. Iron gives soil a brown, yellow or red color. Organic matter is usually black or dark brown. It acts as a sponge to help absorb surface water. Water falling on soil without organic matter is more likely to run off, contributing to erosion. Erosion can increase the sediment load of a stream which increases turbidity and reduces water clarity.

Soil texture refers to the proportions of sand, silt and clay in the soil. Soil with equal amounts of sand, silt and clay is called a "loamy" soil. Soil scientists use a soil texture triangle to determine the textural classification of soil. A simpler classification method presented here uses a dichotomous key. Determining the textural classification of soil is useful in predicting its potential for erosion as well as the plant communities it can support. When water infiltrates through sandy and loamy soils, the potential for erosion is reduced.

Vocabulary: inorganic, organic, humus, soil horizons, topsoil, subsoil, soil color, soil moisture, sediment load, turbidity, soil texture, dichotomous key

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Engage *(classroom, pre-field)*

1. Show students photographs of different types of road-cuts, banks or excavations showing various soil profiles. Have students make predictions about why there are variations in color, texture, vegetation, rocks, etc. Ask which layer is the oldest. Be sure to include a measurement scale so students realize that soil horizons are deep and they'll be examining only the top foot.
2. Recommended pre-field activities include:
   - Practice using a dichotomous key like this one using shoes. http://mypages.iit.edu/~smile/bi8611
   - Edible soil profile/layering activity (http://gen.uga.edu/documents/soil/activity/Edible_Soil.pdf)
3. Explain to students that on the next monitoring trip they will be taking soil core samples to determine the physical characteristics of color and texture of their soil. Introduce soil texture, soil color, soil horizon and soil profile.

Explore *(field activity)*

Materials:

- 3 soil corers
- Scraper tool for cleaning equipment
- Rag or towel
- Laminated soil texture key
- Laminated soil moisture key
- Bucket of water

1. Choose three different areas to sample
2. Examples: along the bank, under nearby trees, the dirt trail along the stream, grassy areas, etc.
3. Clear away surface material that would prevent the corer from going into the soil and gently push aside plants at the sample location. Insert the soil corer into the soil by twisting and pushing downward approximately 14 inches (35 centimeters). Remove the corer from the ground.
4. Repeat this procedure for the next two sampling locations.
5. Lay the three cores side by side. Make observations and record results:
   - Look for layers. Are there more than one?
   - Record the color of each layer.
   - Can you tell dry from wet soil?
   - Measure each layer and record.
5. After completing these observations, determine the texture of each soil layer (not the top organic layer) using the dichotomous key and record.
6. Estimate soil moisture for each distinct layer:
   - Squeeze the soil sample firmly in your hand several times to form an irregularly shaped "ball."
   - Squeeze the soil sample out of your hand between thumb and forefinger to form a ribbon.
   - Observe color, moisture characteristics, ability to ribbon, firmness of ball, loose soil particles, soil/water staining on fingers and soil color.
   - Compare observations with photographs and/or charts to estimate available soil moisture percent. See chart included or go to: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf

Explain *(post-field, class-*

1. Direct instruction of background information
2. Discussion of results
3. Develop a claim based on evidence, for example:
   - Based on our results, what is the soil textural classification at our site?
   - What do our results tell us about the potential for erosion at our site?
   - What do our results tell us about how the type of soil at our site might affect water quality?

Evaluate *(field or classroom)*

1. What does the color and texture of soil tell us about the amount of moisture in the soil and the potential for erosion?
2. What properties of soil can you determine from a soil core sample?
3. How do engineers use soil core samples?

   (Possible answers: To determine the type of soil, make recommendations for foundations, locate underground water resources, look for contaminants, etc.)
4. How do gardeners or farmers use soil core samples?

