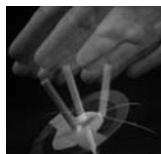
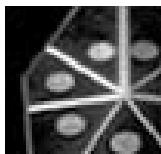


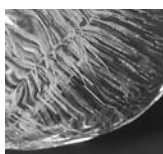
Workshop I



Workshop II



Workshop III



Workshop IV



Workshop V



## Fundamentals of Inquiry Facilitator's Guide



## WORKSHOP IV: STREAM TABLE INQUIRY

A Professional Development Curriculum from the  
**Institute for Inquiry®**

*The fourth in a set of five workshops for teacher professional development.*

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**Caution:** The experiments in this guide were designed with safety and success in mind. But even the simplest activity or the most common materials can be harmful when mishandled or misused. Use common sense whenever you're exploring or experimenting.

You can download your own copy of this guide at [www.exploratorium.edu/ifi/streamtable](http://www.exploratorium.edu/ifi/streamtable). A wealth of background material, for this and the other guides in the series, can be found at [www.exploratorium.edu/ifi/library](http://www.exploratorium.edu/ifi/library).

In order to access these materials, you will need Macromedia Flash Player 5 or higher and Adobe Acrobat Reader 4 or higher, available for free downloading at [www.exploratorium.edu/ifi/help](http://www.exploratorium.edu/ifi/help). These plug-ins may require additional memory.

**You can download any of the  
FUNDAMENTALS OF INQUIRY workshop guides at  
[www.exploratorium.edu/ifi/workshops/fundamentals](http://www.exploratorium.edu/ifi/workshops/fundamentals).**



# Stream Table Inquiry

## Welcome

For more than thirty years, the Exploratorium Institute for Inquiry has been educating teachers, administrators, and professional developers about the theory and practice of inquiry-based teaching and learning. We have witnessed firsthand the power of science coming alive and having real meaning for students and teachers when they learn how to focus on the questions of science, rather than just the answers.

In 2000 we received a major grant from the National Science Foundation to make what we have learned available to even more educators. The result is a series of guides that provide step-by-step instructions and access to support materials online so professional developers and teacher educators can present these workshops on their own.

The *Stream Table Inquiry* workshop takes participants through a full inquiry process. They begin with an exploration of stream flow and erosion, then do a focused investigation on a question they choose. Next, participants have a chance to share what they found during their investigations. The process culminates in a discussion that allows them to reflect on and analyze their inquiry experiences. We hope you find this workshop useful in establishing a vibrant setting for teachers to learn and extend their practice. And we hope that, like us, you will be inspired by seeing teachers become enthused about science, eager to bring the very best ideas and approaches to their students.

—LYNN RANKIN  
Director  
Institute for Inquiry

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# ABOUT THIS WORKSHOP



- **Workshop Overview**
- **The Workshop in Context**

# Workshop Overview

## **A Quick Summary**

This is the fourth of five guides in the FUNDAMENTALS OF INQUIRY curriculum. The guides are designed to help facilitators plan and present professional development workshops for educators interested in developing an understanding of inquiry-based science instruction.

The *Stream Table Inquiry* workshop gives teachers an experience that illuminates the process of doing inquiry. This process includes exploring materials and phenomena, raising questions, planning and doing investigations, and sharing the building of scientific understanding with fellow learners.

For many teachers, a firsthand experience with inquiry can transform their thinking about science teaching and learning, and increase their confidence in their own ability to understand scientific ideas. The thrill of making their own scientific discoveries, of really understanding something essential about the world through their own efforts, is inspiring. Through this experience—and their reflection on the experience—they begin to recognize the benefits that inquiry teaching and learning can offer.

This workshop is the heart of the FUNDAMENTALS OF INQUIRY curriculum. It can be presented on its own, but it is most effective when offered as part of the full curriculum. (For information about the complete series, see page 9.)

The topic of stream tables was chosen because it is prevalent in elementary curricula, and the science content involved is included in the national as well as most state standards. As a result, many educators already have stream table materials available and would not have to start from scratch to prepare for the workshop.

## **Goals**

- To give teachers a personal experience of science inquiry that can transform their thinking about teaching and learning science.
- To motivate teachers to move toward inquiry in their own teaching.
- To provide teachers with an understanding of inquiry teaching and learning.

## **The Goals of the Workshop**

This workshop offers teachers a direct experience of inquiry and a chance to reflect on the process. It helps teachers discover that inquiry has an identifiable structure, that it is possible to learn substantive science content through the process, and that there are many possible paths toward learning these science content ideas.

The main goals of this workshop are to help teachers understand the nature of inquiry learning and to motivate them to find ways to include more inquiry in their teaching.

To accomplish these goals, the facilitator supports learners both in using science process skills to investigate their own interests, and to help them gain access to a core set of scientific ideas about stream flow and erosion. Early in the inquiry, facilitators support learners in taking ownership over investigating their own questions. Later in the inquiry, facilitators increasingly attend to helping learners make sense of their investi-

gations in terms of a core set of scientific ideas. As a result, teachers experience having ample ownership over the learning process, and also learn substantive science ideas through the process. Having this kind of experience leads to an understanding of inquiry learning and increases participants' motivation to try inquiry teaching.

While the *Stream Table Inquiry* experience is not specifically designed for teachers to take back, as is, to their classrooms, it forms a critical part of the process of helping teachers provide more inquiry experiences for their students. This process begins by helping teachers understand the fundamental nature of inquiry learning, which is best understood at the personal, experiential level. It's not enough to just read about it or hear a lecture or see a video. Educators need to know what learning science through inquiry "feels like" in order to gain a personal understanding of the process and become motivated to put more emphasis on inquiry in their teaching.

Ideally, this experience would be followed by other workshops or experiences that give teachers specific strategies or ideas that help them apply their understanding of inquiry to their classroom practice. We recommend *Subtle Shifts: Adapting Activities for Inquiry*, the fifth workshop in the FUNDAMENTALS OF INQUIRY curriculum, as an example of an experience that provides specific strategies for this purpose.

## How the Workshop Works

This workshop takes 6 hours and 15 minutes and is designed to be led by

three facilitators. Typically, planning takes about 9 hours, not including the time necessary to prepare materials. In this guide, we list materials for 36 participants. For fewer participants, quantities of materials and other workshop logistics can be adjusted as needed.

We recommend 12 to 36 participants for the workshop. Having fewer than 12 does not allow for the lively group interaction that is such an important component of the workshop. Having more than 36 makes whole group discussions unwieldy and can necessitate an additional facilitator.

The *Stream Table Inquiry* workshop begins with an introduction in which the facilitator sets the context, explains chart M1: "Map of Inquiry Structure," and introduces the take-home messages.

After the workshop introduction, participants separate into groups and begin the first phase of the

### About the Process of Inquiry: Creating Paths Toward Understanding

The process of inquiry starts when learners become curious or interested in something they've experienced. They begin by asking questions and experimenting with ways to find answers.

The paths they follow to find these answers are usually not straightforward. As learners experiment, new questions and discoveries emerge that lead them in a variety of directions. Although these meandering paths may seem inefficient, they can actually provide learners with a broader experience and deeper understanding of science concepts and ideas than more linear, prescribed investigations.

At the Institute for Inquiry, we consider the inquiry process a journey of discovery, in which learners grapple with complex phenomena and science concepts in order to develop a greater understanding of the world. Since each learner has his or her own way of making sense of the world, there can be as many paths toward understanding as there are learners.

For more on inquiry, see "Pathways to Learning" at [www.exploratorium.edu/ifi/about/philosophy](http://www.exploratorium.edu/ifi/about/philosophy), from which this passage is taken.

process by rotating through two stream table Inquiry Starter stations. These stations focus on different phenomena related to how slope and flow affect erosion. At each station, participants raise and record questions about what they see that interests or intrigues them.

Once they have experienced both stations, participants move to the Focused Investigation phase of the inquiry. They examine the questions that were raised earlier, choose one to investigate, and form small groups with others interested in the same topic. They then carry out their own investigations using an array of materials and equipment.

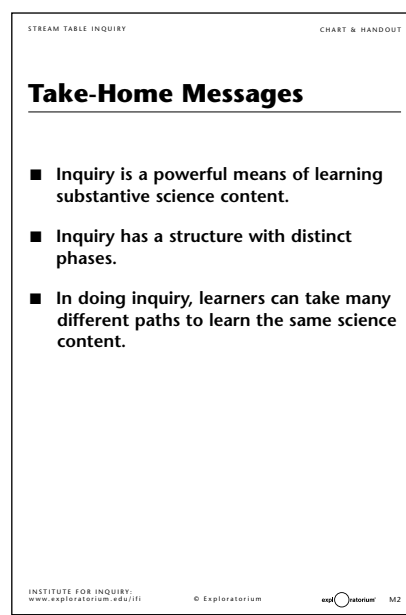
At the end of the investigation, participants progress to the Sharing Understanding phase, in which groups share their findings in order to communicate their investigation process and the scientific ideas they learned through that process. After that, a facilitator synthesizes the findings, reinforcing the scientific ideas that the inquiry was designed to help participants understand.

Then participants move to the Making Meaning discussions, breaking into three groups to reflect on and discuss their experiences.

### **About the Take-Home Messages**

The take-home messages are brief statements that convey the central pedagogical ideas encountered during the workshop. By introducing the messages early on, facilitators set the context for what is to

follow, and inform participants of the purpose and content of the workshop. This transparency of purpose is an important initial step in establishing an atmosphere of trust between facilitators and learners. Such trust is critical in creating a climate in which learners feel comfortable expressing opinions and considering new ideas.



Understanding of the messages deepens as the workshop progresses, and as participants become intellectually engaged in building new ideas based on their firsthand experiences and their conversations with each other. The take-home messages are revisited at the end of the workshop as a way to summarize and reinforce the understandings participants have constructed.



# The Workshop in Context

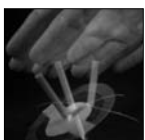
## **FUNDAMENTALS OF INQUIRY**

*Stream Table Inquiry* is the fourth of five workshops in the FUNDAMENTALS OF INQUIRY curriculum, designed to introduce teachers to the benefits of inquiry-based teaching. Though most of the workshops can be used individually, the series is best presented as a comprehensive whole. Below are brief descriptions of the five workshops.

The FUNDAMENTALS OF INQUIRY curriculum is organized into three areas:

### **Elements of Inquiry**

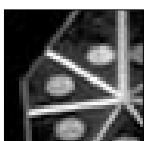
A set of workshops that serve as building blocks for an immersion into inquiry by focusing on various hands-on approaches and process skills related to inquiry learning.



#### **Workshop I: Comparing Approaches to Hands-On Science**

Participants discover that different approaches to hands-on teaching support different goals for learning (about 3.5 hours).

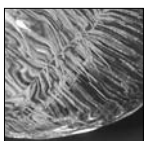
*Preview the workshop at [www.exploratorium.edu/ifi/comparing](http://www.exploratorium.edu/ifi/comparing)*



#### **Workshop II: Process Skills**

Participants identify the tools needed to carry out inquiry—the process skills—and examine the role of these skills in learning (about 3.5 hours).

