beetles
Science and Teaching for Field Instructors

Student Activity Guide

Stream Detectives

Who doesn't love to toss sticks or leaves into a stream and watch them move in the current? Who doesn't love mysteries? In *Stream Detectives*, students get to explore a stream, figuring out how the currents move by using stick and leaf "boats" to track the speed and direction of different currents. Students learn about some of the factors that affect current speed and direction (hydrodynamics), how water shapes stone (weathering), how the channel of a stream changes over time (stream morphology), and how the speed of the current affects the size of sediment that it leaves behind (erosion). Then, they apply this knowledge by using a Stream Detective Key to figure out how the stream features they see in the moment formed in the past, and to predict how they might change in the future. Students learn skills and concepts they can use to interpret and learn about any stream they encounter.

Students will...

- **Draw a map of a section of a stream, including the speed and direction of the currents.**
- **Make explanations about how currents in streams form.**
- **Learn that larger sediments are evidence of faster currents, and smaller sediments are evidence of slower currents.**
- **Think about how water moves, and how weathering and erosion create and shape stream features.**
- **Use a key to practice interpreting stream evidence to make explanations about what the stream was doing in the past, and what it might be like in the future.**

Grade Level:
Grades 4–8, can be adapted to younger or older grades

Timing:
50–65 minutes

Related Activities:
Discovery Swap to study stream organisms

Materials:
For instructor: whiteboard and marker. For students: journals (or paper) and pencils, printed Stream Detective Key,page 18, (1 copy per pair of students).
Optional: metric rulers or tape measures.

Tips:
To ensure a successful experience, review the teaching tips found on page 2 and throughout this guide.

Setting:
A short section of a not-too-roaring stream (river or creek), ideally with space for a group of students to spread out a bit.

NEXT GENERATION SCIENCE STANDARDS

FEATURED PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Constructing Explanations	Cause and Effect	Force and Motion Earth Materials and Systems The Roles of Water in Earth's Surface Processes

For additional information about NGSS, go to pages 15–16 of this guide.

THE LAWRENCE HALL OF SCIENCE
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Stream Detectives

ACTIVITY OVERVIEW

Stream Detectives	Learning Cycle Stages	Estimated Time
Thinking about Streams and Open Exploration	Invitation	8 minutes
Exploring Currents and Stream Features	Exploration	10–15 minutes
Discussing Currents and Sediment Size	Concept Invention	10–15 minutes
Being Stream Detectives	Application	10–15 minutes
Wrapping Up	Reflection	7 minutes
TOTAL		45–60 minutes

TEACHING TIPS

Field Card. On page 22 of this guide is a pocket-sized version of this lesson that you can use in the field.

Read the Instructor Support Section. Beginning on page 10, you'll find more information about pedagogy, student misconceptions, science background, and standards.

Materials and Preparations

If you do this activity regularly in the same spot, you might keep a premade drawing of the section of the stream on sheets for students to use. This will make their data easier to record and share with others (but if the stream changes course, you'll have to change your drawing!).

Before teaching, look at the questions on the Stream Detective Key and figure out which ones can and can't be answered at your stream. For example, at some stream spots bedrock is not visible, so the question about sculpted bedrock would be inappropriate to focus on.

Check in advance to make sure there are sticks/leaves at your exploration site that will work as boats. In very wet conditions, like after a lot of rain or after a stream's water level has just dropped in an area, the sticks right next to the stream may be waterlogged and sink. If there aren't good options nearby, carry down some sticks or leaves from above the creek.

Safety Concerns

Depending on the stream you choose, safety concerns will vary. If you are investigating a river, take extra precautions to make sure your students can investigate safely. If you have a question about whether it's safe for students to explore the river, *don't do it there*! It's not worth the risk. People regularly underestimate the power of river currents. Students don't need to be in the stream to investigate it, but even standing next to a river with a substantial current can be dangerous.

Thinking about Streams and Open Exploration

TEACHING NOTES

1. **Ask students to *Walk & Talk* or *Turn & Talk* about one or more of the following questions:**
   - ▶ *What are stream features you've heard of, and how do you think they form? (An example of a stream feature is a rock or a quiet pool. It's anything that's part of the stream, including how the water moves, or things near the stream that might impact or be impacted by the water in some way.)*
   - ▶ *What are ways streams might change the land around them?*
   - ▶ *What evidence might we find to help us figure out how high water levels have been in the past, or how a stream's path may have changed?*
2. **Come up with a kid-friendly definition of erosion and explain that it's part of what they'll be figuring out.** If students bring up erosion, ask students what they think it means. If they don't bring it up, make sure you do. Before moving on, make sure the group has a shared definition similar to this:
   - ▶ *Erosion is when soil, rock or dissolved material is moved from one part of Earth's surface to another by water, wind, or ice.*
3. **Tell students they'll start with an open exploration of this part of the stream.** Explain that they'll be exploring this section of the stream in different ways, and that first, they'll explore freely.
4. **Suggest that students notice water temperature, stick their face in the stream, float leaves, and explore!.** Suggest that they might want to:
   - Touch the water, and notice the approximate temperature.
   - Put their face or head in the stream (for fun).
   - Float stick or leaf "boats," watching where the current takes them.
   - Explore different parts of the area (within the boundaries).
5. **Show boundaries and give safety warnings, including your program's rules for stream exploration.**
6. **Let students explore!** Let students freely (and safely) explore for 5–10 minutes, but call time *before* they show signs of boredom.

Streams. Merriam-Webster defines a stream as: "a body of water (as a brook or river) flowing on the Earth." We use it here because it includes everything from tiny creeks to big rivers, any of which work for this activity.

Weathering vs erosion. Weathering refers to chemical and physical processes that break down rocks. Erosion is when that stuff, along with soil and dissolved material, are moved by water, wind, or glaciers across the surface of the Earth. Students often call all of this "erosion," which is inaccurate. Do your best to use these terms correctly during the activity, and to help students do so. If you're unsure yourself, you might want to just say, "weathering and erosion" when talking about how water has changed some feature, such as "Looks like weathering and erosion carved out this river bank."

Exploring Currents and Stream Features

1. **Gather students at the same spot as before, and review "downstream" and "upstream."** Ask the whole group to point at which direction the water is going, and then which direction the water is coming from. Briefly explain that water flows from mountains and hills downhill, often towards other rivers, lakes, and/or the ocean. The direction the water is flowing is called "downstream," and the direction it's coming from is "upstream."

Downstream and upstream. To those of us who have spent time around streams it may seem funny to explain these terms, but students with little direct experience with streams may not know what upstream and downstream are, so it's worth reviewing these terms so everyone understands the words and main directions of water flow before looking at individual currents. During the activity, especially with young students, when you say "downstream" or "upstream," try to also say something like, "the main direction the water is heading," so students who are just learning the concept know what you're talking about.

TEACHING NOTES

Make the idea of stream detectives exciting. Making it exciting and empowering for students helps motivate them to be interested in learning about stream shaping.

How long should the section be? The length they should draw will vary with the size of the stream. The idea is that it's long enough to be interesting, but not too complicated and doesn't contain too many features to explore in a short period of time. If it's a small creek where different features tend to be small and close to each other, this may be just a few yards long. If it's a river where stream features are bigger and may be farther apart, it may need to be longer than that.

Modeling observing and describing floating objects. Seeing floating objects move at different speeds and in different directions at the same time helps students develop ideas about what qualifies as a fast or slow current in this stretch of the stream. Hearing you model describing the motion and speed of a leaf helps them understand how to do this when they're on their own.

