INVESTIGATING LOCAL WATER
AN INQUIRY FRAMEWORK FOR TEACHERS

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- Inquiry and Collaboration Tools
- Maps of School Grounds

DRAFT 7-13-2014
**Project Design and Team**

The accompanying materials are a work in progress reflecting an ongoing collaboration between Smith College students and faculty and local elementary school teachers. During a five-week summer project two Smith students developed the following framework and resources for teachers. The students conducted background research and consulted with Smith faculty in the Department of Education and Child Study, the Center for the Environment, Ecological Design and Sustainability and the Spatial Analysis Lab. Field trips and interviews with elementary school teachers and students were integral to the design process: special thanks go to teachers from Jackson Street School and Smith College Campus School who welcomed us into their classrooms. The ideas and approaches proposed in this framework are intended as an invitation to continue the dialogue and we welcome feedback and participation.

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Carol Berner & Al Rudnitsky, Department of Education and Child Study

**Introduction**

Many of our everyday actions and experiences become invisible to us over time. Two such aspects of our lives are water, and thinking. While thinking is by its very nature invisible, water has been rendered unnoticeable through its familiarity. Our goal in creating a continuing series of learning adventures is to heighten students’ awareness of these two vital resources, water and thinking, in constructive and imaginative ways. We offer a framework for teachers consisting of guidelines, suggestions and investigations directing students towards discovering and solving authentic problems whose solutions require learning new ideas.

Setting out on this journey, we were struck by the complexity of water, from its smallest molecular properties to our planet’s water cycle. These nearly infinite scopes of study lend a similarly expansive scope of wonder for students working to understand the nature of this resource. And while water has many fascinating properties and pathways, it is also familiar and important to everyone, every day. With several critical issues surrounding water, and multiple points of entry into a water-themed study, there are thousands of generative questions that can be asked. Launching the investigation on the school grounds allows children to develop and improve their own questions and theories about water and to discover connections to the local community and environment. Our learning adventures focus on some of these pressing questions, and uses them to drive a series of inquiries about one of our most vital and least-noticed resources.

The initial learning adventure has two major learning goals. The first is to guide students to a growing understanding of water. As they participate in open-ended explorations of water on the school grounds, students will encounter big questions about where water comes from, how it moves, where it flows to, how human actions impact the flow of water, and the different states in which water makes its journey. Through a series of investigations, creative classroom activities and collaborative discourse, students will grapple with these questions and imagine solutions to local and global problems of managing water.
Our second learning goal has a wider scope. Our aim is to improve students’ understanding of what ideas are and how they work. This goal focuses on the classroom as a community working together to advance knowledge. The learning adventure is designed to support this goal with tools and resources to initiate group talk, guide collaborative inquiries, and track changes in student thinking. It is integral that students gain a realization of how they solved a problem, in order for them to be more successful in resolving future issues. It is worth a note that understanding is accomplished through active thinking and problem solving and thus, our two goals cannot be separated.

We created these adventures with a conviction that we can help students reconsider the way they think about water: as a scientific concept, as a resource, and as a force of nature. This multifaceted understanding is intricately connected to current and future issues surrounding water, including quality, quantity, and human management. In order for students to begin exploring these problems, they must build a strong sense of interest and conceptual framework for understanding our most important resource. Whether the water is on their school grounds, in a treatment plant, in a nearby river, or in the ocean, students will develop and work on authentic problems and ideas in their efforts to understand its properties and paths. Most importantly, students will be in a position to consider the impact that humans have on water, and its impact on us.
Alignment with Next Generation Science Standards

Integrating a knowledge-building approach to learning with exploration of the local school environment furthers the overarching goal of the Next Generation Science Standards, “to help children continually build on and revise their knowledge and abilities, starting from their curiosity about what they see around them.” (NGSS, Appendix E). The learning adventures provide opportunities for students to advance their scientific content knowledge and inquiry practices in accordance with NGSS developmental progressions.