*Preview the workshop at [www.exploratorium.edu/ifi/skills](http://www.exploratorium.edu/ifi/skills)*



#### **Workshop III: Raising Questions**

Participants examine the kinds of questions learners ask about phenomena and find out how to turn “noninvestigable” questions into “investigable” ones (about 3.5 hours).

*Preview the workshop at [www.exploratorium.edu/ifi/questions](http://www.exploratorium.edu/ifi/questions)*

### **Immersion in Inquiry**

In this workshop, participants plan and conduct an investigation that illustrates how deep conceptual content—in this case, about stream flow and erosion—can be learned through a carefully orchestrated science inquiry process. At the same time, the activity illuminates the process of inquiry itself.



#### **Workshop IV: Stream Table Inquiry**

Participants experience inquiry firsthand, learning scientific process and content through an extended investigation (about 6 hours).

*Preview the workshop at [www.exploratorium.edu/ifi/streamtable](http://www.exploratorium.edu/ifi/streamtable)*

### **Connections to the Classroom**

This last workshop focuses on helping participants make connections between what they have experienced in the previous workshops and what they can do in their classrooms to incorporate more science inquiry.



#### **Workshop V: Subtle Shifts: Adapting Activities for Inquiry**

Participants examine how current classroom activities can be modified to incorporate elements of inquiry (about 3 hours).

*Preview the workshop at [www.exploratorium.edu/ifi/subtleshifts](http://www.exploratorium.edu/ifi/subtleshifts)*

# PLANNING AND PREPARATION



- **Workshop at a Glance**
- **Essential Planning Steps**
- **Sample Room Setup**
- **Materials Overview**
- **Materials List**
- **Charts, Handouts, and Station Cards**

# Workshop at a Glance

**Planning and Preparation**  
9+ hours + materials prep

**Workshop Time:** 6 hours, 15 minutes

**Facilitators Needed:** 3

**Participants Accommodated:** 36

## Planning Time

9+ hours, not including time spent ordering, constructing, and setting up materials.

## Special Materials Note

Some of the materials may need to be ordered ahead of time—it's best to allow six weeks for delivery. See page 21 for details.

You will also need a place to store the materials (including up to 150 pounds of sand) before the workshop.

## Presenting the Workshop Part 1: Engaging in Inquiry

### Introducing the Workshop

One facilitator introduces the workshop to all 36 participants at once, then divides the group in half. **20 minutes**

### Inquiry Starters

During the first 20 minutes, one half of the group works at the slope station; the other half works at the flow station. Then the groups switch stations. Participants record questions and observations. Note that the facilitator remains at his or her Inquiry Starter station while participants rotate. **55 minutes**

### Focused Investigation: Introduction

Participants view all recorded questions and observations, choose one to investigate, and form groups of 2-3 people interested in in the same question. **20 minutes**

### Focused Investigation: Beginning

Small groups begin to carry out their focused investigations. **75 minutes**

### Lunch

**30 minutes**

### Focused Investigation: Concluding

Participants finish their focused investigations. **35 minutes**

### Sharing Understanding: Findings

The whole group reconvenes to hear reports from investigation groups. **50 minutes**

### Quick Cleanup and Break

**15 minutes**

### Sharing Understanding: Synthesis of Findings

A facilitator synthesizes group findings and relates them to scientific concepts. **15 minutes**

## Presenting the Workshop Part 2: Making Meaning of the Inquiry Experience

### Making-Meaning Discussions

The group divides into thirds for small-group reflections and discussions about their inquiry experience. Note that each facilitator is responsible for one of these three discussion groups. **55 minutes**

### Concluding the Workshop

The whole group reconvenes and a facilitator summarizes the main ideas of the workshop. **5 minutes**

**Reviewing the Workshop**  
time as needed

# Essential Planning Steps

## Overview

The *Stream Table Inquiry* workshop requires a substantial amount of planning and preparation. Below you'll find step-by-step instructions, divided into three categories: Before the Workshop, On the Day of the Workshop, and After the Workshop. This workshop requires 3 facilitators for 25–36 participants. If you have 12–24 participants, 2 facilitators should be sufficient.

Some of the preparation is done individually, but much needs to be done as a group. The planning you do as a group is aimed at helping you present scientific and pedagogical ideas in a unified way.

There is a lot to do, including reading through this entire guide individually, doing a 2-hour tutorial on stream table phenomena, reviewing the guide again as a group, discussing facilitation and divid-

ing up the facilitation roles, preparing to lead discussions, arranging for an appropriate space, and collecting, ordering, or constructing a wide array of materials.

A planning timeline is shown below.

It's really important to plan in collaboration with your co-facilitators. Investing the time in planning together is the only way to ensure that you develop a shared understanding of the overall workshop goals. When each facilitator reinforces the same goals, participants experience a strong and cohesive workshop and will be more likely to apply the ideas to their own teaching.

## Planning Time Needed

- **9–12 hours** (spent over a period of weeks) reading the guide, planning the workshop, and doing the tutorial
- **6 hours** gathering and constructing materials
- **3 hours** setting up materials for the workshop

**For materials that need to be ordered, allow up to 6 weeks for delivery.**

## Planning Timeline for Facilitators

Steps	Preparation	Timing
1–2	<b>Read guide and view online preview</b>	up to 8 weeks in advance
3	<b>Plan time, space, and materials</b> <ul style="list-style-type: none"> <li>• order, gather, and prepare materials</li> <li>• schedule time and space for facilitators to meet and prepare</li> </ul>	up to 8 weeks in advance (ordering materials can take up to 6 weeks)
4	<b>Do the stream table tutorial together</b>	up to 3 weeks in advance
5–6	<b>Review guide together and choose roles</b> <ul style="list-style-type: none"> <li>• go section by section, discussing purpose of each section and step</li> <li>• choose facilitation roles (see guide on page 15)</li> </ul>	up to 3 weeks in advance; will probably need more than 1 meeting
7–11	<b>Prepare for your roles as facilitators</b> <ul style="list-style-type: none"> <li>• be prepared to set context</li> <li>• become familiar with main science ideas</li> <li>• address discussion guidelines</li> </ul>	up to 3 weeks in advance
12	<b>Set up for the workshop</b>	one day before the workshop

You'll also want to set aside time after the workshop to talk with your co-facilitators about what went well and what could be improved in subsequent workshops.

## Before the Workshop

**1. Read this guide.** It is essential that each facilitator reads this guide all the way through before doing any of the planning steps. You may want to flag sections that don't make immediate sense to you, com-

ing back to them as the goals of the workshop become clearer.

**2. View a brief online preview of the workshop.** This preview, which introduces the workshop with sound and images, can be viewed by both facilitators and participants. It's available on the Web at [www.exploratorium.edu/ifi/streamtable](http://www.exploratorium.edu/ifi/streamtable).

### **3. Plan materials, space, and time.**

#### **Materials**

- Gather and organize all materials, and plan for construction. See the complete list of materials on pages 23 and 24, and the Materials Overview on page 20.
- Materials will have to be ordered, purchased, and constructed in advance. Plan on ordering materials at least six weeks in advance. Construction takes approximately three hours.
- The tutorial (see page 72) requires using many of the same materials you'll need for the workshop itself, so you will have to gather and construct the materials in order to do the tutorial.
- This guide is written for a workshop with 36 participants, and the materials list reflects this number. However, material and handout quantities can

be adjusted for fewer participants. (We recommend no fewer than 12 participants.)

- Be sure you have a place to store bulky materials until they're needed, including several 50- to 100-pound bags of sand, as well as stream table pans, catch basins, pitchers, and buckets.
- Duplicate and prepare all the charts, handouts, and station cards (see page 25). To make it easy to set up on the day of the workshop, organize charts, handouts, and station cards according to when and where they will be used. Note that the reproducible masters at the end of this guide are arranged in order of use.

#### **Space**

- Reserve space for the workshop, and schedule time and space for facilitators to meet to plan the workshop. For the workshop, you'll need a room large enough for six work tables and two additional tables for extra materials (see page 19). The room also needs to be large enough for three discussion groups of 12 people after the inquiry, or these discussions can be in separate rooms. Be sure there's enough room between discussion groups to prevent distraction.
- Note that the Making Meaning Discussions section (page 56) is written for 3 facilitators, each leading a group of 12. For fewer than 36 participants, divide the entire group into smaller groups. For 12–24 participants, split into only 2 discussion groups so that there are enough people in each group to keep a good discussion going.

#### **Time**

- Once you've chosen facilitation roles (see page 15), create a detailed schedule for facilitators to refer to during the workshop to help keep things on track. Note the beginning and ending times for each step (e.g., Step 1: Participant Introductions, 9:00–9:10; Set the Context, 9:10–9:20).

#### **An Important Note from the Institute for Inquiry**

This workshop is the result of many years of development with educators across the country. While its format may seem adaptable, using it in ways other than those described here will not only change the participants' experience but the outcome as well. We strongly recommend becoming familiar with the planning and presentation of the workshop and experiencing its intended results before considering any adaptation.

- Prepare a simplified version of the schedule for participants, which you can post at the beginning of the workshop. Be sure to include times for breaks. A sample schedule is shown below.

<b>Sample Schedule for Participants</b>	
9:00–9:20	Introducing the Workshop
9:20–10:15	Inquiry Starters
10:15–11:50	Focused Investigation (incorporate break as needed)
11:50–12:20	Lunch
12:20–12:55	Concluding Investigations
12:55–1:45	Investigation Findings
1:45–2:00	Cleanup and Break
2:00–2:15	Synthesis of Findings
2:15–3:10	Making Meaning Discussions
3:10–3:15	Concluding the Workshop

- The Making Meaning Discussions are a very important part of the workshop. In order for participants to get the most out of the discussions, it is important to allow the full amount of time allotted for this part of the workshop.
- This guide assumes that the workshop will be presented all in one day, but other arrangements are possible to accommodate different schedules. The workshop can be presented over two consecutive days, breaking for the day where the lunch break occurs in this schedule. It can also be presented in three two-hour segments with up to a week in between each segment. This works best if you take the first break just before the Focused Investigation phase begins and the second break just after that phase concludes. In any case, it's useful to schedule breaks in the investigation because participants tend to return to investigations refreshed, and facilitators can check in with each other and talk about how the investigations are proceeding.

- The Sharing Understanding: Synthesis of

Findings section is a very important part of the workshop. This guide describes a structure in which the facilitator presents the synthesis of findings in 15 minutes. An alternate advanced model for presenting the synthesis of findings as a discussion is also mentioned (see page 50). The alternate form of synthesis is offered as a possibility for facilitators who are very experienced at leading discussions and are comfortable with the inquiry's science content. It requires at least 30 more minutes than is now allotted for the presentation, so this would have to be added to the schedule.

**4. Do the Stream Table Tutorial** (see page 72). It's essential that all three facilitators meet together and do the tutorial before presenting this workshop. It will help you become familiar with the main science ideas of the stream table inquiry, as well as virtually all the phenomena that participants will encounter and investigate in the workshop. Included are tips on what to do and what to observe for different parts of the activity, as well as simple explanations for many of the concepts involved.