Extend *(post-field, classroom)*

1. Conduct a controlled experiment – grow plants in different soil types.
2. Students could measure soil texture by measurement, calculating proportions and percentages, use the texture triangle to determine texture class. (This would also be a good performance evaluation or challenge activity).
3. Project Learning Tree* activity #70: Soil Stories

Resources

- http://inst.pcssd.org/science/CD_content/anc/red530.pdf
- http://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_rock/cub_rock_lesson05_activity1.xml
- http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/edu/
- www.ctahr.hawaii.edu/oc/freepubs/pdf/SCM-9.pdf
- http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf

* See "Guidelines to Investigations" for Project Learning Tree activities

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Watershed Monitoring Network Soil Data Sheet

Watershed: ______________________________ Names: ______________________________

Location: ______________________________ Class: ______________________________

Site: ______________________________ Date: ______________ Time: ______________

Sample #	Layer Depth[1]	Texture[2] (Circle no more than 3)	% Moisture[3]
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
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		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	
		Sandy Clay Loam Silt	

[1] Layer Depth – Measure from ground surface to top of obvious layer
[2] Refer to Texture Key
[3] Use Moisture Chart

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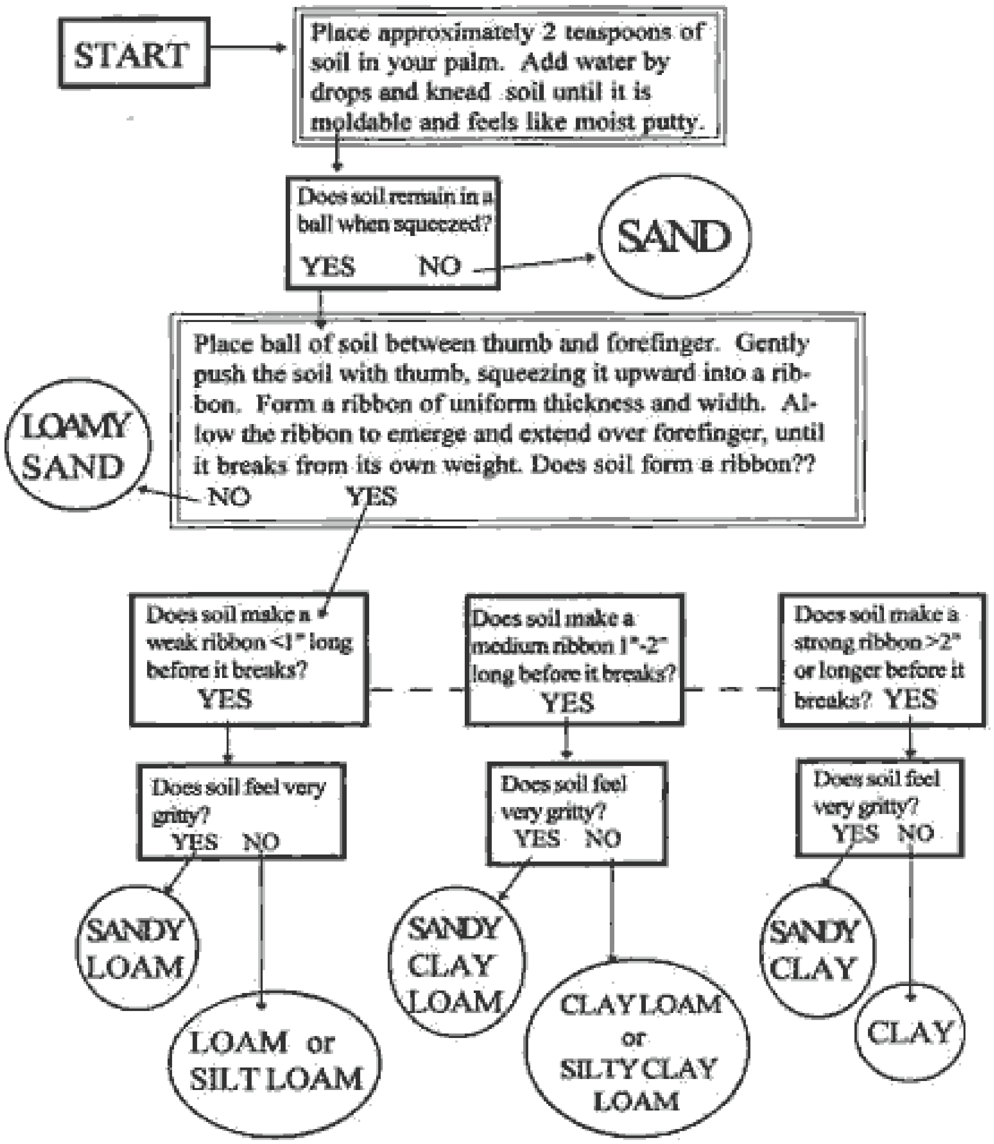
Key to Soil Texture by Feel