Pedagogy: Science and Engineering Practices

Learning adventures are designed to spark students’ interest and curiosity about how scientists work and how scientific ideas develop. Through field investigations, group discourse, and theory-building students will discover and refine questions; document evolving ideas through mapmaking and journaling; and design solutions to problems they identify. These activities provide multiple opportunities and points of entry to practice and assess growth in the NGSS Science and Engineering Practices:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Content: Core Disciplinary Ideas

The proposed learning adventures invite children to follow a developmental progression outlined for each of the core ideas about water in the NGSS. For example in the Learning Adventure “Where does water go?” 2nd graders investigating water on the school grounds will observe and map the flow of rainwater on the school grounds to explore how it moves across grass and pavement, while 5th graders may design experiments and conduct research to understand the watershed implications of infiltration and runoff. Both groups are working on grade level goals for ESS2.C: The Roles of Water in Earth’s Surface Processes and are addressing the same overarching question How do the properties and movements of water shape Earth’s surface and affect its systems?

Learning adventures align with the four content domains of NGSS Disciplinary Core Ideas, with the most extensive and relevant connections to curriculum and performance expectations in the domain of Earth and Space Science. See chart below highlighting the developmental progression of core ideas and framing questions related to water.

Common Core State Standards in English Language Arts are addressed throughout the learning adventures in the context of reading informational text; writing in ‘water journals’; and speaking and listening in knowledge building classroom discourse.
### Chart of Developmental Progressions for NGSS Core Ideas Relating to Water

Excerpted from:

→ “INCREASING SOPHISTICATION OF STUDENT THINKING” →

<table>
<thead>
<tr>
<th>Core Idea</th>
<th>K-2</th>
<th>3-5</th>
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<tbody>
<tr>
<td><strong>CORE IDEA: Earth’s Systems</strong>&lt;br&gt; <em>How and why is Earth constantly changing?</em></td>
<td></td>
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<tr>
<td>ESS2.A</td>
<td>Earth materials and systems&lt;br&gt; <em>How do Earth’s major systems interact?</em></td>
<td>Wind and water change the shape of the land.</td>
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<tr>
<td></td>
<td></td>
<td>Four major Earth systems interact. Rainfall helps to shape the land and affects the types of living things found in a region…</td>
</tr>
<tr>
<td>ESS2.C</td>
<td>The roles of water in Earth’s surface processes&lt;br&gt; <em>How do the properties and movements of water shape Earth’s surface and affect its systems?</em></td>
<td>Water is found in many types of places and in different forms on Earth.</td>
</tr>
<tr>
<td>ESS2.D</td>
<td>Weather and climate&lt;br&gt; <em>What regulates weather and climate?</em></td>
<td>Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region and time. People record weather patterns over time.</td>
</tr>
<tr>
<td>ESS2.E</td>
<td>Biogeology&lt;br&gt; <em>How do living organisms alter Earth’s processes and structures?</em></td>
<td>Plants and animals can change their local environment.</td>
</tr>
<tr>
<td><strong>CORE IDEA: EARTH AND HUMAN ACTIVITY</strong>&lt;br&gt; <em>How do Earth’s surface processes and human activities affect each other?</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESS3.A</td>
<td>Natural resources&lt;br&gt; <em>How do humans depend on Earth’s resources?</em></td>
<td>Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.</td>
</tr>
<tr>
<td>ESS3.B</td>
<td>Natural hazards&lt;br&gt; <em>How do natural hazards affect individuals and societies?</em></td>
<td>In a region, some kinds of severe weather are more likely than others. Forecasts allow communities to prepare for severe weather.</td>
</tr>
<tr>
<td>ESS3.C</td>
<td>Human impacts on Earth systems&lt;br&gt; <em>How do humans change the planet?</em></td>
<td>Things people do can affect the environment but they can make choices to reduce their impacts.</td>
</tr>
</tbody>
</table>
Learning Adventure: “Where Does Water Go?”

**Inquiry 1. Imagining a Wet World**  
*Framing Question: Where do you think water goes when it rains?*

**Overview:**  
The first part of the learning adventure is focused on the dry surrounding environment of the school. The main student activity involves creating maps of the school grounds that predict what students think the school grounds will look like during and right after a heavy rain. Back in the classroom the maps are discussed and the class works at putting their best ideas together in the form of a class map along with ideas to back up their conjectures about where water will show up after a rain.

Students will be using maps to record their observations and to make their predictions. Teachers have to decide what the students will need to learn in order to use the maps effectively as a tool. We offer some sample maps that are the type students will be using (See Teacher Resources).