Remember that the facilitator tutorial, which takes about two hours, will require many of the same materials as the workshop. Some materials will need to be ordered ahead of time, and some will need to be constructed. (See Step 3, above.)

**5. Review the workshop guide as a group.** Read through this guide again with all the facilitators. It's crucial to go over it together, section by section, in order to come to a shared understanding of the purpose of each section and of each of the steps.

Read through each section and discuss the purpose of the section as a whole. Then, read through each step and discuss the following:

- What is happening during the step?

- What is the purpose of the step?
- Who will present the step?

It's important to do this collaboratively. Only by planning together can each facilitator orient his or her role toward building on what has come earlier, and reinforce the overall goals of the workshop in each step.

**6. Choose facilitation roles.** As you go over the guide section by section together, divide up the facilitation roles. A sample division of workshop roles is shown at right, but you can choose to divide them in other ways that are more comfortable for you.

There are some roles for which all facilitators must take responsibility. These include helping people form investigation groups, facilitating the focused investigations, and leading a Making Meaning discussion group.

There are some roles that need to be done by different facilitators because they occur at the same time. For example:

- Whoever collects and posts the sentence strips at the end of the Inquiry Starters phase should not set the stage for investigation because these may happen at the same time.
- Whoever presents the Synthesis of Ideas during the Sharing Understanding phase should not set the context for and lead groups in sharing investigations, act as a timekeeper when investigations are shared, or coordinate the cleanup. This allows the person giving the synthesis of ideas to concentrate fully on listening to the groups share their investigations.

Certain roles require particular attention when preparing. These include:

<b>Facilitator Roles</b>	<b>Sample division of roles for facilitators A, B, &amp; C</b>	<b>Page</b>
<b>Introducing the Workshop</b>		
<input type="checkbox"/> Introduces the workshop	A	27
<b>Inquiry Starters</b>		
<input type="checkbox"/> Introduces the Inquiry Starters and demonstrates the stream table	B	29
<input type="checkbox"/> One facilitator at each of the two Starter Stations	A,B	31
<input type="checkbox"/> A third facilitator floats between the two Starter Stations and keeps track of time	C	31
<input type="checkbox"/> Collects and posts sentence strips including QWWNDWATT questions	C	32
<b>Focused Investigation: Introduction</b>		
<input type="checkbox"/> Sets the stage for investigation	B	33
<input type="checkbox"/> Helps people form investigation groups during the gallery walk	A,B,C	36
<b>Focused Investigation: Beginning</b>		
<input type="checkbox"/> Each facilitator is in charge of various groups during the investigation	A,B,C	38
<input type="checkbox"/> Presents the shake bottle thinking tool	B	41
<b>Focused Investigation: Concluding</b>		
<input type="checkbox"/> Sets the context for concluding the investigation	B	44
<input type="checkbox"/> Finds a group willing to share their investigation first	C	45
<b>Sharing Understanding: Findings</b>		
<input type="checkbox"/> Sets the context for and leads the groups in sharing investigations	B	47
<input type="checkbox"/> Acts as timekeeper while groups share investigation findings	A	47
<input type="checkbox"/> Coordinates a cleanup and divides people into discussion groups	A	49
<b>Sharing Understanding: Synthesis of Ideas</b>		
<input type="checkbox"/> Presents a synthesis of what groups shared	C	51
<b>Making Meaning Discussions</b>		
<input type="checkbox"/> Leads a making meaning discussion group	A,B,C	57
<b>Concluding the Workshop</b>		
<input type="checkbox"/> Concludes the workshop	A	63

- introducing the workshop
- facilitating the investigations
- presenting the Synthesis of Ideas
- leading a Making Meaning discussion group.

When preparing for these roles, keep the ideas in Steps 7–10, below, in mind.

**7. Be prepared to set the context.** Setting the context for the workshop is crucial. The facilitator who introduces the workshop should study the information in Step 2 of Introducing the Workshop (page 27) and practice setting the context in his or her own words.

- Also during the introduction, be prepared to explain why you chose to present this workshop. How does it fit with other professional-development experiences participants have had? How is it related to district and state goals and standards? What do you want teachers to get from the experience? You might also want to relate the workshop to the *National Science Education Standards*. For more information, see page 70.

**8. Keep the main science ideas and the take-home messages in mind.** During the investigation, facilitators help groups work toward an understanding of the stream table inquiry's main science ideas, which are the content goals of the inquiry. The facilitator who presents the Synthesis of Findings needs to be very familiar with the main science ideas in order to recognize how the investigations relate to those ideas. (Refer to M12: "Main Science Ideas about Stream Flow and Erosion.")

- Become familiar with the take-home messages, the pedagogical ideas participants are meant to take away from the workshop. These can be reinforced during the inquiry and the Making Meaning Discussions. (See M2: "Take-Home Messages.")

**9. Address discussion guidelines.** For the Making Meaning Discussions after the inquiry, it's a good idea to have guidelines that can help the discussions proceed smoothly. All three facilitators should agree on what those guidelines should be and write them out on the M15: "Discussion

Guidelines" chart to post at the beginning of the Making Meaning Discussions. Guidelines such as the following work well:

- Be sure everyone gets a chance to talk
- Share time equally
- Listen carefully to each other and treat each other's opinions respectfully
- Address each other directly rather than talking to the facilitator

**10. Assess the need for additional information.** Be sure to read "*Stream Table Inquiry* and the *National Science Education Standards*" on page 70. This section offers background information about the Institute for Inquiry's approach to inquiry learning, as well as information on how this workshop supports the *National Science Education Standards*. You may want to copy this section for participants.

- The additional resources below may also be of interest to you or participants. Before presenting this workshop, read through them and decide which, if any, to copy for distribution.

### Additional Resources

- ❑ "Pathways to Learning: A Design for Teaching and Learning through Inquiry" by the Exploratorium's Institute for Inquiry. Available at [www.exploratorium.edu/ifi/about/philosophy](http://www.exploratorium.edu/ifi/about/philosophy).
- ❑ "Inquiry: Thoughts, Views, and Strategies for the K–5 Classroom." *Foundations*, vol. 2. Arlington, VA: National Science Foundation, 1999. (Inquiry overview can be found in Chapters 1–6 and 13; inquiry in practice is covered in Chapters 7–10; assessing inquiry is in Chapters 11 and 12). Available at [www.nsf.gov/pubs/2000/nsf99148/htmstart.htm](http://www.nsf.gov/pubs/2000/nsf99148/htmstart.htm).

**11. Prepare for your roles as facilitators.**

After reviewing the guide with the group, you should read through the steps again individually,



### A Note about Scripts

The scripts in this guide are intended to illustrate one way of presenting information and instructions to workshop participants. While the content of the scripts is crucial, the exact wording is not. After thoroughly familiarizing yourself with the scripts and noting the important points, you may decide to convey the information in your own words rather than reading the scripts to participants word for word.

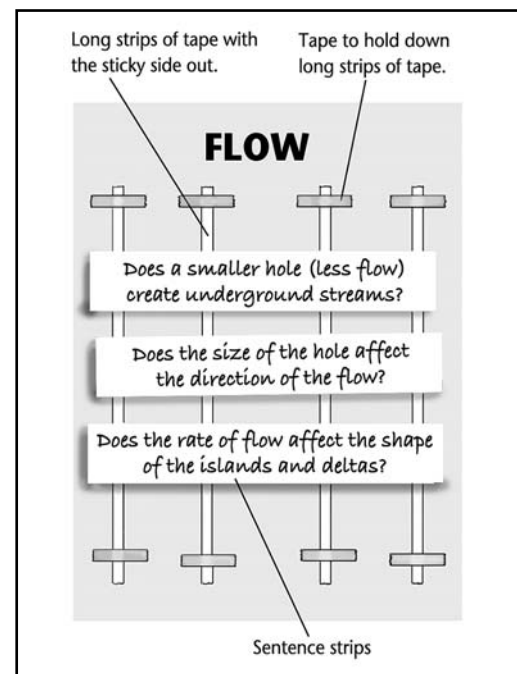
paying particular attention to those for which you are responsible. Carefully study the prompts and facilitation hints, highlighting any points you decide are particularly important or useful. Note that many steps in the workshop contain scripts (in *italic* type and marked with arrows). You may choose to read the scripts or to present the scripted information in your own words (see “A Note about Scripts,” above). Be sure you are very familiar with the contents of the scripted information you will be presenting.

## 12. Set up for the workshop.

- Setting up all the materials for the workshop is time-consuming. Unless you can arrive two to three hours before the workshop begins, plan to arrange the room the day before the workshop.
- Be sure to prepare the sand mix for the stream tables the day before the workshop, as well, since this can also be a time-consuming process. (For details, see page 22.)
- Decide how to set up the room. You'll need space for six work tables and two additional tables for extra materials. In the Making Meaning Discussions, you'll need either separate rooms for the three discussion groups of 12 people, or

you'll have to rearrange tables so the discussions can take place in one room. Be sure there's enough room between discussion groups to prevent distraction.

- Figure out in advance where to post charts M5: “Slope” (5 copies), M6: “Flow” (5 copies), and M7: “QWWNDWATT (Questions We Will Not Deal With At This Time)” for the Gallery Walk in the Focused Investigation: Introduction section. These charts should be posted so that the Slope charts are in one area, the Flow charts in another area, and the QWWNDWATT charts are in a third area. (See Sample Room Setup, page 19.)
- Prepare charts for attaching sentence strips by placing long vertical strips of tape, sticky side out, to a chart page (see below). Then, all the sentence strips can be stuck to the tape strips rather than each needing its own tape.



**Quick taping method**

- Different facilitators will work with different investigation groups. Decide in advance how to divide the groups. One approach is to divide them by topic—one facilitator covering the groups investigating the effect of slope on erosion, a second facilitator covering the groups investigating flow, and a third covering the remaining groups. With this approach, however, there's no way to know if the groups will divide evenly. Another option is to assign certain tables to each facilitator. If there are six tables, for example, each facilitator can cover two.

## **On the Day of the Workshop**

**1. Organize handouts and charts to be distributed and posted.** Have handouts ready to distribute. Have charts not posted yet ready for posting. See page 25 for details.

**2. Watch your schedule.** To keep things on track, refer to the detailed facilitator schedule you created before the workshop (for more information, see page 13).

**3. Saturate the sand (optional).** If you have time, saturate the sand in each stream table pan before participants arrive. If the sand starts out dry, participants are more likely to focus on phenomena related to saturation, rather than on the main science ideas, because their first and second runs will be so different (see Stream Table Tutorial, Experiment 5, page 76).

## **After the Workshop**

After the workshop, you and your co-facilitators

### **Preparing the Room for the Workshop**

Consult the Charts, Handouts, and Station Cards list on page 25, the Materials section on pages 20–24, and the Sample Room Setup on page 19.