2. **Explain that students are going to become "stream detectives," learning how to figure out any stream's past, and how it might change in the future.** Tell your students they'll be learning things about stream features that will allow them to look at this stream, or any other stream they encounter, and figure out what happened in the past, what's going on in the stream currently (haha), and what might happen in the future—kind of like stream detectives!

3. **Tell students they'll each draw a map of a small section of the stream as you use a whiteboard to demonstrate how.** Tell students that first they'll draw a map of a small section of the stream, showing different features and different speeds of the current. Use a whiteboard to model and explain the following:

   a. Before beginning their maps, students should drop some leaf/stick boats at a couple of points along the stream so they can figure out which place will be most interesting to investigate.

   b. Tell students to choose a part of the stream that is not too long (give an example), and then draw an overhead view showing the stream banks.

   ▶ *To begin your map, pick a part of the stream and draw where the stream bank (or the edge) of the stream is.*

   c. Next, they will drop leaves and sticks in different parts of the stream, notice the relative speed and direction of currents, and label this on their map using arrows. Explain that they will need to test the current in lots of places to figure out the different speeds and directions of currents. Suggest that they try close to shore and where the stream bends, and suggest tearing up a leaf and dropping each piece near each other at about the same time, but far enough apart to show different currents. As an example, drop leaves or pieces of leaves in a few places, saying aloud how fast/in what direction you see them moving, then adding arrows to your whiteboard map with labels like "fast, slow, or very slow."

d. Tell students they'll also add features like rocks, pools, and beaches to their maps, and model this on the whiteboard. Tell students that after they've finished labeling currents, they should label other stream features. Define any terms students might not fully understand (such as a beach can be made of sand or rocks. A pool is an area where the water is calm, and often deeper).

   ▶ *You don't have to draw each feature exactly how they appear in real life, you just need to show where they are. So if you see a pool, you could just draw a circle and write "pool" in it.*

4. **Explain that students will work in pairs with each student drawing their own map, and ask if there are any questions.**

5. **Send students out to spend 10–15 minutes exploring.**

6. **As students explore, help them find interesting places to test currents with their "boats," and support them as they test currents and make maps.** Walk around to each group to check in about their explorations, and encourage them to ask questions, make observations, and come up with explanations.

7. **After students have had time to test currents and make maps (but before they lose interest), call the group back together.**

Discussing Currents and Sediment Size

1. **Gather students where there are interesting currents, including a fast current and an eddy (circular upstream current) and/or rock in a current, where they can all see them.** Gather students where they can all view a fast current and an eddy (and other features, if possible). Ideally, this will be a spot where there is a turn in the stream, with faster current on the outside of the turn, and slower or upstream currents on the inside of the turn, and/or a spot with a rock in the current.

2. **Ask a couple of students to share any surprising or interesting observations they made, then demonstrate what they described by dropping sticks or leaves in the stream.** Use the stream to demonstrate whatever questions, observations or ideas students bring up, such as "So Ramon said they noticed a place where the current moves very fast, then slows down in a pool. Let's toss a stick in and see if we can observe it, too."

3. **Point to a fast part of the stream (without saying that) and ask students to predict what the current will do at that place, and to include their evidence and reasoning.** Point to a spot in the current (where it's fast) and ask students to turn to someone nearby and predict what they think will happen to a stick/leaf dropped there. Which direction will the current take it? Will it move fast, slow, or very slow? Why do they think that?

4. **Drop the stick (or leaf) in the place you asked students to think about, and describe what happens to it out loud.** Drop a stick in, see where it goes, and comment on what happens. E.g. "Wow, look at how fast it's moving. Oh look, when it hit that spot, it started to slow down, and now it's curving to the left...

5. **Do the same with other leaves or sticks in different parts of the stream next to where you've gathered, prompting students to observe what happens.**

6. **Ask students to *Turn & Talk* and discuss causes of different speeds and directions of currents.** Ask students to make possible explanations with a partner for what causes currents to be faster or slower, and what causes them to move in different directions.

   ▶ *Now that we've observed slower and faster currents, does anyone have a possible explanation for what causes currents to be faster or slower in a stream? Or what might cause currents to flow in different directions?*

TEACHING NOTES

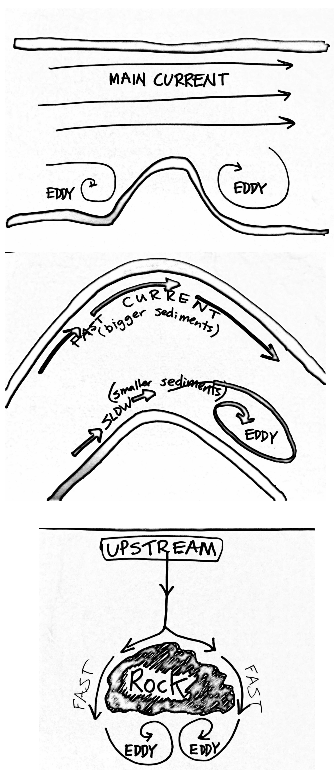
Choosing good floaters. Use pieces of sticks or leaves that float and are big enough to easily see from a distance.

Modeling. By making your own observations out loud, you're modeling for students what to look for, how to describe different currents, and how to judge whether a current is fast or slow.

Keep it brief. Don't let this part drag on too much. If students seem into it, then keep grooving, but BEFORE they seem "over it," move on to the discussion.

TEACHING NOTES

Examples of whiteboard diagrams. See the Background Section on page 17 for more information on eddys.



More on currents and sediment sizes. When water first slows down from moving fast, big rocks drop out while smaller sediments remain suspended in the current. Eventually, after more slowing, smaller rocks fall out, then sand, then silt and clay. So clay is evidence of very very slow moving water, and big rocks are evidence of fast moving water.

7. **Hear a few students' ideas, then explain (and draw on a whiteboard) how curves and obstacles affect currents, tying in anything students said, and defining an eddy.** Listen to a couple of students' ideas, then explain the effect of curves and obstacles on stream currents. If students shared any of the following ideas, point this out (such as, "Danya thought maybe rocks in a stream could affect the speed of currents…")
   - ▶ *There are many things that can affect stream currents, like the steepness of the slope (the steeper the slope, the faster the current). Rocks and the shape of the stream can also affect currents.*

   Depending on the features available in your spot, and what students have said, say things like these:
   - ▶ *When there is a curve in a stream, the current on the outside of the curve is usually faster. On the inside of the curve there is often slower current and a circular upstream current. A circular upstream current is called an eddy.*
   - ▶ *When there is a rock in a stream, the current speeds up on either side of it, but then there is a space just downstream of the rock and below water level that has to be filled, and the way for the water to reach it is from below, which forms an eddy below the rock, with an upstream current.*
   - ▶ *When an obstacle sticks out from a stream bank, like a point, rock, or downed tree, an eddy also often forms for similar reasons. Again, the current is often faster right next to the obstacle, and water fills in the space just below the obstacle from downstream, forming an eddy.*

8. **Review erosion and sediments, and ask them to make explanations for how the speed of the current might affect the size of sediments the stream can carry.** Remind them that erosion is when sediments (soil, rock, or dissolved material) is moved from one part of Earth's surface to another by water, wind, or ice. Point out to students that streams carry more than just leaves; currents can carry sand, pebbles, or even larger rocks. Then ask them to discuss how the speed of the current might affect the size of sediments the stream can carry:
   - ▶ *What effect do you think the speed of the current might have on the size of the sediments the stream can carry?*
   - If students struggle with the question, simplify it to a narrower version:
   - ▶ *Do you think a fast current or a slow current could carry bigger sediments?*

9. **Listen to a few student responses, then point to a fast current and explain that the faster the current, the larger the sediments it can carry (you might be able to see it, but not necessarily).** Explain to students that faster moving water can carry small particles, but also larger, heavier particles (like small rocks, or if it's really fast, even big rocks), while slow water can only carry small particles, like sand or silt. If you are at a place where students can actually see bigger sediments under faster water and smaller sediments under slower water, point this out.