Begin at the place marked "start" and follow the flow chart by answering the questions, until you identify the soil sample. Please note that soils having a high organic matter content may feel smoother (siltier) than they actually are.



Source: Adapted from WOW!: *The Wonders of Wetlands*, Environmental Concern Inc.
The Earth Partnership Program, UW- Madison Arboretum, (608) 262-9925

Reference: http://uwarboretum.org/eps/restoration/study_site/soil_texture_key.htm

Guideline for Estimating Soil Moisture

Soil Moisture percent	Coarse (Fine Sand and Loamy Fine Sand)	Moderately Coarse (Sandy Loam and Fine Sandy Loam)	Medium (Sandy Clay Loam, Loam, and Silt Loam)	Fine (Clay, Clay Loam, and Silty Clay Loam)
0-25	Loose and dry, leaves sand grains on fingers with applied pressure, will hold together if not disturbed.	Dry, forms a very weak ball, aggregated soil grains break away easily from ball.	Dry. Soil aggregations break away easily. No moisture staining on fingers, clods crumble with applied pressure.	Dry, soil aggregations easily separate, clods are hard to crumble with applied pressure.
25-50	Slightly moist, forms a very weak ball with well defined finger marks, light coating of loose and aggregated sand grains remains on fingers.	Slightly moist, forms a weak ball with defined finger marks, darkened color, no water staining on fingers, grains break away.	Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away.	Slightly moist, forms a weak ball, very few soil aggregations break away, no water stains, clods flatten with applied pressure.
50-75	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon.	Moist, forms a ball with defined finger marks. Very light soil/water staining on fingers, darkened color, will not slick.	Moist, forms a ball, very light water staining on fingers, darkened color, pliable, forms a weak ribbon between thumb and forefinger.	Moist, forms a smooth ball with defined finger marks, light soil/water staining on fingers, ribbons between thumb and forefinger.
75-100	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.	Wet, forms a ball with wet outline left on hand, light to medium water staining on fingers, makes a weak ribbon between thumb and forefinger.	Wet, forms a ball with well defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and fore-finger.	Wet, forms a ball, uneven medium to heavy soil/ water coating on fingers, ribbons easily between thumb and forefinger.
100%	Wet, forms a weak ball, moderate to heavy soil/ water coating on fingers, wet outline of soft ball remains on hand.	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/ water coating on fingers.	Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/ water coating on fingers.	Wet, forms a soft ball, free water appears on soil surface after squeezing or shaking, thick soil/water coating on fingers, slick and sticky.

Simplified from: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/wy/soils/?cid=nrcs142p2_026830

Note: This chart is for Available Soil Moisture percentages which are based off of the percent of water currently available for plant use in relation to the available water capacity. This is not a measurement of saturation but rather the amount of water stored in the soil that is available for a plant to use.

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Soil Permeability

In this investigation, students will determine the permeability of the soil at their monitoring site by calculating infiltration rates. This information will be useful in predicting the potential for flooding, erosion and the likelihood of vegetative growth at their site.