#### **Post the charts**

- Schedule of the workshop
- M1: "Map of Inquiry Structure"
- M2: "Take-Home Messages"
- M5: "Slope" (5 copies)
- M6: "Flow" (5 copies)
- M7: "QWWNDWATT" (1 copy)

NOTE: Put tape on Flow, Slope, and QWWNDWATT charts (see instructions on page 17 for quick-taping method).

#### **Set up the stations**

(See Materials Overview on page 20 for details of stream table setups)

6 Slope Stations, each with the following:

- M3: "Starter Station Card"
- 15 sentence strips
- 2 marking pens

6 Flow Stations, each with the following:

- M4: "Starter Station Card"
- 15 sentence strips
- 2 marking pens

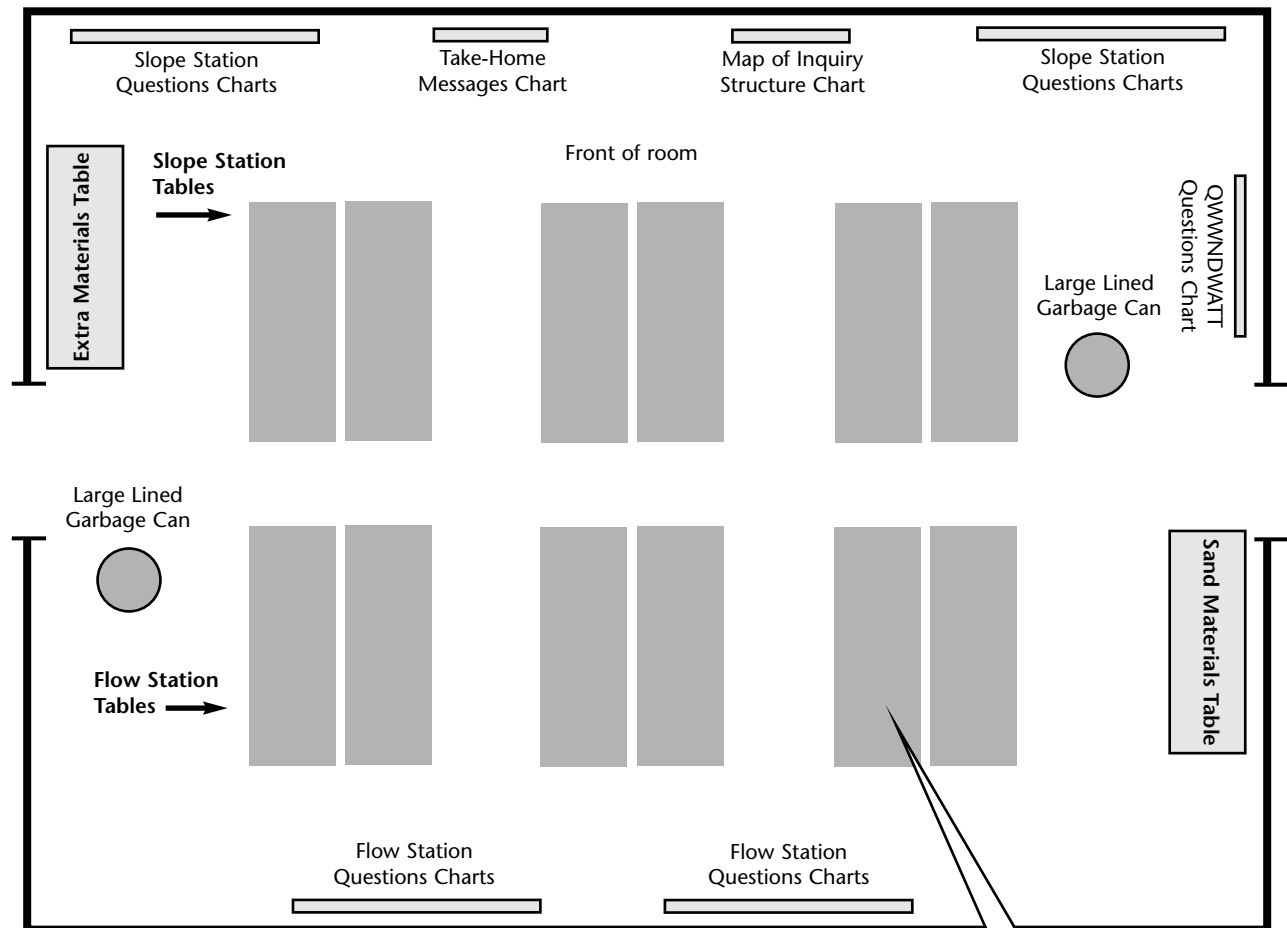
1 stream table prepared for a facilitator-led demonstration

#### **Set out other materials**

- Tape for attaching sentence strips to charts
- Notebooks or paper and pens for participants to use

should take some time to reflect on your experiences. Issues of logistics, communication, outcomes, and expectations can be addressed at this point. The Facilitation Review (page 66) will allow you to assess the results of your work and identify the successes and challenges that can help guide subsequent workshops.

# Sample Room Setup



## Essential features

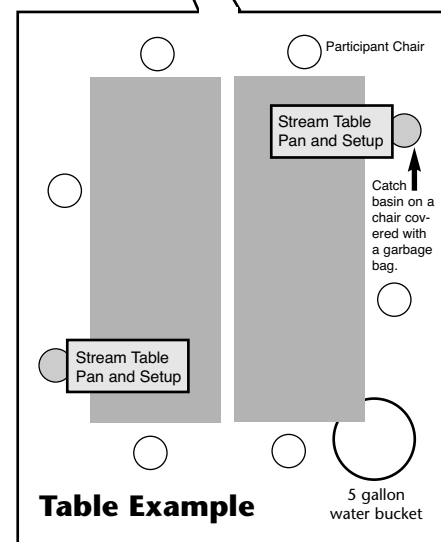
### Work Materials

- One 10-gallon container for preparing standard sand mix
  - Six 5-gallon buckets of water
  - Two 30-gallon garbage cans on wheels (to dispose of sand)
  - One table for extra materials (not including sand)
  - One table for extra sand and extra stream table setups
- (NOTE: Each kind of sand should be labeled in its own 5-gallon bucket.)
- Enough wall space for posting up to 15 charts

### Work Tables

Note that each work table has 8 chairs: 6 for participants, and 2 to hold catch basins. Work tables too small to fit 8 chairs comfortably can be doubled up as shown.

- 3 work tables with 2 slope setups on each table (for 3 participants each), for a total of 6 slope setups
- 3 work tables with 2 flow setups on each table (for 3 participants each), for a total of 6 flow setups



# Materials Overview

This workshop requires many materials. Some will have to be made, some will have to be purchased, and some you may already have on hand. Included in this section are instructions on setup, information on the basic materials needed, how to adapt materials from existing curricula, and more.

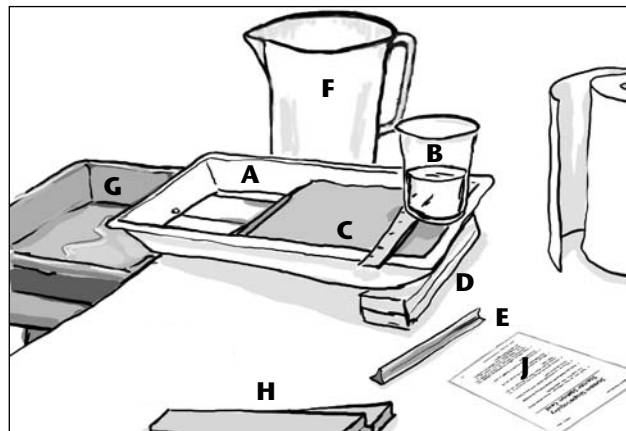
## Basic Stream Table Setups

Each stream table setup includes items A–G below. Items H–J are specific to either the slope or flow stations.

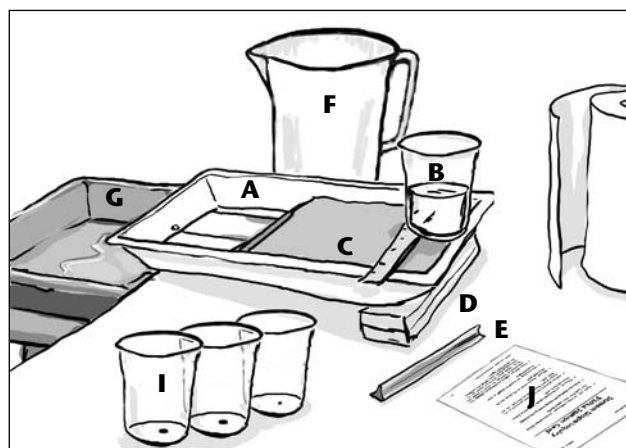
- A** a stream table pan filled with 2 quarts of “standard mix” sand (see page 22)
- B** “drip” container (with  $\frac{1}{8}$ ” hole) for water to flow into the stream tables
- C** a ruler to support the drip containers
- D** 1” × 2” blocks to prop up the stream table
- E** a “wood angle” scraper to move and smooth sand
- F** a water pitcher
- G** a basin to catch water flowing out of the stream table pan
- H** *for slope stations only*: additional 1” × 2” blocks
- I** *for flow stations only*: additional drip containers (with  $3\frac{1}{16}$ ”,  $\frac{1}{16}$ ”, and  $\frac{3}{32}$ ” holes)
- J** *for flow or slope stations*: inquiry starter station activity cards

## Adapting Materials from On-Hand Sources

Stream tables materials are included in many curricula you may have on hand. Most of these materials can be adapted for use in this workshop. The most important item is the stream table pan. In



**Slope setup**—note extra blocks (H) for changing the slope of the pan



**Flow setup**—note extra drip containers (I) with holes of different sizes

this guide the pans described are 22” × 11” × 2½”. This size is most effective because it is long enough to see the important phenomena, not so long that it requires an inordinate amount of sand, and shallow enough so the water from the drip containers creates streams rather than craters. If your pans are a different size, adjustments for additional materials are described in the Materials Notes section on the following page.

## Making Materials

The materials you will need to make are the drip containers and the 1" × 2" wooden blocks. If your stream table pans are 22" × 11" × 2.5", you can order

the wood angle scrapers and the rulers; otherwise you will need to make them. See the Materials Notes section below for construction details.

## Materials Notes

(Prices are circa 2006)

### Stream Table Pans

You can make your own stream table pans by drilling a  $\frac{3}{8}$ " drainage hole into the edge of a plastic pan between the bottom of the pan and the drainage wall. Try to find pans close to 22" × 11" × 2½". Good-quality plastic pans (18" × 15" × 4"), called Tray Totes, are available from NASCO Scientific, 800-558-9595, for about \$6.00 each (order #WO517500). Large kitty litter or cement-mixing pans will also work.

Premade stream table pans (22" × 11" × 2½") with drainage holes are available from Delta Scientific, 800-258-1302, for about \$7.50 each (order #WXR200-5090).

Whichever type of stream table pan you choose, the size of your pan will determine the lengths you need to make the following other materials: rulers, wood-angle scrapers, 1" × 2" wooden blocks (see below for details).