10. **Explain that when water slows down, the sediments that can't be carried drop out of the current and are left behind at the bottom of the stream.** If it slows down just a little, just the bigger sediments drop out. If it slows down a lot, even the tiny sediments like mud or silt drop out.

11. **Explain that if the water level drops or the direction of the stream changes, we can see the rocks or pebbles that have been left behind on the bottom of the streambed.**

12. **Point to an area next to the stream out of the water that has larger rocks present, and ask students if the water was moving fast or slow when it was carrying those rocks.** [Fast.]

13. **Point to an area out of the water that has smaller rocks and/or sand present, and ask students if the water was moving fast or slow when that sand/rocks got left there.** [Slow.]

14. **Explain that as stream detectives, students can figure out what the speed of current used to be in a former stream flow area by looking at the size of sediments left behind.** Point to an area like a small beach where in the past, the stream has deposited rocks or sand, but the water level has gone down, so it's exposed.
    - ▶ *Even though there is no longer a current flowing here, you can be stream detectives and look at the size of sediments to figure out what the speed of the current used to be in this spot.*

Being Stream Detectives

1. **Tell students that as stream detectives, there are lots of cool things they can figure out besides how fast or slow the water moved.** Explain that they can figure out things like how high the stream has been, how it has affected the stream banks, and lots more.

2. **Pass out the Stream Detective Keys, page 18, and explain that it's a tool to help them figure out what has happened in the stream's past, and what might happen in the future.**

3. **Briefly explain each question on the key.** One by one, explain each question on the key, just enough to get them excited about answering them.

4. **OPTIONAL: Use your whiteboard to model how to record information about these questions on their maps.** Model how to add information students figure out by using their keys. For example, if they find a spot where it looks like the stream bank is being cut away, they might label it "bank cut."

5. **Tell students to work with their same partners to check out the stream and to try to answer some of the questions.** Prompt students to go out and try to answer some of the questions on their key. Explain that they could focus mostly on one question, or try to answer several different questions.

6. **As students work, model curiosity and excitement, and check in with anyone who may be distracted or confused.** Help struggling students by asking them to focus on a specific question, point out on their key what kind of evidence they can look for to answer the question, and then help them look for evidence in the stream.

TEACHING NOTES

Applying these ideas. These ideas can help explain complex patterns. For example, you might find a pocket of fine silt in the middle of rocks and gravel, which might be explained by noticing a rock just up stream that might have created a slower eddy where the silt was deposited.

Take a break if students need a quick break from standing around. This could include a short game or other energizing activity, or moving to another part of the stream before introducing the keys (only if necessary).

Bedrock. Bedrock is the solid rock that lies beneath the soil and smaller stones on Earth's surface. Streams tend to erode the soil and smaller stones away, exposing the bedrock.

Choosing questions to describe. You might not use every question for every stream, or every group. If there are questions that aren't relevant to your stream, or if you're working with younger students who might struggle to remember every question you pose, you can ignore some.

Deciding whether to have students record more. Read your group and make a decision about whether to have them record some of the other stream evidence they find in their journal during this time. Less focused groups might be better off just using the key and answering questions, without also recording what they find in their journals.

Wrapping Up

1. **Before students lose interest, call the group back together and ask pairs to share discoveries with another pair.** Gather the students. Tell each pair to find another pair, and to share their discoveries for a few minutes, including anything that was especially interesting or surprising.

2. **Tell groups of four to try to figure out something about the past and future of this stream, using evidence.** After pairs have shared with each other for a short while, challenge the groups to talk about something they figured out about the stream's past, and something they predict about its future based on evidence.

3. **Let a few students share out discoveries with the whole group, asking follow-up questions and encouraging discussion.** Get the attention of the whole group and ask a few students to share out what they discovered. Encourage other students to participate by using a hand signal if they came up with something similar, and to agree or disagree respectfully. Ask follow-up questions, such as "What's the evidence that makes you think that?", "Can you show us what you mean?", "Did anyone come up with evidence that supports a different explanation"?

4. **Highlight the use of cause and effect as a thinking tool to figure things out.** Explain that as students make observations to figure out what the stream was like in the past, they are thinking about causes and effects. Point out that the evidence students looked for to answer their questions are all effects of different causes.

   ▶ *In order to answer questions about the stream—including how high it was in the past, how fast the current was—you were looking for the effects caused by different things—such as high water levels, fast currents—that happened in the past.*

5. **Explain that scientists often figure things out about the natural world by thinking about what could have caused the effects they can observe.**

6. **Offer some *Walk & Talk* or *Turn & Talk* questions for students to discuss as they move away from the site, or as the group transitions to the next activity.** Suggested questions:
   - *What surprised you?*
   - *What discoveries did you make?*
   - *What are some stream features you are still curious about?*
   - *What did you find confusing? What questions do you still have about this section of the stream?*
   - *Pretend your partner is someone younger, & describe all you know about how stream features are shaped.*
   - *What predictions do you have for how this section of the stream might change in the future? What's your evidence?*

TEACHING NOTES

Macroinvertebrate exploration follow-up. Consider doing a stream macroinvertebrate exploration (see Discovery Swap activity) later on. Ask students to use what they know about how the stream moves to predict where they might find organisms, and the types of adaptations those organisms might have. For example, "What kinds of adaptations might you expect organisms that live in fast currents to have?"

Optional application:

TEACHING NOTES

1. **Give students the opportunity to apply their newfound skills to another stream, or a different part of the same stream.** If your students seem interested, and if you have the opportunity, consider doing a similar shorter investigation at another part of the stream, or at a different stream. This will provide them with a solid application experience of their new skills, and increase the likelihood they'll retain and apply them later in other contexts.

TEACHING NOTES

Instructor Support

Teaching Knowledge

Introducing content. In this activity, students construct their own understanding of streams through exploration, observation, discussion, and the use of the Stream Detective Key. There are also a few key points where the instructor shares conceptual content. These are strategically placed in the activity to help support students in making more focused observations, or in constructing explanations about how the stream has changed, or may change, over time. But make sure to play the role of a "Guide on the Side" throughout the activity, and to encourage students to make their own observations and gain new knowledge through the Stream Detective Key, rather than you immediately giving them answers when they have questions. Asking students to think about how they could make observations or otherwise find evidence to answer their questions through observations and other methods, rather than giving them answers immediately, can empower them to develop skills related to essential science practices.

Science language. Science is about coming up with the best explanation for all the available evidence. It also involves being open-minded about another explanation that could be better. In science, nothing is ever proven. That's why scientists tend to use language of uncertainty when discussing ideas and explanations. Try to use sentence starters like, "Maybe…" "I wonder if…" "That evidence makes me think…" "The evidence seems to show…" and encourage students to phrase their statements in similar language. That said, some scientific explanations, like gravity, have so much supporting evidence that it's appropriate to use language of more certainty when talking about them.