Time: *45 minutes*

When: *Throughout the monitoring season*

Suggestions: *Compare infiltration rates in different seasons and at different places in your monitoring site (i.e. riparian zone vs. upland, forest floor vs. trail)*

Learning Objectives:

Students will demonstrate the ability to:

- *define soil permeability and compare the permeability of different types of soils to understand their physical properties.*
- *calculate infiltration rates of soil.*
- *collect and analyze data, use data tables and graphs to describe patterns in nature.*
- *explain the relationship between soils, permeability, erosion and water quality.*

Materials: *1 large metal coffee can, can opener, duct tape, 1L plastic soda bottle, block of wood (12-inch 2x4),*

Standards:

NGSS (DCI):

- *Elementary: ESS2.A*
- *Middle: ESS3.A, LS2.B*

Refer to standards matrix *for complete grade-level listing of all current and common core standards*

What is the relationship between soil permeability and water quality?

The permeability of soil describes how water (or other liquid) and air are able to move through the soil. In the case of rainfall or irrigation, water moves very easily through highly permeable soils and very slowly through soils with low permeability. The permeability of a soil can be determined by calculating its infiltration rate.

Soils with sandy textures have large pore spaces that allow rainfall to drain very quickly through the soil. Sandy soils are known to have high permeability, which results in high infiltration rates and good drainage. Clay textured soils have small pore spaces that cause water to drain slowly through the soil. Clay soils are known to have low permeability, which results in low infiltration rates and poor drainage.

As more water fills the pore space, the air is pushed out. When all pore spaces in the soil are filled with water, the soil becomes saturated. The roots of many types of plants are not able to survive in saturated soils. Saturated soil on level ground results in standing water which can cause flooding. Saturated soils on sloping ground results in runoff, and may lead to an increased volume of water entering a body of water. This condition can result in erosion and flooding, as well as an increased level of pollutants entering the body of water.

The water table is the surface below ground where water-saturated soils meet air-saturated soils. How deep this zone is changes from season to season and from year to year because rainfall and vegetation change; in wetter years, the water table moves up closer to the surface. If you are putting in a well for your home, you are definitely interested in where the water table is. The deeper the water table, the more it costs to put in the well.

Vocabulary: permeability/permeable, impermeable, pore space, drainage, saturated, infiltration rate, runoff, erosion, water table

Engage *(classroom, pre-field)*

1. Ask the students: Are there areas around the school ground where your shoes get muddy? Are there places that always get puddles after it rains? Why? What might be different about the soil in those areas that seem to collect more water?
2. Infiltration demonstration: Set up a ring stand with a funnel and a 500 ml beaker beneath the funnel. Fill one funnel with gravel and the other with fine sand. Have 2,500 ml beakers filled with water. Tell students you will be pouring the same amount of water through each beaker at the same time. Ask them to write down their prediction about which funnel will drain the fastest – make sure they provide an explanation. Other questions might include, "If we pour in 500 ml, will 500 ml drain out? Why? What's different about the materials that would cause differing amounts of water to drain through? If all water doesn't drain through, where is the remaining amount? (Could tie in conservation of mass standard.)
3. Extend the demonstration by calculating the infiltration rate for each funnel.

Explore *(field activity)*

Materials:

- 1 Large metal coffee can
- Can opener
- Duct tape
- 1L plastic soda bottle
- Block of wood (12-inch 2x4)
- Metric ruler
- Trowel
- Scissors
- Permanent marker
- Stopwatch/timer
- Data sheet