### Rulers

You'll need rulers that are slightly longer than the width of your stream table pan. Twelve-inch wooden rulers, which fit across 11" stream table pans, are available from Delta Scientific, 800-258-1302, for about \$.35 each (order item #WX180-2162). If you need longer rulers, consider cutting meter sticks or pieces of lumber to size. Check that they support the drip containers without flexing too much.

### 1" × 2" Wooden Blocks

Cut lengths of 1" × 2" lumber into pieces the width of your stream table pans.

### Wood Angle Scrapers

L-shaped "wood angles" are used to smooth and shape the sand in the stream table. Get wood angles for the 11"-wide stream table pans from Delta Scientific, 800-258-1302, for about \$2.55 each (order item #WX010-2530). For other size pans, cut pieces of  $\frac{3}{4}$ " L-shaped wooden molding to fit the width of your stream tables. Other alternatives are putty knives or pieces of wood cut to fit your stream tables.

### Drip Containers

Get 70 to 100 quart-sized (32 oz.) clear deli containers. These can be purchased or ordered from restaurant supply stores. (Sometimes, local supermarkets with salad bars and take-out counters will agree to donate these or sell them to you at cost.)

Get an electric drill and  $\frac{1}{8}$ ",  $\frac{3}{16}$ ",  $\frac{5}{16}$ ", and  $\frac{3}{32}$ " drill bits.

Place a container open-side-down on a smooth surface. Drill a hole in the center of the bottom. Slowly pull out the drill bit while it is still spinning to make a smooth hole. If there are plastic ridges around the hole, drill it again from inside the container to smooth out the edges. Immediately after drilling the hole, mark the diameter size on the container. Make:

- 24 containers with  $\frac{1}{8}$ " holes
- 15 containers with  $\frac{3}{16}$ " holes
- 15 containers with  $\frac{5}{16}$ " holes
- 15 containers with  $\frac{3}{32}$ " holes

NOTE: Although several curricula include pint-sized containers, quart-sized containers are more effective for use in this workshop.

### Water Pitchers and Catch Basins

Half-gallon water pitchers are used for pouring water on the stream table and filling the drip containers; catch basins catch the runoff. Note that dishpans make fine catch basins.

### Centimeter Cubes (Gram Pieces)

You can order 50- to 100-centimeter cubes (to model houses) from Delta Scientific, 800-258-1302, about \$3.95/100 pieces each (order item #WXR-031-0463).

### Shake Bottles

You'll need 12 shake bottles (1–2 oz. clear pill bottles with sealable caps)—one for each stream table setup. Suitable vials are available from Delta Scientific, 800-258-1302, for about \$1.50/10 (order item #WXR221-4156). You'll need to fill the shake bottles halfway with "standard mix" sand (see page 22) and then fill them the rest of the way with water.

### Sand and Gravel

For this inquiry, you'll need:

Pea gravel	30 lbs.
Coarse sand	100 lbs.
Fine sand	100 lbs.
Very fine "sand" (baking soda)	30 lbs.

### Where to Get Sand and Gravel

*Pea Gravel:* Pea gravel is small-sized (about pea-sized) gravel. Other small-sized gravel, such as aquarium gravel, will also work well. It allows participants to experiment with larger particles (relative to sand), or to channel the water. It is available at large hardware, masonry, or building supply stores.

*Coarse Sand:* Uniformly coarse sand is often available from masonry or building supply stores, as well as from aquarium supply stores. Try to find a 3-grit sand. Other sizes that will work are 10- or 12-grit, or so-called 2/12 sand.

*Fine Sand:* Uniform fine sand is usually available from large hardware, masonry, or building supply stores. Try to find 30-grit sand (for construction), sometimes called "medium" sand. It comes in 50- or 100-pound bags for about \$5 each.

*Very Fine Sand:* In the past, similar demonstrations and kits have used diatomaceous earth for very fine sand, but because of health and safety concerns, we use baking soda instead. Large, 10-pound containers of baking soda are often available at bulk supply stores.

### Making the "Standard Mix" of Sand

The "standard" sand mix recommended for this inquiry consists of equal parts fine sand and coarse sand, and a smaller amount of very fine sand (baking soda). This works well in stream tables because the range of grain sizes responds in more interesting and complex ways than a uniform grain size. Mix 1 lb. baking soda, 2½ lbs. coarse sand, and 2½

lbs. fine sand. Or use a 5-to-5-to-1 ratio, by volume (e.g., 5 liters coarse, 5 liters fine, 1 liter baking soda). Place the mixture in a 10-gallon-sized container (such as a Roughneck Tote). To combine the sand mixture, add enough water to get it completely damp and mix well. Then, when you are ready to set up the stream tables, put 2 quarts into each stream table pan.

### Finding the Right-Sized Sand

Sand sold in different parts of the country usually comes from local quarries. This makes it difficult to help educators nationwide find similar kinds of sand. The most difficult sand to get is a uniform coarse sand, such as a 3-grit sand. (Standard grit sizes have to do with how many holes per unit area there are in a screen, so the higher the grit, the finer the particle size.)

If you can't get uniform sand, you'll need to use another recipe for the "standard mix." Lack of uniform sand also makes it more difficult to investigate the effects of particle size on erosion. However, even if you have difficulty finding the right-sized sand, there are alternatives that will help you find ways to make do with what you can get.

When trying to make an alternative recipe for the "standard mix," you want to find a range of grain sizes, from coarse to very fine. Many building supply stores stock what is called "play sand" or "utility sand," which may include coarse as well as fine particles. Mix this with the very fine sand, and you're set. If you can't find play or utility sand, you may be able to get sand with some coarse particles from an aquarium store or a local quarry. And if this isn't possible, just make do with the mix of particle sizes in between.

#### Sand Grain Sizes

**Pea Gravel** (in approximately pea-sized particles) is available at hardware stores. Gravel is about the size of this dot: ●

**Coarse sand grains** are about the size of this dot: ●

**Fine sand grains** are about the size of this dot: •

# Materials List

Quantities are based on 36 people.

Item	Materials for Tutorial	Flow Station	Slope Station	For Inquiry Starters Extra Materials Table	For Focused Investigation Extra Materials Tables	Total Materials
<b>Materials for preparation only</b>						
<input type="checkbox"/> 10-gallon container for preparing standard sand mix	1					1
<input type="checkbox"/> drill (for making drip holes)						1
<input type="checkbox"/> drill bits: $\frac{1}{8}$ " , $\frac{3}{16}$ " , $\frac{5}{32}$ " , $\frac{3}{32}$ "						1 each
<input type="checkbox"/> saw (for cutting wood blocks)						1
<b>Materials for starting the investigation</b>						
<input type="checkbox"/> 5-gallon buckets	1	3	3		5	11
<input type="checkbox"/> stream table pans (p. 21)	4	6	6		12	24
<input type="checkbox"/> baking soda (used for very fine sand) (p. 22)	4 qts. total (2 qts. for standard mix)	5 lbs. for standard mix	5 lbs. for standard mix		30 lbs. total (10 lbs. for standard mix)	45 lbs. total (22.5 lbs. for standard mix)
<input type="checkbox"/> fine sand (p. 22)	4 qts. total (2 qts. for standard mix)	12.5 lbs. for standard mix	12.5 lbs. for standard mix		75 lbs. total (25 lbs. for standard mix)	110 lbs. total (55 lbs. for standard mix)
<input type="checkbox"/> coarse sand (p. 22)	4 qts. total (2 qts. for standard mix)	12.5 lbs. for standard mix	12.5 lbs. for standard mix		75 lbs. total (25 lbs. for standard mix)	110 lbs. total (55 lbs. for standard mix)
<input type="checkbox"/> pitchers (~ $\frac{1}{2}$ gallon) (p. 21)	4	6	6		12	24
<input type="checkbox"/> catch basins (dishpans) (p. 21)	4	6	6		12	24
<input type="checkbox"/> wood angle scrapers (p. 21)	4	6	6		12	24
<input type="checkbox"/> 12" rulers (p. 21)	4	6	6		12	24
<input type="checkbox"/> $\frac{1}{8}$ " drip containers (p. 21)	4	6	6		12	24
<input type="checkbox"/> $\frac{3}{16}$ " drip containers (p. 21)	2	6			9	15
<input type="checkbox"/> $\frac{5}{32}$ " drip containers (p. 21)	2	6			9	15
<input type="checkbox"/> $\frac{3}{32}$ " drip containers (p. 21)	2	6			9	15
<input type="checkbox"/> wooden blocks 1" x 2" x 11" (p. 21)	12	12	24		24	60
<input type="checkbox"/> levels	1			4		4
<input type="checkbox"/> trash bags (to protect chairs from water)	4	6	6		12	24
<input type="checkbox"/> nitrile or latex gloves (optional)				25		25
<input type="checkbox"/> shims (doorstop-shaped wooden blocks from hardware stores)	4			25		25
<input type="checkbox"/> hand lenses				12		12
<input type="checkbox"/> masking tape (for sentence strips)		1	1			2
<input type="checkbox"/> sentence strips		100	100			200
<input type="checkbox"/> marking pens		12	12			24

**Materials (cont.)**

Item	Materials for Tutorial	Flow Station	Slope Station	For Inquiry Starters Extra Materials Table	For Focused Investigation Extra Materials Tables	Total Materials
<b>Extra materials for the investigation</b>						
<input type="checkbox"/> pea gravel (p. 22)	1 lb				30 lbs	30 lbs
<input type="checkbox"/> protractors					6	6
<input type="checkbox"/> food coloring (two different colors)					6 vials	6 vials
<input type="checkbox"/> pipettes (or eyedroppers)					6	6
<input type="checkbox"/> shake bottles (p. 21)					12	12
<input type="checkbox"/> centimeter cubes (“houses”) (p. 21)					100	100
<input type="checkbox"/> measuring cups					3	3
<input type="checkbox"/> measuring spoons					3	3
<input type="checkbox"/> scale (for grams) optional					1	1
<input type="checkbox"/> toothpicks	1 box				1 box	1 box
<input type="checkbox"/> ball of string					1	1
<input type="checkbox"/> 100 mL graduated cylinder (optional)					1	1
<input type="checkbox"/> clear tub—similar size to stream table (optional)					1–3	1–3
<input type="checkbox"/> pens, and notebooks or loose sheets of paper (4 per person) for keeping notes during the inquiry						as needed
<input type="checkbox"/> large chart paper (for investigation findings)					20	20
<b>For cleanup</b>						
<input type="checkbox"/> trash containers (for sand disposal) 30-gallon, wheeled		1	1			2
<input type="checkbox"/> rags or paper towels	as needed	as needed	as needed	as needed	as needed	as needed



# Charts, Handouts, and Station Cards

Masters begin on page 78. They are identified by the letter *M* (for Master) and numbered in order of use.

## Charts

If you have access to a copy machine that can enlarge to poster size, enlarge these masters 400% to create charts that are 34" × 44". Otherwise, hand-copy facsimiles of the charts onto chart paper or poster paper approximately the same size.

If you prefer to use an overhead projector, chart masters can be copied onto transparencies.