Content Knowledge

Stream valley system. During this activity, students are learning about hydrodynamics (the study of liquids in motion), stream morphology (the study of stream channels and how they change over time), and surface hydrology (the study of water quality and distribution and movement, including the study of sediment transport and erosion). For context, let's take a step back to look at the bigger picture of the greater system that those are all part of. What you see in a stream valley is the result of a combination of factors that influence each other as part of a system. Plate tectonics pushes up landforms (and sometimes pushes in other directions), building features like mountains and hills. Weathering and erosion are constantly tearing down landforms. Climate affects the amounts of precipitation and wind that take part in erosion. Areas with wetter climate and more water moving through them will tend to have more erosion, although wetter areas will also have more plants holding soil in place. And even mountains affect climate! The complex interactions between these factors explains much about the landforms we see. Oh yeah, and don't forget gravity! That said, most of the changes students see in a stream valley they can explain through weathering and erosion.

TEACHING NOTES

Gravity and streams

Pulling water through a stream system. Water has mass. It's heavy stuff. The pull of gravity between the Earth and water in the air cause it to fall to Earth. Once water hits Earth in either liquid or solid form, gravity causes it to move downhill, slowly with ice, and quickly with liquid water. The gravitational pull between the water and Earth pulls all this water through the drainage system, in most cases till it eventually reaches a larger body of water, like the Ocean (gravity also pulls rocks and soil downhill).

Laminar and turbulent flow (smooth and rough). Liquids flow, and there are two general types of flow that hydrodynamic scientists use to describe it: laminar flow and turbulent flow. Laminar flow is smooth, while turbulent flow is rough. Slower moving water tends to move through smooth, laminar flow. But above a certain speed, even without obstructions, laminar flow turns into turbulent flow. Then flow gets much more complicated once you add hard objects into and around streams.

Speed of streamflow. Two major factors that influence streamflow are gravity and the interaction between water and hard objects. Generally, steeper streams (with greater stream gradient) flow faster. When streams are less steep, they flow slower. When streamflow is blocked it can stop, but not for long! Other factors that affect the speed of currents in a stream are things like how deep the water is, whether the water is near the shore or near the middle, and the smoothness of the streambed/bank or irregularities that stick out, like large rocks. The water generally flows fastest near the surface, in the middle of the stream, and slowest along the streambed and banks, where friction slows it down. When a stream curves, the water's momentum causes more water to move along the outer bank of the curve and "pile up." This causes the water to be deeper and flow faster along the outer bank, than along the inner bank. Over time, the fast and deep water along the outer bank can cause the outer bank to weather and erode more and more and perhaps become undercut. The inside of the curve, where the flow is slower, tends to build up, because sediments are dropped there by the slower water. This can cause the curve to become even more pronounced, and in flat areas it can result in meandering streams that move in dramatic back and forth curves. Over time, as the stream erodes its banks, and as sediments get taken away from some parts, and carried and deposited in other parts, the shape and dynamics of a stream can change drastically. The amount of water and the speed it moves can also be very different in a stream depending on the seasons. In the summer, a stream may be tiny, and it can be hard to imagine how the big rocks and logs in it got where they are. But in the spring it may turn into a raging torrent that can carry and move much larger sediments.

The interaction between water and hard objects

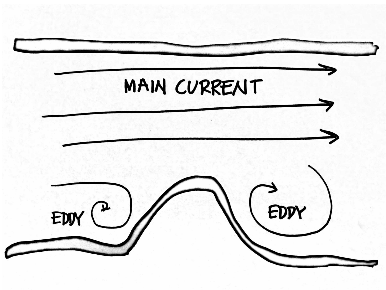
Rapids. Rapids are an example of turbulent flow. Rapids form when the current is fast. Rocks above and below the surface cause obstructions to flow, and make the water more turbulent as it moves around and over them.

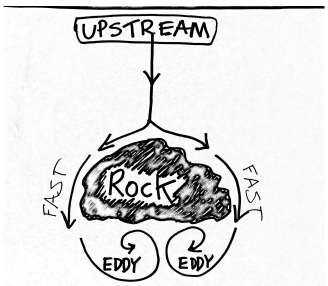
TEACHING NOTES

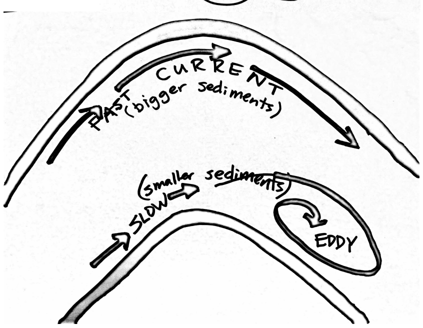
Sample Whiteboard Diagrams. Use the diagrams in the text as examples of what you might draw on a whiteboard as you explain how eddies are created to students.

The white water you often see in rapids is created as the water churns and splashes around rocks and air bubbles get mixed into the water. Riffles are like rapids, but smaller and shallower. Riffles are important to stream ecosystems, because lots of macroinvertebrates live in them, and fish often hang out below them to catch and eat any critters that drift downstream.

Eddies. Eddies are currents that flow in a different direction from the main direction of streamflow, like flowing upstream, or in circles. Some people mistake them for whirlpools. Eddies are formed by obstacles that block the stream flow. When stream flow is obstructed by a rock, the water flowing towards the rock can't keep flowing in a straight line, and has to move around it. This creates a void just downstream of the rock, which gets filled by water flowing upstream, counter to the main current. Eddies tend to form on the downstream side of just about every rock in a rapid. Eddies also form behind parts of the riverbank that stick out and obstruct the current. They form on the inside of river curves too. An eddy fence is the abrupt line between the downstream current and the upstream current. If the currents are strong enough, temporary whirlpools can form along an eddy fence.







Formation of sediments. Sediments are loose pieces of rock or minerals. They can be as tiny as clay or silt, or as huge as boulders. Large rocks get broken down over time by weathering (chemical and physical processes that wear them down) and erosion (as they're moved mostly by water, but also by wind or glaciers). Through these processes, boulders high in the mountains can be broken down into tiny grains of sand as they are transported all the way to coastal beaches. Scientists have come up with categories to describe different sizes of sediments by their approximate diameters: clay = less than 0.002 mm, silt = 0.002–0.05 mm, sand = 1–2 mm, gravel = 2–6.3 cm, cobble = 6.3–20 cm, boulder = more than 20 cm.

Sediments in streams. As a stream flows, it weathers and erodes sediments from its banks. The speed of the stream and the size of sediments along the bank and the streambed determine how much erosion happens and how far a stream will carry the sediments. Streams with a steeper slope, in which the water flows faster, can carry larger sediments. Faster flowing water generally causes more weathering and erosion too, because the force of the water on the banks is greater. Slower streams can carry only smaller sediments, such as sand and silt. About 25% of the sediments, mostly minerals, dissolve in the water, and are carried in **solution**. About 50% can't dissolve, but are light

TEACHING NOTES

enough to be carried and kept off the streambed by the current, and are carried in **suspension**. The other 25% roll or bump along the streambed as water flows over them and are called **bedload**. Suspended sediments fall out of the water column and settle on the streambed or banks when the water slows down and can no longer carry them. When sediments that are too big to be suspended in and carried by the water drop out to the bottom of the stream, they can still roll along the streambed, as they get pushed by the water or bumped by other sediments. As they bump along the bottom of the stream, these sediments can cause more weathering and erosion, cutting down into the streambed and loosening more sediments to be carried downstream. The rocks and other sediments in and along the banks of a stream become smooth and rounded as they bang into each other. Water also contributes to the smoothing of stone, through chemical weathering of rock as it dissolves minerals in the rock.