1. Remove the top and bottom of the coffee can to create an open metal cylinder. If necessary, cover any sharp surfaces with duct tape. On the inside of the coffee can, measure 3 cm up from the bottom and make a mark with your permanent marker. Repeat this several times around the bottom of the can. Carefully connect the marks to create a line around the inside of the coffee can 3 cm from the bottom. Repeat on the outside of the can.
2. Choose three different locations. (ie. bare soil, vegetated, trail, etc.)
3. Push the coffee can into the soil surface up to the 3 cm mark. Use the wood block to push the can in if the soil is compact. In very difficult soils, place the can on the soil surface. Use a trowel around the exterior of the can to create a small groove for the can to fit into. Be careful not to disturb the soil on the inside of the can. If the site is covered with vegetation, trim it as close to the soil surface as possible.
4. Groups can be set up to have 1 student pour, 1 student time and 1 student record.
5. Fill the 1L container with water. Have the timer ready to start as soon as the water touches the ground.
6. Slowly pour the 1L of water onto the soil. Stop timing when all the water has drained into the soil. Record the time in seconds. Repeat two more times at the same location.
7. Average the results and record on your data sheet.
8. After the infiltration test, students can dig under the cans to look at the soil.

Explain *(post-field, class-*

1. Direct instruction of background information.
2. Discussion of results.
3. Develop a claim based on evidence – for example:

- "What soil-type/particle-size might be present at our site based on our results?"
- "What do our results tell us about the potential for erosion at our site?"
- "What do our results tell us about how the permeability of soils at our site might affect surface water runoff and erosion?"

Evaluate *(field or classroom)*

1. What is an example of erosion happening around your neighborhood or local area?
2. Where is the eroded material going?
3. How might an increased volume of surface water entering a stream affect the water quality of the stream?
4. A creek runs through the local dog park. It has been raining steadily for the last week and puddles have formed throughout the park. How permeable do you think the soil is? How will the water quality of the creek be affected?

Extend *(post-field, classroom)*

1. Students could build soil column models using different mixtures of soil to compare permeability rates of their constructed models to the permeability rate of their field results. They could also compare the movement of various types pollutants through various soil mixtures.

2. Students could build a stream model with a riparian zone and observe ways in which the riparian zone improves water quality and erosion.

3. Project WET * Activity: Get the Ground Water Picture

4. Wonders of Wetlands * Activity; How Thirsty is the Ground

Resources

- http://inst.pcssd.org/science/CD_content/anc/red530.pdf
- http://www.education.com/science-fair/article/soil-permeability

* See "Guidelines to Investigations" for Project WET and Wonders of Wetlands activities

Developed by Vancouver Water Resources Education Center with funding from the WA Department of Ecology

Watershed Monitoring Network Soil Permeability Data Sheet

Watershed: ______________________________ Names: ______________________________

Location: ______________________________ Class: ______________________________

Site: ______________________________ Date: ________________ Time: _________

Test #1

Describe sample location:

____

Time how long it takes for 1 liter of water to drain into the soil:

Trial 1: ______________ Trial 2: __________________ Trial 3: ______________

Average: ________________

Test #2

Describe sample location:

____

Time how long it takes for 1 liter of water to drain into the soil:

Trial 1: ______________ Trial 2: __________________ Trial 3: ______________

Average: ________________

Test #3

Describe sample location:

____

Time how long it takes for 1 liter of water to drain into the soil:

Trial 1: ______________ Trial 2: __________________ Trial 3: ________________

Average: ________________

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Erosion Sources and Soil Compaction

In this investigation, students will inventory potential erosion sources near and on their monitoring site. Students will also determine the compaction level of soils using a soil compaction meter. This information will be used to predict the potential for erosion at the sampling location, the likelihood of vegetative growth and to determine what activities contribute to erosion and compaction.

Time: *30 minutes*

When: *Seasonally*

Suggestions: *Erosion survey can be done both on the way to the site and at the site.*

Learning Objectives:

Students will demonstrate the ability to:

- *describe what happens to soil pore space when soil is compacted.*
- *compare various human activities which may contribute to erosion and compaction of soils.*
- *explain the relationship between soil compaction, erosion and water quality.*
- *predict areas where erosion will be the greatest.*

Materials: *Dickey John Compaction Meter (with both ½inch and ¾inch tip), data sheet and pencil, erosion/ impervious surface survey*

Standards:

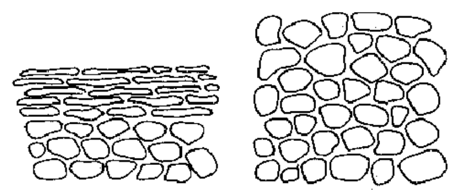
NGSS (DCI):

- *Elementary: ESS2.A*
  ESS3.C
- *Middle: ESS3.C*
  LS2.B

Refer to standards matrix *for complete grade-level listing of all current and common core standards*

How is water quality impacted by soil erosion and compaction?