	Page
<input type="checkbox"/> "Map of Inquiry Structure" chart for Introducing the Workshop & throughout	M1
<input type="checkbox"/> "Take-Home Messages" chart for Introducing the Workshop and Concluding the Workshop	M2
<input type="checkbox"/> "Slope" chart (5 copies) for Inquiry Starters	M5
<input type="checkbox"/> "Flow" chart (5 copies) for Inquiry Starters	M6
<input type="checkbox"/> "QWWNDWATT" chart for Focused Investigation: Introduction	M7
<input type="checkbox"/> "Sand and Water Thinking Tool" chart for Focused Investigation: Introduction	M8
<input type="checkbox"/> "Main Science Ideas for the Stream Table Inquiry" chart for Sharing Understanding: Findings	M11
<input type="checkbox"/> "Discussion Guidelines" chart (3 copies) for Making Meaning Discussions	M14
<input type="checkbox"/> "What I Valued about the Inquiry Experience" chart (3 copies) for Making Meaning Discussions	M15

## Handouts

Handouts should be photocopied, one for each participant, unless otherwise noted.

	Page
<input type="checkbox"/> "Starting the Investigation" for Focused Investigation: Introduction (2 per group)	M9
<input type="checkbox"/> "Main Science Ideas about Stream Flow and Erosion" handout for Sharing Understanding: Findings	M12
<input type="checkbox"/> "About the Process of Inquiry: Creating Paths Toward Understanding" handout for Sharing Understanding: Synthesis of Findings	M13
<input type="checkbox"/> "What I Valued about the Inquiry Experience" handout for Making Meaning Discussions	M15
<input type="checkbox"/> "Inquiry Structure for Learning Science Content" handout for Making Meaning Discussions	M16
<input type="checkbox"/> "Take-Home Messages" handout for Concluding the Workshop	M2

## Station Cards

Make 6 photocopies of each Station Card to place at the Flow and Slope Starter Stations

	Page
<input type="checkbox"/> Stream Slope Inquiry Starter Station Card for Inquiry Starters	M3
<input type="checkbox"/> Stream Flow Inquiry Starter Station Card for Inquiry Starters	M4

## Facilitator Tools

	Page
<input type="checkbox"/> Facilitator's Notetaking Sheets for Sharing Findings	M10a&b

# PRESENTING THE WORKSHOP

## Part 1: Engaging in Inquiry



- **Introducing the Workshop**
- **Inquiry Starters**
- **Focused Investigation: Introduction**
- **Focused Investigation: Beginning**
- **Focused Investigation: Concluding**
- **Sharing Understanding: Findings**
- **Sharing Understanding: Synthesis of Findings**

# Introducing the Workshop

## Overview

At the beginning of the workshop, the facilitator establishes the tone by stating the purpose of the workshop and explaining how participants will work together. Being open about intentions and transparent about purpose are important to build trust and demonstrate respect for the participants as learners. **NOTE:** Each chart posted for Part 1 of the workshop should remain in place until Part 2 begins.

## 8 Steps ♦ 20 Minutes

**1. Ask participants to introduce themselves (5 minutes).** Begin the workshop by introducing the facilitators, then ask participants to introduce themselves.

**2. Set the context.** Relate the following information to participants in your own words:

- *In this 6-hour-and-15-minute workshop, you'll experience a full scientific inquiry on the topic of stream flow and erosion.*

*This experience will give you the opportunity to explore the nature of scientific inquiry and to see how it can be a valuable approach for learning. In doing this inquiry, you'll be learning some science content about stream flow and erosion, you'll use science process skills to help you learn that content, and you'll learn about the process of inquiry itself. It is a process that can be used to study many topics, not just those addressed here.*

*This workshop isn't designed to prepare you to do a stream table inquiry in your classroom. Instead, it's meant to be an experience that will give you insight into the possibilities of learning science through inquiry. The eventual goal is to find ways to*

*give students more inquiry experiences. The first step toward this goal is to experience and understand inquiry, which we'll focus on today.*

*During the inquiry, it's important for you to set aside your familiar role as teachers and give yourselves the freedom to explore the science of stream tables and the process of inquiry as learners. Then, in the last hour, we'll have a reflective discussion where we'll draw on your experience as learners to examine the pedagogy of inquiry.*

**NOTE:** If you have planned a follow-up workshop to apply ideas about inquiry to the classroom (such as *Subtle Shifts: Adapting Activities for Inquiry*, the fifth workshop in the FUNDAMENTALS OF INQUIRY curriculum), mention that workshop. Explain that it will provide an opportunity to discuss taking steps towards implementing inquiry in the classroom.

**3. Explain the Inquiry Structure.** Referring to chart M1: "Map of Inquiry Structure," explain:

- *This map outlines what you will be doing in the three phases of the inquiry.*

*In the Inquiry Starters phase of the inquiry, you'll begin by spending 20 minutes at each of two stations.*

- *You'll be exploring different stream table materials in a variety of ways. As you do, pay attention to anything that interests and intrigues you.*
- *You'll also be raising and recording questions about the phenomena.*

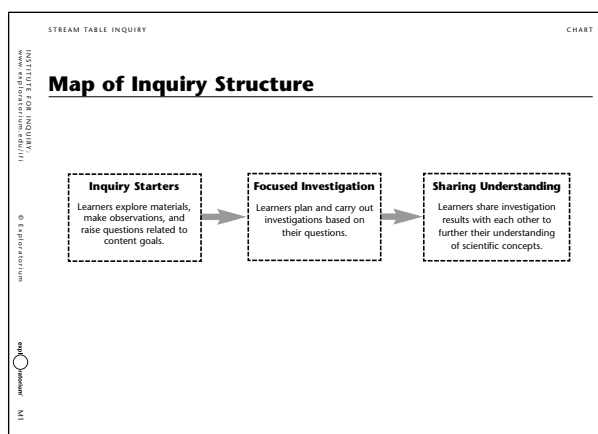
## Materials Reminder

**During this part of the workshop, facilitators will need to:**

- **Distribute materials for taking notes**
- **Post workshop schedule for participants**
- **Post chart M1: "Map of Inquiry Structure"**
- **Post chart M2: "Take-Home Messages"**

In the *Focused Investigation* phase, you'll choose one of the questions raised during the *Inquiry Starters* phase and investigate it in a small group. During this time, we encourage you to take notes on what you do and observe. As you investigate, you will refer to those notes to help you remember details about what you did, to aid you in building your understanding. This phase will take about 90 minutes.

In the *Sharing Understanding* phase, each small group will have 2–3 minutes to share the findings of the investigations. Then a facilitator will synthesize your findings and connect them to the main science ideas of the inquiry. Doing this will help reinforce your understanding of the main scientific ideas about stream flow and erosion. This completes the inquiry but does not complete the workshop.



M1

**4. Describe the Making Meaning Discussion.** Referring to the schedule that you have made for the participants, explain:

- When the inquiry is complete, we will shift from

### Take-Home Messages

- Inquiry is a powerful means of learning substantive science content.
- Inquiry has a structure with distinct phases.
- In doing inquiry, learners can take many different paths to learn the same science content.

M2

focusing on learning about stream tables to learning about the process of inquiry by taking time to reflect on the learning experience you just had. During the *Making Meaning Discussion*, you'll have about an hour to think about and discuss what you did and what you valued during the inquiry process.

### 5. Read the Take-Home Messages.

Referring to chart M2: "Take-Home Messages," read each

point aloud. Tell participants:

- Today, through direct experience and discussion, you'll be working to develop your own understanding of the pedagogical ideas these messages express.

**6. Explain the timing of the workshop.** Tell participants that the entire workshop will take about 6 hours, plus time for breaks. Go over the posted workshop schedule.

**7. Tell participants why you chose to present this workshop.** Describe how the workshop relates to the specific goals, standards, and other professional development activities of your district. You may also want to talk about how the workshop relates to state and national standards. For more on how *Stream Tables* connects to the *National Science Education Standards*, see page 70.

**8. Prepare participants for work at the stations.** Tell people:

- We're about to start working with these materials, so please clear your tables. You'll see that there are two setups at each table. Each setup is for a group of three people. Please adjust your groups, if you need to, so no one is working alone.

# Inquiry Starters

## Overview

The Inquiry Starters are meant to introduce participants to the inquiry topic in a way that generates curiosity and elicits a wide range of questions and observations that can be pursued during the Focused Investigations.

This inquiry begins with participants working in groups of 3 (you may need 1 or 2 groups of 2 people each), interacting with two different kinds of stream table setups at two different stations. At one station, participants see what happens when they vary the slope of their stream table setups. At the other station, they see what happens when they vary the flow of water down the slope.

After 15 minutes, a facilitator asks participants to write questions on sentence strips, which the facilitator will later collect and post on charts. Next, participants switch stations, work for 15 more minutes, then write more questions.

The materials at these stations have been carefully selected to encourage exploration within the bounds of the desired content area. At the same time, these materials exhibit a number of engaging phenomena that allow people to have a range of choices for entry points into investigations. Exploration time is kept short so that people do not start focusing on a particular phenomenon before they have had a chance to see all of the “tools” available in both setups.

Remember that all charts should remain posted for Part 1 of the workshop.

## 9 Steps ♦ 55 Minutes

### Steps 1–5, 5 Minutes

#### 1. Introduce Inquiry Starters.

Refer to the Inquiry Starter box on chart M2: “Map of Inquiry Structure,” and tell participants:

► We’re about to begin the Inquiry Starters phase of the workshop. This phase consists of activities

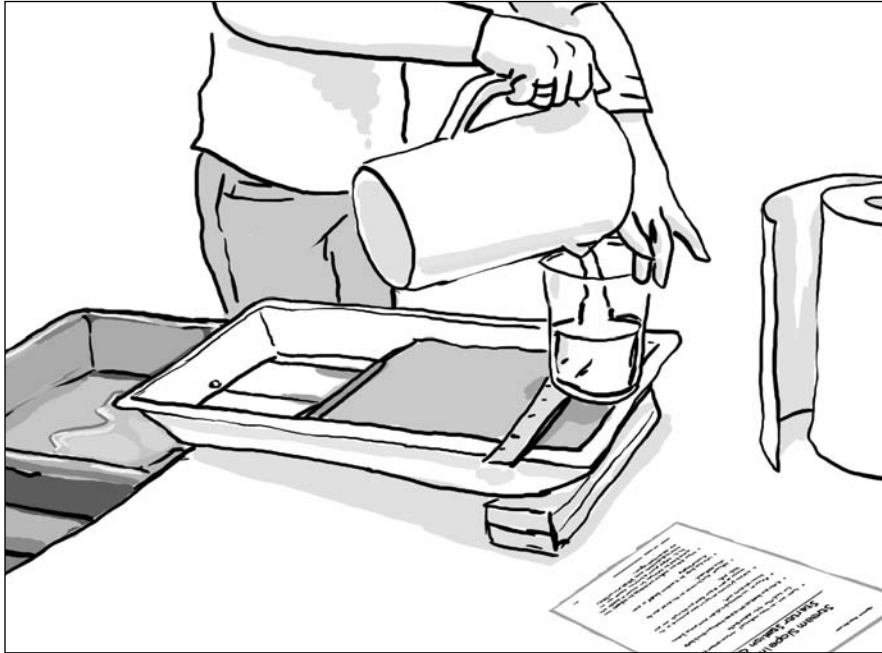
meant to generate interest, elicit questions, define topics for the investigation, and allow you to become familiar with the phenomena associated with stream tables and some of the tools you can use for the investigation.