Some other stream features

As water moves through a stream system it weathers and erodes the land, creating a **stream valley**, with water flowing at the lowest point of the stream valley. Most of the changes you see in a stream valley are from weathering and erosion. A **floodplain** (aka: alluvial plain) is the wide and flat bottom of the valley. This is where water goes when the stream floods. It's the flat area above the banks of a stream. A **pothole** is a circular hole in the bottom or bedrock of a stream caused by the grinding of swirling sand or gravel. A **bar** is a shallow area in a stream formed where sediments have been deposited. Sandbars are mostly made of sand, and gravelbars are mostly made of gravel. A **drainage basin** is the area of land drained by a river system, which is also called a **watershed**. What's confusing is that a watershed is also a word used for a ridge of land that divides two areas drained by different river systems. When water flows over a rock (not just around it) or a ledge, then reverses to flow upstream just below the rock, it's called a **hole**. When a stream is constricted it may force a current downward, then back up again and down again, so it looks like boiling water. These are called **boils**. The path of the deepest water in a river is called a **thalweg**, a term we really didn't need to include here, but it's just so much fun to say! Thalweg!

TEACHING NOTES

Common Relevant Misconceptions

- **Misconception.** Changes to Earth's surface happen through catastrophic events, like floods and earthquakes.

  More accurate information. The changes are actually through a combination of slow and steady erosion combined with catastrophic events, like floods. Although most of the changes that happen in a stream take place during floods, weathering and erosion is constant.

- **Misconception.** Erosion is when water washes away soil.

  More accurate information. Water wind and ice do erode soil, but also rock. It's just easier to see soil erode than rocks, because it takes more time and or force to erode rock.

- **Misconception.** Rocks do not change.

  More accurate information. Many students think of rocks as stable, unchanging entities. The idea that water can wear holes into rocks or smooth jagged rock edges over time is hard to grasp. The concept of giant boulders weathering over time to become tiny grains of sand is perhaps even more unfathomable. In this activity, as students observe rocks in the stream and investigate the effects of the stream on its banks and bed, they have the opportunity to make sense of the powerful erosive force of water, and to construct a more accurate understanding of rocks as entities that can change over time.

- **Misconception.** Weathering and erosion are the same thing.

  More accurate information. Weathering refers to processes by which rocks break down. Chemical weathering happens when chemical reactions change the composition of rocks, such as when acid rain wears down rocks. Physical weathering is when rocks break down without a chemical change. This includes abrasion by wind, water, or ice, animals burrowing into rocks and disrupting them by moving around, plant roots entering cracks and forcing them apart, and other changes in pressure, often related to temperature changes, which cause rocks to break apart. For example, when water seeps into cracks in rocks then freezes and expands, the pressure can break the rocks apart. Erosion, on the other hand, refers to the movement of sediments by water, wind, and ice.

- **Misconception.** Erosion is always bad.

  More accurate information. Erosion is often in the media in relation to landslides and destructive storms, which can promote the idea that erosion is always bad. In reality, erosion is a natural process that has shaped the landscapes that we see all around us. As erosion removes sediments from mountains, over long time scales, mountains become shorter and more rounded. As water flows towards the coast it erodes the land, carving river valleys and canyons. Where sediments get deposited nearer the coast, they can form vast deltas, rich in minerals, and important for agriculture. This Stream Detectives activity gives students a chance to think about how erosion changes the shape of a stream over time, moving sediments from one area to another.

Connections to the Next Generation Science Standards (NGSS)

BEETLES student activities are designed to provide opportunities for the "three-dimensional" learning called for in the NGSS. To experience three-dimensional learning, students need to engage in Science Practices to learn important science ideas (Disciplinary Core Ideas) and deepen their understanding by relating that content to overarching Crosscutting Concepts. Students should be exploring and investigating rich phenomena, and figuring out how the natural world works.

In *Stream Detectives*, students engage in the practice of *Constructing Explanations* and have the opportunity to relate what they learn to the Crosscutting Concept of *Cause and Effect*. Students will build understanding of Disciplinary Core Ideas related to *Force and Motion, Earth Materials and Systems*, and *The Roles of Water in Earth's Surface Processes*.

Featured Science and Engineering Practices

Engaging students in constructing explanations. According to the National Research Council's *A Framework for K–12 Science Education*, a major goal of science is to deepen human understanding of the world through making explanations about it—students should develop their understanding of science concepts through making their own explanations about natural phenomena. In *Stream Detectives*, students engage in this practice when they use the Stream Detective Key and evidence from their surroundings to make explanations about what the stream was doing in the past or what it might be like in the future. They also make possible explanations about what might affect the speed and direction of currents. For students to be fully engaged in this practice, they need to go beyond just making explanations as described above. They also need to consciously use appropriate language of uncertainty ("I think that..."), base their explanations on evidence, and consider alternate explanations based on that evidence.

Featured Crosscutting Concepts

Learning science through the lens of cause and effect. When scientists make explanations for how or why something happens, they're thinking about the connection between cause and effect. What we can observe of the natural world are the "effects" of many potential "causes." Understanding relationships between cause and effect leads to a deeper understanding of the world, which is helpful in making predictions and explanations about what might happen in similar conditions in the future.

In *Stream Detectives*, students think about the effects of the streambed and stream banks on the speed of the stream's currents, and vice versa—the effects of the stream on the streambed and stream banks. They take cause and effect thinking a step further as they make observations about the present stream and think about what happened in the past to cause it to look the way it does, and when they consider what effects the present stream might have on the streambed and stream banks in the future. For students to reap full benefit of the Crosscutting Concept, they also need to reflect on its usefulness as a thinking tool. This happens when the

TEACHING NOTES

About the Next Generation Science Standards (NGSS): The development of the Next Generation Science Standards followed closely on the movement to adopt nationwide English language arts and mathematics Common Core standards. In the case of the science standards, the National Research Council (NRC) first wrote a Framework for K-12 Science Education that beautifully describes an updated and comprehensive vision for proficiency in science across our nation. The Framework-validated by science researchers, educators and cognitive scientists-was then the basis for the development of the NGSS. As our understanding of how children learn has grown dramatically since the last science standards were published, the NGSS has pushed the science education community further towards engaging students in the practices used by scientists and engineers, and using the "big ideas" of science to actively learn about the natural world. Research shows that teaching science as a process of inquiry and explanation helps students to form a deeper understanding of science concepts and better recognize how science applies to everyday life.
In order to emphasize these important aspects of science, the NGSS are organized into three dimensions of learning: Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas (DCI's). The DCI's are divided into four disciplines: Life Science (LS), Physical Science (PS), Earth and Space Science (ESS) and Engineering, Technology and Applied Science (ETS).

Read more About the Next Generation Science Standards at http://www.nextgenscience.org/ and http://ngss.nsta.org/

TEACHING NOTES

Importance of teaching science practices. "Engaging in the practices of science helps students understand how scientific knowledge develops...It can also pique students' curiosity, capture their interest, and motivate their continued study..." -National Research Council, A Framework for K-12 Science Education. Focus on these science practices will help to ensure a more scientifically literate public who will be better able to make thoughtful decisions.