During their investigations into water, students will use a ‘Water Journal’ and a ‘Knowledge Board’ to record their ideas and comment on other students’ ideas. These are explained below when they are introduced (see Teacher Resources for examples). The overall aim of instruction is to create an environment in which student questions and ideas drive the class conversation as classmates share initial answers to the question:

*When it rains on our school grounds, where does the water go?*

It is important for teachers to elicit and document students’ initial ideas and theories about water and its movement. Looking back at their early ideas helps students see what idea improvement means.
Launching Inquiry 1a: Appealing to Imagination

The adventure begins by getting students thinking and talking about water after watching a video.

About the video (being developed): Point is to dramatize water in the environment and be clear that it moves through the environment. Among the things that will be introduced... Imagination grabbing still shots of floods, torrents, ocean storms, deserts, droughts, dry reservoirs. Video then focuses on local water: “run off” and flooding.

Knowledge-Building Discussion (following the video):
Key questions to get students to express their ideas and begin to document their initial ideas:

- Where does the rain come from?
- Where does water go after it rains?
  (and how does it get there?)

Students can answer these questions individually in a ‘Water Journal.’ Teachers, either before or after students write, could have a class discussion about these questions. The discussion could be recorded on chart paper. Alternately, teachers could ask students to write “their most important” idea (entered in their Water Journal) on a post-it note to display. Seeing the ideas of their classmates is the beginning of a Knowledge Building Board. (See Teacher Resources for ideas about Water Journals and a classroom Wonder/Knowledge Center).

<table>
<thead>
<tr>
<th>At-A-Glance Inquiry 1a: Appealing to Imagination</th>
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<tbody>
<tr>
<td>Students:</td>
</tr>
<tr>
<td>- Watch a short video dramatizing water moving through the environment</td>
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<tr>
<td>- Start thinking, talking, writing, and exchanging ideas about water</td>
</tr>
<tr>
<td>- Write in Water Journal and see class ideas posted on chart paper or Knowledge Board</td>
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</tbody>
</table>
**Inquiry 1b: Introducing mapping water on the school grounds**

Tell the class that the best way to understand how water moves through the environment is to begin right outside the school doors. Imagine what it looks like during a really hard rain.

Teachers should use guided imagery here. Ask students to close their eyes. “Take” them out a door into the schoolyard. “Walk” them (descriptively) to different parts of the yard. At different “stopping points” ask them to think about what they are seeing (Are their feet wet? Is something dripping on them? Is it slippery? Is water disappearing?) and even try to remember what they are visualizing. Try to stop and ask them to visualize at a variety of interesting locations (grass, blacktop, playground, drains, downspouts, curbs, etc.).

After students open their eyes, ask them what they saw. You might ask about different locations. No need to get too specific or detailed since students’ next task will be to create a map of the school grounds that depicts what they have been visualizing. It is worthwhile to show that different people have different visualizations about where water is and where it goes. This is a good time to notice and talk about the reasons students give to support their ideas.

Students should find out that their investigation begins with “dry land” maps. They will be going outside (with a partner or small group -- see below). They will each have a map of the school grounds. Their goal is to create a shared version, one that they (pretty much) agree shows where water is and where it goes during and right after a rain. They will be visiting the various places in the yard and recording their ideas about what a wet schoolyard will look like.

**Using maps**

Before going out to map the grounds, students should all be familiar with the map of the school grounds and they should have ideas about good symbols to use to map their ideas. This lesson should make use of the enlarged image of the school grounds. Teachers should discuss the image enough to have confidence that students know how to read it. The teacher might draw a puddle on the map (demonstrating how to do that). Students might suggest how to draw a ‘stream’, a hard surface, a soft surface, storm drains, etc. Students may want to practice marking on the 8 ½ x 11” maps, individually or in small groups, to build confidence and familiarity.

Looking closely at an enlarged image of the school grounds will engage students in noticing and asking questions about the map and how it works. Once students seem to understand how to use the map, it’s time to head outside.