However, before we begin, I’d like to acknowledge that there may be some individuals in this group who are already quite knowledgeable about stream flow and erosion, and who might be tempted to share their knowledge with others. But it’s best for everyone to try to find something to explore and investigate at their own level. An im-

## Materials Reminder

During this part of the workshop, facilitators will need to:

- Keep all previously posted charts in place
  - Set up 6 Slope Stations, each with M3: “Stream Slope Inquiry Starter Station Card,” 15 sentence strips, and 2 marking pens
  - Set up 6 Flow stations, each with M4: “Stream Flow Inquiry Starter Station Card,” 15 sentence strips, and 2 marking pens
- (NOTE: One stream table setup, initially used for a facilitator-led demonstration, can then be used by a group of participants.)
- Post chart M5: “Slope” (5 copies)
  - Post chart M6: “Flow” (5 copies)
  - Post chart M7: “QWWNDWATT”
  - Prepare QWWNDWATT example on a sentence strip (see page 32)
  - Tape (for attaching sentence strips to charts)



**Demonstrating the stream table**

important part of the inquiry experience is the opportunity for both experts and novices to learn for themselves.

**2. Explain stations to participants.** Refer to the tables with the “flow” setups and tell people:

- People at these tables will be exploring with materials that relate to the flow of water in stream tables. At each setup, there are containers with different-sized holes to regulate the amount of water flow.

Show the holes at the bottom of the container. Then refer to the tables with the “slope” setups and tell people:

- People at these tables will explore with materials that relate to the slope of the stream tables, using different numbers of blocks to prop up their stream tables.

Show what a block looks like.

- Everyone will spend 15 minutes at each of the two kinds of setups. During these 15 minutes, people should try to change the variables of slope or flow at least once to notice the effect. For

instance, you don't have to try every size hole, but you should try at least two so you can notice the effect of more or less water flow.

**3. Demonstrate a stream table.** At the setup you have prepared, demonstrate as you explain:

- At each of these stations, the station card says to start with an even surface of sediment about  $\frac{2}{3}$  of the way down the pan, to have two blocks stacked under the stream tables, and to use the drip container with the  $\frac{1}{8}$ ” hole.

Look at how your stream table is prepared now. To do subsequent runs, prepare the sand in the same way.

To start, place a ruler across the back of the stream table about 2 inches from the back wall,

STREAM TABLE INQUIRY

**Stream Flow Inquiry Starter Station Card**

- Start with an even surface from the top to about  $\frac{2}{3}$  of the way down the stream table.
- Raise the back of the stream table on two blocks.
- Place a ruler across the back of the stream table about 2 inches from the back wall.
- Fill the  $\frac{1}{8}$ ” drip container with water and support it in the center of the stream table on the ruler and the back wall.
- Observe what happens to the water and to the sediment.
- You can keep the container topped up so it drains steadily.
- When you are ready to try varying the slope of the stream table by changing the number of blocks, use the L-shaped piece of wood to prepare an even surface of sediment about  $\frac{2}{3}$  of the way down the stream table again.

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STATION CARD

**Stream Slope Inquiry Starter Station Card**

- Start with an even surface of sediment extending from the top to about  $\frac{2}{3}$  of the way down the stream table.
- Raise the back of the stream table on two blocks.
- Place a ruler across the stream table about 2 cm. from the back wall.
- Fill the  $\frac{1}{8}$ ” drip container and support it in the center of the stream table on the ruler and the back wall.
- Observe what happens to the water and to the sediment.
- You can keep the container topped up so it drains steadily.
- When you are ready to try varying the slope of the stream table by changing the number of blocks, use the L-shaped piece of wood to prepare an even surface of sediment about  $\frac{2}{3}$  of the way down the stream table again.

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*and place the drip container in the center so the hole is over the sand.*

*Fill the drip container with water from the pitcher and watch what happens. You can fill the container as many times as you like. Then, when you're ready to vary either the size of the hole or the number of blocks, use the scraper to push back and smooth the sand so you can start over.*

*You'll find when you start over that the sand will be saturated with water and will stay saturated while you work. Because any excess water runs off, once it's wet, it won't get any wetter, even if you add more water.*

*While you are working, facilitators will be circulating. Ask us any questions if you want help. We may also stop to watch and talk to you.*

#### **4. Describe cleanup procedures.** Say:

- *Notice that there are catch basins (dishpans) under each stream table setup. Please adjust your stream table so the water flows into the basin. As the basin starts to fill up, use one of your pitchers or measuring cups to scoop the water back into the 5-gallon bucket at your station. The water will become a bit cloudy, but that won't make a difference in your experiments.*

*Note also that there are paper towels at each table for spills, and rubber gloves available for those who want them. Finally, during the Focused Investigations, and for the final cleanup, we have some large garbage cans that are for sand disposal only—no trash.*

#### **5. Describe the question-writing procedure.** Tell participants:

- *After you've explored at a station for 15 minutes, I'll ask you to stop working with the materials. Then you'll be working with your group to write the questions that came up during your explorations onto sentence strips.*

*If you have an intriguing observation that you're*

*having a hard time phrasing as a question, it's fine to write it as an observation—observations can also drive investigations.*

*Do this quickly—you'll have just 5 minutes. See if you can come up with a few questions at each station. When you're finished writing your questions and observations, leave them on the table and switch to the other station. You'll explore and write more questions or observations there.*

#### **6. Begin work at the stations (15 minutes).**

Ask people to begin working at their stations. Facilitators should circulate to make sure everyone understands how to work the stream table. One facilitator should be assigned to the Flow Station and one to the Slope Station; the third floats between the two stations and keeps track of time.

The facilitators' main role during this time is to help people set up their stream tables correctly and help them observe closely by asking questions about what they notice.

After 10 minutes, announce that there are 5 minutes left. Encourage any group that hasn't yet changed slope or flow variables to do so soon. Give a one-minute warning and tell participants to finish the run they are doing.

#### **7. Have participants write down their questions (5 minutes).** Explain:

- *Take 5 minutes now to write your questions and observations. Later, we'll post them to make public all the things the group is curious about.*

*Once all the questions have been generated and posted from both stations, you'll be able to choose questions you want to investigate in a more focused way for a longer period of time.*

*Write all the questions and observations that came up as you explored, not just ones that interest you most, because others might become interested in one of your questions. Don't agonize over*

the wording. It's better to write a range of questions than to have only one that is perfectly worded.

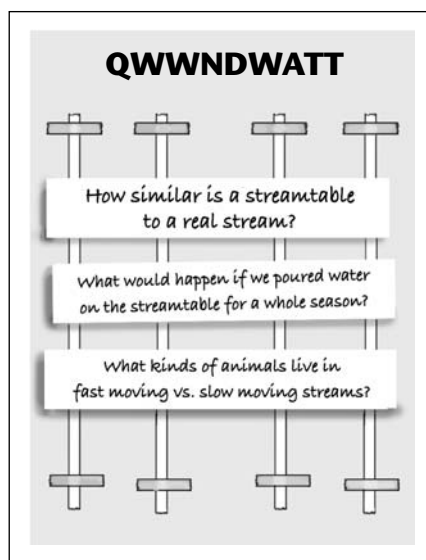
**8. Tell participants to switch stations.** After 5 minutes, tell participants:

► Time is up.

Please leave your questions at your tables and switch to the other station. Spend another 15 minutes using the materials, and then 5 minutes writing questions, just as you did at the first station.

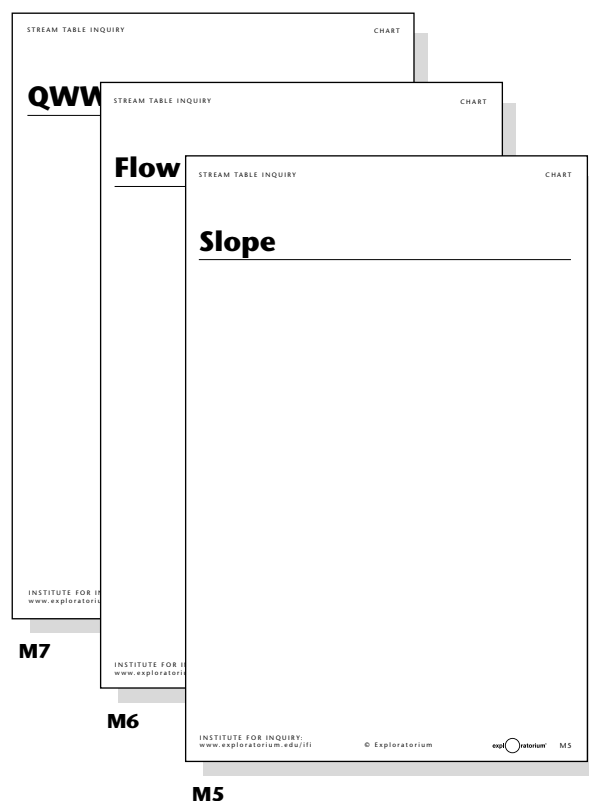
**9. Collect and post sentence strips, including “QWWNDWATT” questions.** As groups switch stations, collect sentence strips with the questions and observations. Post the ones from the Slope Station on one of the M5 charts, labeled “Slope,” and those from the Flow Station on one of the M6 charts, labeled “Flow.”

While collecting questions to post, watch for any examples of “QWWNDWATT” questions (“Questions We Will Not Deal With At This Time,”



Examples of QWWNDWATT

see page 35). These are questions that are either not on the topic of stream tables, or cannot be answered with the time or materials available. Post these sentence strips; you'll be referring to them in the next part of the workshop to illustrate a technique for handling this sort of question. (NOTE: If you don't find a good QWWNDWATT example, you can use this question: “How similar are stream tables to real streams?”)



## Facilitation Hints for Inquiry Starters

### For Step 6

#### ■ Suggest Leveling

Some people may notice that the water always flows toward one wall of the stream table and may wonder if the stream table is sloping that way. If you notice this,

you can suggest they use a shim to adjust the slope, and a level to check the adjustment—to see if eliminating the sideways slope makes a difference. Levels and shims can be found on the additional materials table.

#### ■ Encourage Questioning

If you hear participants asking questions, remind them to try to jot down or remember their questions so they can write them on sentence strips when they stop.



# Focused Investigation: Introduction

## Overview

In this section, participants transition from the Inquiry Starters phase of the inquiry, where they explored materials and raised questions, to the Focused Investigation phase, where they will choose a question and carry out an investigation.