About Crosscutting Concepts in the NGSS. Crosscutting concepts are considered powerful thinking tools for how scientists make sense of the natural world. The seven "big ideas" listed as crosscutting concepts are: Patterns; Cause & Effect; Scale, Proportion & Quantity; Systems and System Models; Energy & Matter: Flows, Cycles and Conservation; Structure & Function; and Stability & Change. These concepts may sound familiar, as they are quite similar to the themes referred to in science literacy documents as being important ideas that unify all disciplines of science and engineering.

Translating the codes used in the NGSS: Each standard in the NGSS is organized as a collection of performance expectations (PE) for a particular science topic. Each PE has a specific code, provided here so that they can be easily referenced in the NGSS documents. The first number or initial refers to the grade level: K - kindergarten, 1 - first, 2 - second,etc...MS - middle school, and HS - high school. The next letters in the code refer to the science discipline for the standard: LS, PS, ESS, ETS. The number following the discipline denotes the specific core idea within the discipline that is addressed by the PE, and the last digit identifies the number of the PE itself.

(Continued on next page)

instructor highlights cause and effect at the end of the activity, and points out to students specific instances where they used the idea to deepen their thinking.

Featured Disciplinary Core Ideas

Building a foundation for understanding Disciplinary Core Ideas. The NGSS make it clear that students need multiple learning experiences to build their understanding of Disciplinary Core Ideas. *Stream Detectives* provides students with an opportunity to develop understanding of some Disciplinary Core Ideas related to *Force and Motion* (PS2.A), *Earth Materials and Systems* (ESS2.A), and *The Roles of Water in Earth's Surface Processes* (ESS2.C).

When students think about how streams erode sediments and how physical geography affects the speed of stream currents, they build an understanding of how the interactions between objects and the motion of objects can be explained by forces (PS2.A). Investigating the relationships between the sediments of the stream bank/bed and the water flowing in the stream develops students' understanding of interactions between different parts of the Earth system (ESS2.A), particularly the geosphere (rocks, soil, sediments) and hydrosphere (water). Finally, as they think about how these interactions shape and change the land over time, they build an understanding of the important role water plays in Earth's surface processes (ESS2.C).

Performance Expectations to Work Toward

No single activity can adequately prepare someone for an NGSS performance expectation. Performance expectations are examples of things students should be able to do, after engaging in multiple learning experiences or long-term instructional units, to demonstrate their understanding of important Disciplinary Core Ideas and Science Practices, as well as their ability to apply the Crosscutting Concepts. As such, they do not represent a "curriculum" to be taught to students. Below are some of the performance expectations that this activity can help students work toward:

3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

Activity Connections

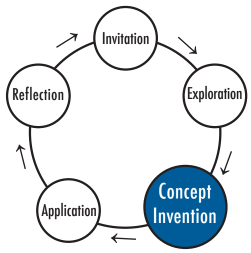
Other activities that you could use to engage students in exploring streams, and in particular organisms in streams, include *Interview an Organism* and *Discovery Swap*.

This is a focused exploration activity and combines well with other focused explorations, such as *Bark Beetle Exploration, Spider Exploration, Lichen Exploration*, or *Fungi Exploration*.

TEACHING NOTES

(Continued from previous page)

So...3-LS4-4 means it's part of a third grade standard (3) for life science (LS), addressing the fourth core idea (4), Biological Evolution: Unity and Diversity, within the life science standards, that deals with Biodiversity and Humans. It's also the fourth performance expectation (4) that makes up the complete LS4 standard at this grade level.



This activity takes students through a full learning cycle. Within a sequence of many activities, it is primarily a concept invention.

Stream Detective Key: Contents

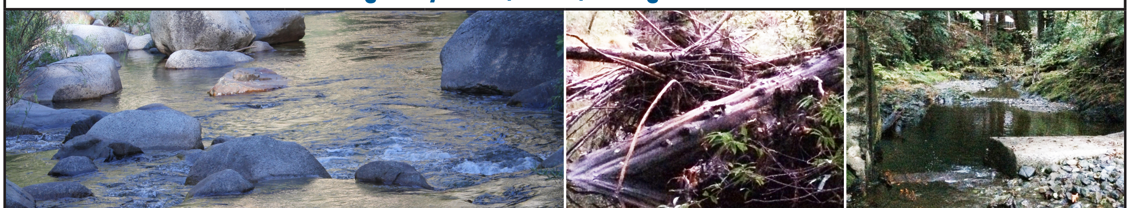
Evidence Of Other Water Levels

What are other levels the river has been? What is the highest?

Go to Page 1

Stream Blocking

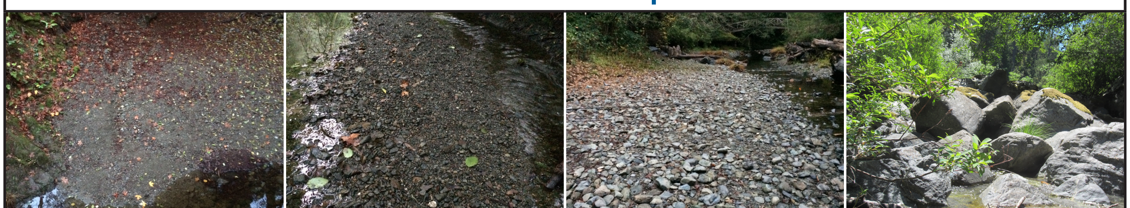
How has the stream been changed by dams, rocks, or logs that have blocked the stream?



Go to Page 1

Evidence Of Past Water Flow

Where has stream water flowed fast or slow here in the past?



Go to Page 2

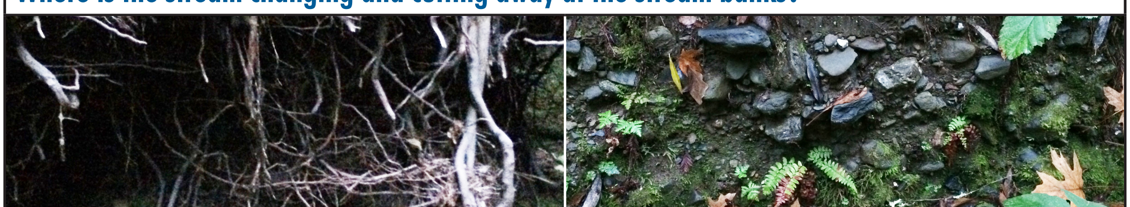
Living Trees

What are living trees doing to the stream banks?

Go to Page 2

Roots Or Layers Showing

Where is the stream changing and cutting away at the stream banks?



Page 2

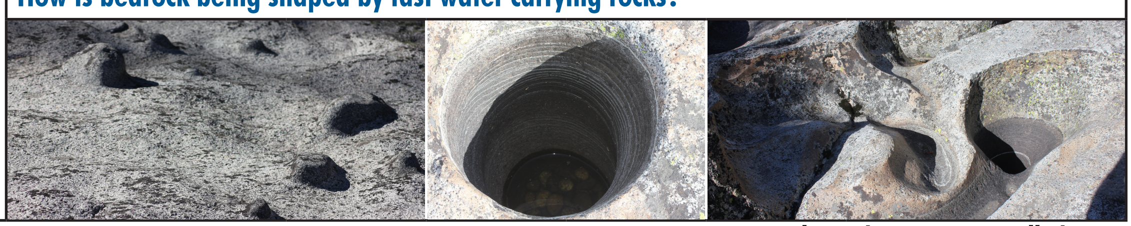
Rocks

What can you tell about what is happening with rocks in and around the stream?