Soils can be changed dramatically by pedestrian, animal or vehicle traffic, especially when the soil is wet and/or bare. As soil particles are squeezed together, the pore space between particles is reduced in size. This condition creates "restrictive" layers in the soil, where water can't flow freely and so results in ponding, surface runoff and erosion. Since compacted soils cannot hold much water, very little falling rain moves down (infiltrates) into the soil. Paved areas like parking lots force rainfall to flow across the hard surface and not through soil layers. Water rushing across any hard surface picks up pollutants and ends up in a stream or other low spot. Flooding increases as rain delivers water to streams from compacted, impervious or bare surfaces. Water flowing through soil gets cleaned by filtering and soil organisms. Compacted soil cannot help to clean water.



Soil pores play an important role in the health of the soil environment. All living organisms need both air and water. If all the soil pores are filled with water or compacted, less air is available for plant roots which results in the loss of surface vegetation. Surface vegetation acts as a sponge, so soil that lacks surface vegetation is more likely to experience surface runoff and erosion. Even when plants can grow in compacted soil, their roots are shallower and so the plant is weaker. This is why people aerate their lawns.

The compaction meter measures in psi (pressure per square inch). The higher the psi, the more compacted the soil. At 300 psi and higher, almost no plant roots penetrate.

Vocabulary: erosion, pore space, infiltration, pollutant, impervious, compaction, surface runoff, hardpan, detritus, psi

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Engage *(classroom, pre-field)*

1. Show students photographs of different types of ground surfaces - i.e. natural/forested vs. compacted forested (such as a road due to recreational vehicle use.) Ask them if the spaces between soil particles would be the same or different for both of these scenarios. Ask them to predict the differences in how water might move through the soils in both scenarios.
2. Fill two clear tubes with equal amounts of loamy soil. Plug one end with cotton or a fine mesh screen that will hold the soil. Use a dowel or other device to compact the soil in one of the tubes. Pour equal amounts of water through each tube to compare the percolation/infiltration rate differences in each condition.
3. Explain to students that on the next monitoring trip they will look for places where erosion might be an issue during the next rainfall. They also will be measuring the compaction of the soil at their monitoring site using a soil compaction meter.

Explore *(field activity)*

Erosion and Impervious Surface Checklist

Materials:

- Erosion and impervious surface survey

1. Take the survey as you walk from the school or bus to your site. In the first column, check what you find on the walk in.
2. When you reach your site, look around both on the edges of the water and at least about 50 feet away on either side. In the second column, check off what signs of erosion and hard surfaces you find at your monitoring site.

Explore *(field activity)*

Compaction Meter Testing

Materials:

- Dickey John Compaction Meter (with both ½inch and ¾inch tips)
- Data sheet
- Pencil

1. Select multiple locations to measure soil compaction. Choose comparative sites that you think may be compacted or are simply curious about. Sites can be bare soil or covered in detritus, but avoid extremely rocky areas and do not attempt to test hard surfaces. Some examples of test areas: a path, under a tree, the bank, an undisturbed vegetated area or areas on the erosion checklist.
2. Select tip for the meter. If soil appears firm, use the ½" tip; if soil appears soft, use the ¾" tip. Screw tip onto bottom of meter.
3. Push meter vertically into soil using even pressure on both handles. Go slowly to record readings every three inches (as noted by the lines on the rod). Stop when you can't push the meter any further. The meter has two scales (unit=psi). Read the outer for the ¾ inch tip and inner for ½ inch tip: just remember the bigger tip is the bigger circle. The colors roughly show how well a plant can grow. Green is good soil for plants; red is not.
4. Take multiple readings in one area before moving to the next location. Don't measure the same exact hole twice.