>> *In progress: map symbols and key (puddle, storm drain, etc.) and sample student map <<
At-A-Glance Inquiry 1b: Introduce Mapping Water on the School Grounds

Teachers:
- Use guided imagery to engage students in visualizing rain on the school grounds
- Record ideas on chart paper; note patterns and differences in visualizations
- Introduce mapping as a tool for inquiry and recording ideas
- Engage students in looking closely at enlarged map of the school grounds
- Model how to use the map until students are familiar with reading it and marking symbols
- Model and have students practice using 8 ½ x 11” maps (individually or in small groups)

Materials Needed:
- Large-scale map of school (3’ x 3’ printed map or Smartboard projection)
- 8 ½ x 11” maps of school (for student practice)
- Optional: different map of the same area for comparison

‘Mystery Map’ of Jackson Street School:
What do the red lines show?
Inquiry 2. Schoolyard Investigation: Dry Land Mapping

Students now enter into the role of water explorers as they build theories about where water flows on their school grounds. This work begins as they map their ‘predictions’ about where water will accumulate and flow in the schoolyard. Teachers should break this process into areas of the yard. How many areas will depend upon the age of the students and the size and complexity of the grounds.

Teachers need to decide how to form groups. Students can work independently from beginning to end. They can also work with a partner or in groups of three. Regardless of group arrangement, students should be asked to make their own map and then, back in the classroom, work with their group to create an “agreed upon” map.

While outside, students will need their working map (on a clipboard) and their journals. As they map the area they should make notes in their journal explaining the evidence / reasons for their map decisions. Students can sketch smaller areas of the ground to show their evidence. If possible, students should be able to use cameras to record the evidence for their map. Back in the classroom teachers may want to ask students to write about what they noticed. Students should include some questions in their journals. What are they wondering about?

Back in the classroom
Students should write one thing they are wondering about on a post it and put their “wondering” on the Knowledge Building Board.

Students should meet with their group mates and, working on a shared map, discuss their ideas, how they can combine them, and - when they cannot agree - they should note what they need to look at outside in order to make a decision. Teachers should remind students about good collaboration (See Teacher Resources for B.R.A.V.E. guidelines for group talk). The point is not to be right but to combine their ideas to arrive at better ones. Teachers may need to help groups reach a consensus. They should remind the group that they will be going out in the rain and so they will have evidence to evaluate their predictions.

In this cycle of individual and collaborative mapmaking, there should be some whole class discussions. These could begin with a sharing of maps. There should be similarities among the maps. It is worth pointing these out and the shared reasons for there being so. There should also be differences. These too are worth exploring. Students should share the things they are wondering about and some select group of ‘wonderings’ should be posted on the Knowledge Board to continue working on. Students might need some help / modeling to get the idea of building on other’s notes. And when ideas start to come together, students should be shown how to combine their ideas into a new improved idea. << samples to be added >>
At-A-Glance Inquiry 2: Schoolyard Investigation: Dry Land Mapping

Students outdoors:
- Explore a section of the school grounds (in groups and/or with a partner)
- Mark predictions on a working map using symbols
- Write in a journal their reasons/explanations for decisions
- Students may sketch smaller areas to show their reasoning/explanations
- If possible, take photographs to record evidence (e.g. storm drain, place puddles form)

Students back in the classroom:
- Write in journal about what they notice and what they’re wondering
- Write one thing they’re wondering on a post-it and post on Knowledge Board
- Meet with group mates to combine ideas and construct a shared map
- Meet as a whole class to share maps, discuss patterns and differences, and post additional “wonderings” to knowledge board

Materials Needed:
- 8 x 11 map of school grounds (1 for each student and 1 for each small group)
- Clipboard with pencil
- Journal (paper for writing and sketching)
- Camera (if possible 1 per team)
- Post-its for students to record “wonderings” and post on knowledge board
- Enlarged map to facilitate whole group discussion of predictions
**Inquiry 3. Investigating Rain on the School Grounds**

It is worth noting that rainy days during the time the class is working on the dry land sections could be tricky. Essentially - no fair looking until predictions are completed. Making a big deal of “not looking” would probably backfire. If students bring observations into the dry land discourse - so be it. More evidence for the conversation. Onward.

The class has arrived at a shared set of predictions about what the school “map” will look like when it rains. Now is the time to find out. The class should be prepared (raincoats) to go out into the rain for an extended period of time. Students may be interested in looking at weather forecasts to anticipate the next rainy day. On the rainy day the idea is to go out and see where water accumulates and where it goes.