Go to Page 3

Sculpted Bedrock

How is bedrock being shaped by fast water carrying rocks?



Go to Page 3

Stream Detective Key: Page 1

Evidence of other water levels: What are other levels the river has been? What is the highest?

Dead leaves, grass, twigs etc., caught in bush or tree branches

Logs left high on rocks

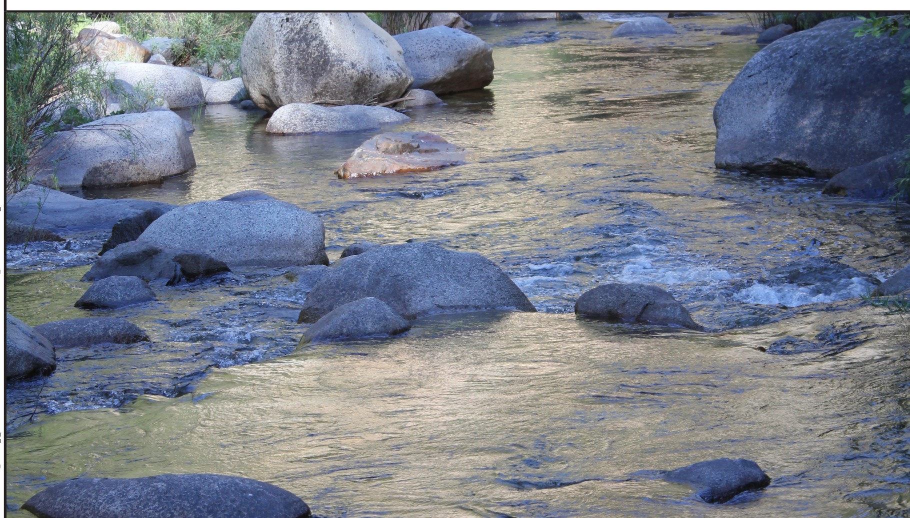
Lines on river banks or rocks like bathtub rings, showing evidence of higher water levels

©Dru! via Flickr.com

Plants that used to be underwater

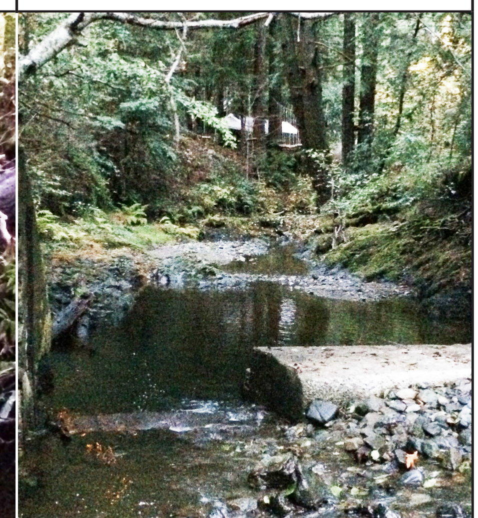
Stream blocking: How has the stream been changed by dams, rocks, or logs that have blocked the stream? Have pools or rapids formed?

Rocks in the stream made a rapid



Fallen logs carried by high water caught on boulders made a dam.

Humans built a cement chunk that made a dam



Unless otherwise notes, all photos are ©Kevin Beals

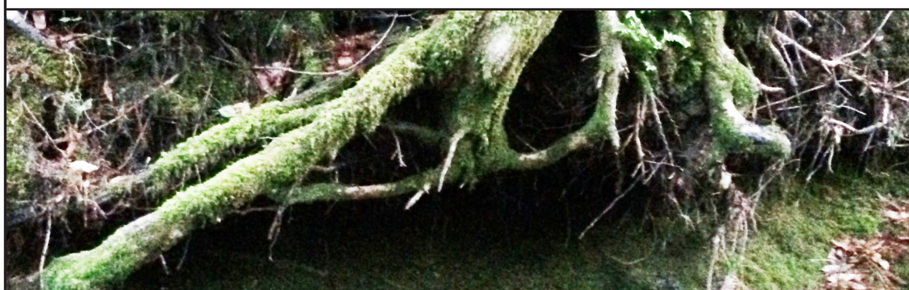
Stream Detective Key: Page 2

1

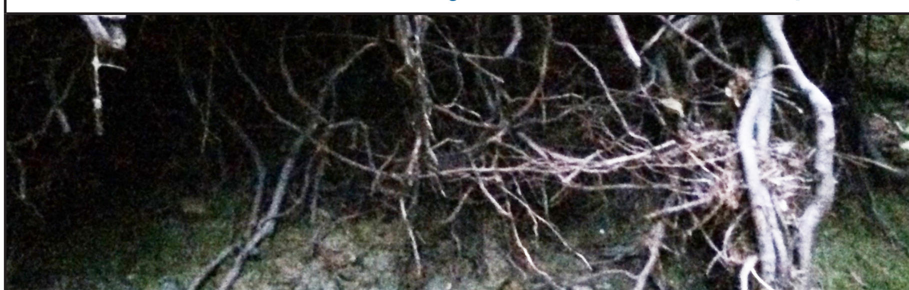
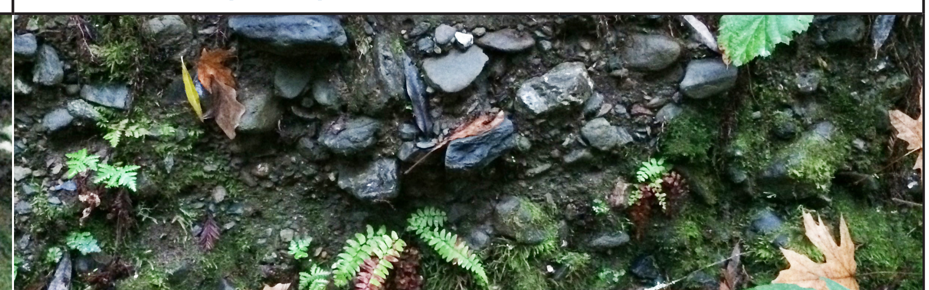
Evidence of past water flow: Areas of sand and stone formed underwater in the stream. Where has stream water flowed fast or slow here in the past?

Sand (rocks between 1-2mm) left by slow moving water	Gravel (rocks between 2-6mm) left by medium moving water	Cobble (rocks between 6-20mm) left by fast moving water	Boulders (rocks over 20mm) left by very fast moving water	Undercut river bank created by fast or very fast moving water
				

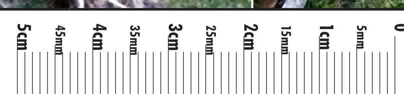
Living trees: What are living trees doing to the stream banks?

Tree roots holding soil and rocks together.	Tree pushing rock crack apart where rocks may fall into stream.
	

Roots or layers showing: Where is the stream changing and cutting away at the stream banks?

Tree roots showing. Tree roots grow underground. If you see tree roots, that means it used to be the river bank, but soil covering the roots has been washed away.	Rock layers showing. The stream has washed soil away, showing old rock layers. What do the rock layers tell you about what used to be here?
	

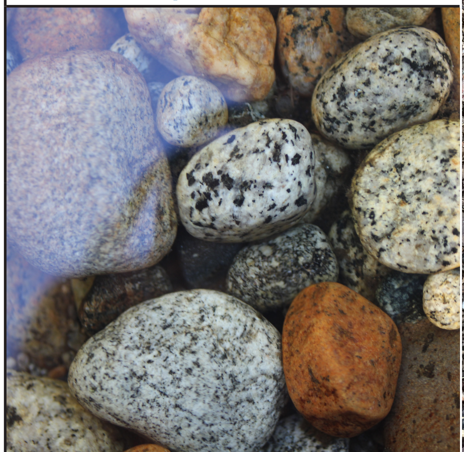
Ruler!
Measure those rocks!