NOTES: If you are slowly measuring and the meter quickly shoots downwards you may have just found a tunnel. If you are measuring and the meter becomes momentarily difficult to push downward and then becomes easier, you may have just passed through a compacted layer, or hardpan.

Explain *(post-field, classroom)*

1. Direct instruction of background information
2. Discussion of results
3. Develop a claim based on evidence – for example:
    - What do our soil compaction results tell us about the potential for erosion at our site?
    - Will the soil compaction measurements stay the same, or change throughout the year?
    - Are we contributing to the compaction of soil at our site as a result of our water monitoring activities?
    - Are all the bare places on your site also the most compacted?
    - Are there more impervious surfaces than surfaces where water infiltrates on your site?

Evaluate *(field or classroom)*

1. How does the soil compaction meter measure the compaction in the soil?
2. What soil factors contribute to the potential for soil to become compacted?
3. What areas might be most eroded during the next rainfall?
4. What does soil compaction tell us about the potential for erosion and ability to grow healthy plants?
5. What happens to the soil pore spaces as people and horses walk on trails through the forest?
6. How do you think the compaction of urban soils compares to native/forest soils?
7. Can compacted soil become "un-compacted"?
8. Based on the number of impervious surfaces you found both on your walk in and on your site, do you think your water body will flood in the next big rainstorm?

Extend *(post-field, classroom)*

1. Controlled experiment - students could build stream tables filled with soil: Plant grass seeds. Simulate a road or other traffic by "building" a road or trail through the system. (Seam roller for wallpapering works well as a mini-compacting device.) Compare plant growth in compacted vs. non-compacted areas. Simulate rain fall or flood event to observe erosion.
2. Have students research why engineers test the soil prior to a building or development project.

Resources

- http://inst.pcssd.org/science/CD_content/anc/red530.pdf
- Impervious Surfaces and Pollutants in Local Waterways - City of Eugene: www.eugene-or.gov/DocumentCenter/View/13795
- *http://www.faribaultcountyswcd.com/FileLib/Impervious%20Surface%20Activity%20PDF.pdf*
- http://www.dpi.nsw.gov.au/agriculture/resources/soils/structure/compaction

Watershed Monitoring Network Soil Compaction and Erosion Survey

Watershed: ____ Names: ____

Location: ____ Class: ____

Site: ____ Date: _______________ Time: ______________________

Erosion and Hard (Impervious) Surface Survey

Check all the places you see both on the walk into your site and on your site.

Walking to Site	At Site	
☐	☐	Paved trails
☐	☐	Gravel/dirt trails
☐	☐	Mole hills
☐	☐	Paved parking areas
☐	☐	Other paved areas
☐	☐	Bare soil
☐	☐	Steep areas with several bare places away from water
☐	☐	Steep areas with several bare places next to water
☐	☐	Digging or other construction signs
☐	☐	Trenches scoured by water
☐	☐	New plantings without mulch (like bark chips)
☐	☐	New plantings with mulch (like bark chips)
☐	☐	Signs of mud on paved areas
☐	☐	Gravel with visible wet or dried mud

Developed by Vancouver Water Resources Education Center with funding from the WA Department of Ecology

Watershed Monitoring Network Soil Compaction Survey

Watershed: ______________________________________ Names: ____

Location: _______________________________________ Class: ____

Site: ____ Date: ______________ Time: _____________________

Soil Compaction data

Location	**Trial #**	**Tip used (¾" or ½")**	**PSI by Depth (inches)**					**Notes**
			0-3"	**4-6"**	**7-9"**	**10-12"**	**>12"**	
(Example Data) *On the path*	*1*	*¾"*	*100* *(PSI)*	*150*	*300*			*Bare soil, hit a root?*

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