There are numerous options here. One is to divide the schoolyard into the sections they have been working on and assign groups a particular section. The class may have identified “high interest” areas based on their predictions which will be important to map in the rain. Managing the rain investigations literally depends upon the vagaries of weather. Extended dry weather means take advantage of the rainy day and get as much evidence as possible. Extended wet weather would allow groups several visits as each group makes its map. Downpours may necessitate writing notes on maps and journals under the cover of an awning, playground structure, etc.

In addition to maps, journals, and photographs, rain investigations may include listening to the rain and recording the sounds of rain falling on different surfaces (for example falling on grass (permeable) and bouncing off pavement (impermeable)).

**Back in the classroom**
Maps can be combined in class discussion. Photographs that depict the wet (and dry) grounds would be excellent supporting evidence for the class map.

Questions and prompts for both whole class and Knowledge Building Board conversation:

*How did the predictions work out?*

*What ideas held water? (get it?)*

*What did we learn in the comparison?*

Students could write in their journals about their best and worst predictions and what they learned from each. Teachers will need to pay close attention to students’ ideas in order to recognize a promising question or problem for whole class discussion. (See Teacher Resources 12 Principles of Knowledge Building for ideas about identifying promising contributions).
The discussions that emerge from the comparison of predictions to outcomes are likely to focus on the topography (that is - what is high and what is low and how does that influence water?), the volume of water, and permeability. It would be ideal to make these concepts explicit and an official part of class discussion. “Mystery Maps” of the school grounds showing contour lines, permeable surfaces, and storm drain, will provide a helpful tool for inquiry and visualization. Now that the school grounds are mapped out, the next question the class needs to pursue is:

**Where DOES the water go (after it appears to be gone)?**

<table>
<thead>
<tr>
<th>At-a-Glance Inquiry 3: Investigating Rain on the School Grounds</th>
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</thead>
<tbody>
<tr>
<td>Students outdoors: (Note that weather conditions will drive the timing and structure of investigations)</td>
</tr>
<tr>
<td>- Prepare to go out on the next rainy day (raincoats, weather forecasts)</td>
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<tr>
<td>- Go outside in the rain to observe and document where water accumulates, flows, etc.</td>
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<tr>
<td>- Work in small groups on sections determined by class (original or revised sections)</td>
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<tr>
<td>- Mark maps, record evidence in journals, sketch, and take photographs</td>
</tr>
<tr>
<td>- Listen to rain and record sounds of rainfall on different surfaces</td>
</tr>
<tr>
<td>Students back in the classroom:</td>
</tr>
<tr>
<td>- Combine maps in class discussion drawing on evidence to support findings (journal notes, sketches and photographs)</td>
</tr>
<tr>
<td>- Compare predictions and findings</td>
</tr>
<tr>
<td>- Write in journals about best prediction, worst prediction, what we learned from each other</td>
</tr>
<tr>
<td>- Post ideas and questions to Knowledge Board</td>
</tr>
<tr>
<td>- Collaborate on constructing big ideas about movement of water (topography, volume, permeable surfaces, storm drains and other water “engineering” solutions)</td>
</tr>
<tr>
<td>- Explore Mystery Maps of school grounds (contour, permeable surface, storm drains)</td>
</tr>
</tbody>
</table>

**Inquiry 4. Where does the water go?** (next adventure to be developed)

*Framing Question: Where does the water go after it appears to be gone?*

The discussion can begin as a whole class. In clarifying the question of “where does the water go” students will want to know “how far to go” and the answer is begin with where it leaves the school and go to where you think the water ultimately ends up. Wherever that is, groups need to work out the “stops in between.”

Flow Paths to investigate will include:
- Down the drain (storm water runoff)  
- Into the ground (groundwater)  
- Into plants/into the sky (evapo-transpiration)
INVESTIGATING LOCAL WATER
AN INQUIRY FRAMEWORK FOR TEACHERS

TEACHER RESOURCES (see PDF)

A. Classroom Resources to Support Learning About Water
   - Wonder Center
   - Water Journals
   - Water Questions
   - Vocabulary

B. Inquiry and Collaboration Tools
   - B.R.A.V.E. Rubric for Group Talk
   - Knowledge Building Discourse & Principles
   - Two Visible Thinking Routines (‘I Used to Think,…’ & ‘Think/Puzzle/Explore’)
   - Visual Thinking Strategies

C. Maps of School Grounds (Jackson Street School)
   - Contours
   - Drainage
   - Impervious Surfaces