Stream Detective Key: Page 3

Rocks: What can you tell about what is happening with rocks in and around the stream?

Rounded rocks = Have been traveling in the stream a long time. Sharp edges have worn off as they tumble in currents.



Sharp-edged rocks Have not been in the stream very long.

Rock fall = where rocks have fallen from somewhere uphill

Rock Crack = where rock is cracking and might be because:

- **The rock there is weak.**
- **Movements of huge chunks of rock have caused stress**
- **Repeated freezing and thawing (only in places with lots of freezing and thawing during the year.**

Sculpted bedrock: How is bedrock being shaped by fast water carrying rocks?

Softer rock has been weathered and eroded away by fast water carrying rocks, leaving behind harder rock "bumps."

Softer rock has been weathered and eroded by fast water carrying rocks, leaving behind different smooth shapes.

Pothole (or "Candy Dish"). Rocks have been swirled around by water currents, wearing holes in rock over many years.

FIELD CARD

Cut out along outer lines and fold along the centerline. This makes a handy reference card that will fit in your pocket.

Stream Detectives

Thinking about Streams & Open Exploration

1. *Walk & Talk* or *Turn & Talk*:

   ▶ *What are stream features you've heard of, and how do you think they form?*

   ▶ *What are ways streams might change the land around them?*

   ▶ *What evidence might we find to help us figure out how high water levels have been in the past, or how the stream's path may have changed?*
2. Come up with a kid-friendly definition of erosion & explain it's part of what they'll be figuring out. E.g.:

   ▶ *Erosion is when soil, rock, or dissolved material is moved from one part of Earth's surface to another by water, wind, or ice.*
3. Explain: First, you'll freely explore this part of the stream.
4. Explain: Notice water temperature, stick your face in the stream, float leaves, & explore!
5. Show boundaries & give safety warnings, including your program's rules for stream exploration.
6. Let students explore (5–10 min.)!

Exploring Currents & Stream Features

1. Gather students at same spot as before, & review downstream & upstream.
2. Explain: You'll be "stream detectives," learning to figure out any stream's past, & how it might change in the future.
3. Explain: You'll each draw a map of a small section of the stream (demo on whiteboard):
   a. Explain: Before beginning maps, drop "boats" along the stream to find which place is the most interesting to investigate.
   b. Explain: Choose a part of the stream that isn't too long (give example), and then draw an overhead view showing the banks.
   c. Explain: Drop "boats" in different parts of stream, notice speed & direction of currents, & label this on map using arrows.
   d. Explain: Also add features like rocks, pools, & beaches to maps (model this on whiteboard).

   ▶ *You don't have to draw each feature exactly how they look in real life, you just need to show where they are. So if you see a pool, you could just draw a circle and write "pool" in it.*
4. Explain: Work in pairs with each student drawing own map.
5. Send students out to spend 10–15 minutes exploring.
6. Support students as they test currents & make maps.
7. Call group back together.

Discussing Currents & Sediment Size

1. Gather where there are interesting currents, including a fast current, an eddy &/or rock in current, where they can all see.
2. Ask ~2–3 students to share surprising/interesting observations, then demo what they describe with "boats" in the stream.
3. Point to fast part of stream & ask students to predict what the current will do at that place, using evidence & reasoning.
4. Drop "boat" in place you asked students to think about, & describe what happens to it out loud.
5. Do same with other "boats" in different parts of stream, asking students to make observations.
6. *Turn & Talk* re: causes of different speeds & directions of currents.

   ▶ *Does anyone have a possible explanation for what causes currents to be faster or slower in a stream? Or what might cause currents to flow in different directions?*
7. Hear ideas, then explain & draw how curves & obstacles affect currents, tying in anything students said, & defining an eddy. Say things like these:

   ▶ *Many things can affect stream currents, like steepness, rocks, and stream shape.*

   ▶ *Curve: Current on the outside of the curve is usually faster. On the inside, current is often slower.*

   ▶ *Eddy: A circular upstream current is called an eddy.*

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▶ *Rock: Current speeds up on either side, but space just downstream of rock below water level has to be filled, and water fills from below, forming an eddy.*

▶ *Point to rock or log sticking out from stream bank: Current is often faster next to an obstacle, & water fills space just below the obstacle from downstream, forming an eddy.*

8. Review erosion & sediments, ask students to make explanations for how the speed of the current might affect the size of sediments the stream can carry. If they struggle, ask:

▶ *Do you think a fast current or a slow current could carry bigger sediments?*

9. Listen to responses, then point to a fast current & explain: the faster the current, the larger the sediments it can carry.
10. Explain: When water slows, sediments that can't be carried drop to the bottom of the stream. If water level drops or the direction of the stream changes, we can see rocks or pebbles left behind on the bottom of the streambed.
11. Point to area out of water that has larger rocks, & ask students if the water was moving fast or slow when it was carrying those rocks.
12. Point to area out of water with smaller rocks/sand, & ask if water was moving fast or slow when they got left there.

▶ *Even though there is no longer a current flowing here, you can be stream detectives and look at the size of sediments to figure out what the speed of the current used to be in this spot.*

Being Stream Detectives

1. Explain: As stream detectives, there are lots of cool things you can figure out besides how fast or slow the water was.
2. Pass out Stream Detective Keys, & explain it's a tool to help figure out what has happened in the stream's past, & what might happen in the future.
3. Briefly explain each question on the key.
4. OPTIONAL: Model how to record information about these questions on their maps.
5. Explain: Work with same partners to check out the stream and to try to answer some of the questions.
6. As they work, model curiosity & excitement, & check in with anyone who may be distracted or confused.

Wrapping Up

1. Gather & ask pairs to share discoveries with another pair.
2. Groups of four try to figure out something about the past and future of this stream, using evidence.
3. A few students share out discoveries with the whole group, asking follow up questions and encouraging discussion.
4. Explain: Cause and effect is a thinking tool to figure things out.

▶ *In order to answer questions about the stream—how high it was in the past, how fast the current was, etc.—you were looking for the effects caused by different things—high water levels, fast currents, etc., that happened in the past.*

5. Explain: Scientists often figure things out about the natural world by thinking about what could have caused effects they observe.
6. *Walk & Talk* or *Turn & Talk* suggested questions:
   - What surprised you?
   - What discoveries did you make?
   - What are some stream features you are still curious about?
   - What did you find confusing? What questions do you still have about this section of the stream?
   - Pretend your partner is someone younger & describe all you know about how stream features are shaped.
   - What predictions do you have for how this section of stream might change in the future? What's your evidence?

Optional:

- Students apply newfound skills to another stream, or a different part of the same stream.

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ABOUT BEETLES™

BEETLES™ (Better Environmental Education Teaching, Learning, and Expertise Sharing) is a program of The Lawrence Hall of Science at the University of California, Berkeley, that provides professional learning sessions, student activities, and supporting resources for outdoor science program leaders and their staff. The goal is to infuse outdoor science programs everywhere with research-based approaches and tools to science teaching and learning that help them continually improve their programs.

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Science and Teaching for Field Instructors

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UNIVERSITY OF CALIFORNIA, BERKELEY

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