First, facilitators set the stage for the focused investigation by explaining what participants will be doing, and by introducing the materials that will be available for use in the investigation. Facilitators also present a “thinking tool”—in this case, a simple statement written on a chart—that can help participants think about what they will be observing as they work. Next, facilitators guide participants in selecting questions they want to investigate. This process includes a “gallery walk,” in which participants walk around the room, reading all the questions on the posted charts. Finally, participants form investigation groups, select a work space, create brief investigation plans, and collect materials for their investigations. As usual, charts from preceding parts of the workshop should remain posted.

## Thinking Tools

Note that “thinking tools” are introduced in Step 4 in this section and in Step 6 in the next section. Thinking tools can be ideas, questions, or demonstrations meant to help people make sense of what they encounter during their investigations. They are a way to impart direct information during an inquiry, without taking away from participant ownership. The thinking tools are sometimes mentioned during the Making Meaning Discussions when participants reflect on their inquiry experience.

## 7 Steps ♦ 20 Minutes

### Steps 1–6, 10 Minutes

#### 1. Set the stage for in-

**vestigation.** Address the whole group and refer to the “Map of Inquiry Structure” chart (M1). Tell participants:

► Now we’re moving from Inquiry Starters to Focused Investigations.

*We’ll begin by taking a few minutes to survey all the questions that have been raised. Then I’d like you to select one you’re interested in investigating, and form investigation groups of two or three people who want to work on the same or a similar question.*

*As you carry out your investigations, your group will be on a path toward trying to find out ways to answer your question. As you work, you will probably cover some of the same territory other groups do, and some that may be unique to your investigation.*

*During your investigations you will do most, if not all, of the following:*

- Interact with materials
- Plan and carry out investigations
- Make observations
- Ask questions
- Talk to each other to share ideas and observations
- Propose explanations
- Make predictions and test them
- Revisit questions and explanations in light of new observations
- Record and represent thinking by writing and making drawings

## Materials Reminder

During this part of the workshop, facilitators will need to:

- Keep all previously posted charts in place
- Post chart M8: “Sand and Water Thinking Tool”
- Distribute handout M9: “Starting the Investigation”

**2. Help prepare people for difficulties they may encounter.** Alert participants to the possibility that they might feel frustrated or experience difficulties during the investigation. While this is a natural part of the process, people appreciate knowing in advance. Say:

- *Because investigating is a creative process, there are likely to be difficulties as well as creative breakthroughs along the way. These difficulties are a normal part of the process. As long as you understand this, you'll be prepared if you hit any rough patches.*

*For instance, you may answer your original question quickly and need to find a way to restart your investigation. If this happens, look for another question that interests you, reflect on your investigation to see if other interesting questions came up that you haven't pursued yet, or look at what other groups are doing to find possibilities that interest you.*

*Another difficulty may be that you get started on your question, but get to a point where you don't know what to do next. If you get stuck,*

- *Try talking to a facilitator.*
- *Check in with other groups to see what they're doing.*
- *Reflect on your experiences in writing, or try to explain what you're doing to someone else.*
- *Give yourself permission to take a break and get a little distance before going back to it. This may help you think of a new approach.*

*While getting stuck can be frustrating, it can actually be exciting because it can be an indication that you're right on the verge of learning something new. When people feel they ought to know how something works, and it doesn't work that way, they can either give up, or they can begin to change their way of thinking about the situation. If you find yourself in that situation and can persevere, on the other side of the frustration can be the*

*joy of having learned something that you truly didn't know before.*

*Remember, getting stuck can be a natural part of the process. It doesn't mean you're doing anything wrong, and there are ways of getting past it.*

**3. Introduce additional materials.** Tell participants:

- *In a minute, you'll begin to consider what question you'll want to investigate for the next two hours. Before you select a question, you should know what additional materials are available so you can factor that into your decision.*

*The basic setups with the pans, sand, blocks, and drip containers are available for you to use, and there are additional setups available so you can make side-by-side comparisons if you like.*

**Show where materials for additional setups can be found.** If a facilitator is helping to dispense sand, indicate who that is. If not, tell people that everything they need is labeled for self-service.

**Explain about the sand mixture:**

- *The sand we've been using is a mixture of different-sized particles, from coarse to fine. We've also added very fine particles of baking soda. If you want to work with uniform sizes, coarse sand, fine sand, and baking soda are all available.*

*We put two quarts of sand [two of the quart-sized drip containers] in each tray. Use that amount if you want to be consistent with what we've done.*

**Explain about the other tools:**

- *There are also a number of tools you can use in your investigation.*
- *To adjust the slope, use the levels and wooden shims.*
  - *To measure, there are rulers, protractors, scales, measuring cups, and measuring spoons.*

- To mark places on the stream table, use the string, food coloring, and “houses” (centimeter cubes or game-board houses).
- To direct the flow of water, there are toothpicks and gravel.

Explain about cleanup:

- Reuse water by pouring it back in the 5-gallon buckets, not in the sink.

Dispose of sand in garbage cans, not in the sink.

**4. Introduce chart M8: “Sand and Water Thinking Tool” to help participants focus their investigations.** The first thinking tool for this investigation is simply a statement written on a chart. Refer to the chart and explain:

- We want to give you both physical and mental tools for investigating streams. You’ve just seen some of the physical tools, and now here’s an example of a mental tool—something we’ll call a thinking tool. During your investigation, it can be helpful to keep this thought in mind.

**5. Explain the process of selecting questions to investigate and talk about “QWWNDWATT” questions.** In this step, the facilitator introduces the different categories of questions. Say:

- Next, you’ll be selecting questions to investigate and forming investigation groups.

But first, let’s look at the categories into which the questions are organized. There are questions from the Slope Inquiry Starter. These include questions about the effect of changing the slope of the stream table as well as questions about other phenomena that you noticed at the slope station.

There are also questions from the Flow Inquiry Starter. Some of these questions are about the effect of flow and some about other phenomena that you

noticed at the flow station.

Address the “QWWNDWATT” sentence strips on the corresponding chart.

- Finally, there are questions on this chart labeled “QWWNDWATT” that I want to explain. QWWNDWATT stands for

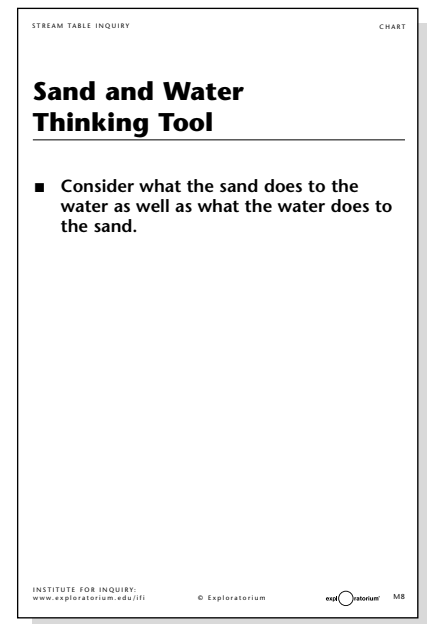
“Questions We Will Not Deal With At This Time.”

These are perfectly good questions; they’re just questions that require more time and materials than we have available today, or that fall outside the area of phenomena the inquiry was meant to address.

For example, questions that require more time or materials than we can deal with today could be ones such as “What would be the effect of running the water for an entire season?” or “Would we get the same effects in a real river?” Questions that might come up, but are outside the topic of stream flow and erosion could be “What kinds of objects float in water?” They’re all good questions, but not ones we’ll be able to investigate today.

If you think we have placed a question in the QWWNDWATT category that you would like to investigate, please talk to one of us about it. If you can show us how it fits the topic and how you can investigate it, we’ll be happy to make that question available for investigating.

**6. Introduce the “gallery walk,” the process of forming investigation groups and creating investigation plans.** Tell participants:



**M8**

- In a few moments, you'll be doing what we call a gallery walk, going around the room and examining the range of questions we have here. Even if you already know what question you want to focus on, doing this will give you a picture of the entire groups' thinking and may generate ideas that you can carry into your own investigation.

Once you've looked at all the categories, stand near the chart with the question you are most interested in. Find one or two others who are interested in a similar question to form an investigation group. Don't worry about being locked in to only one question. These questions are just a way to get started. Other questions are likely to come up for you as you investigate, and you'll probably find

that your question changes as a result. The main thing is for you to start with something you're really interested in that will sustain you through the investigation.

## 7. Distribute handout M9: "Starting the Investigation," then have participants begin the gallery walk (10 minutes). Say:

- Each group will fill in two identical "Starting the Investigation" sheets, meant to help you get started. One is for your investigation group, and a facilitator will be collecting the other a little later.

You can start your gallery walk now. When you've formed your groups and completed your sheets, gather your materials and begin your investigation. Take breaks as you need them while you work.

STREAM TABLE INQUIRY HANDOUT

### Starting the Investigation

Once you have formed your group and have chosen your investigation question, answer the following questions. Make two copies, one for yourself and one for the facilitator.

- Your names
- What question(s) will you try to answer?
- What materials will you need?
- What will you do first?

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M9

## Facilitation Hints for Focused Investigation: Introduction

### For Step 7

#### ■ Help Working Groups Form

Most groups form without needing facilitation. Some groups may take just a few minutes while other groups may take longer. It's not important to complete the gallery walk within the 10 minutes scheduled. The process almost works by itself.

However, if people are having trouble finding partners, encourage them to try to find others with related, though not necessarily identical interests. Inform them of any person or pair who you

know has a related interest, or ask them to try to find a mutual interest with someone they are comfortable working with.

If there are groups larger than three, help them break into smaller groups. Explain that the resulting groups can work next to each other, share information, and cover more ground with two approaches to the same question.

#### ■ Help Participants Complete Handout M9: "Starting the Investigation"

If groups have questions about completing the sheets, have them

try to think of the materials they might need and what they might start doing with them that could help them answer their question.

Asking people to think about what they will do in addition to what they will need is meant to encourage thoughtful choice of materials. It is not meant to be a formal plan, which is more likely to develop after they get started.

#### ■ Have Facilitators Confirm Groups They Will Work With

See Essential Planning Steps, Step 6, page 15.

# Focused Investigation: Beginning

## Overview

This section is the heart of the inquiry, where facilitators support learners in finding and proceeding along their own paths toward learning the main science ideas. This part of the guide focuses on facilitation of the investigation and suggests responses to situations facilitators may encounter.

For the next 75 minutes, participants will work in groups on their focused investigations. For 65 of those 75 minutes, learners will carry out their investigations while facilitators circulate, observing and guiding participants as needed. With 10 minutes left (just before lunch), facilitators introduce the shake bottle thinking tool (see page 41). After the lunch break, participants return for the final 35 minutes of their investigations, described in the next section of this guide.

Remember that, as a facilitator, you want people to have a positive personal experience with the materials and phenomena, as well as the opportunity to learn through social interaction with their fellow learners. You want people to learn particular science content through investigating their own questions: Finding their own way of getting started on the investigation, following their own path through the investigation, and constructing their own understanding of the science concepts. While facilitating, it's important to keep in mind the main science ideas, which are the content goals of the inquiry (see M11: "Main Science Ideas for the Stream Table Inquiry," shown at right), and to think about how to help participants arrive at an understanding of those ideas.

Be certain that you're clear about which groups each facilitator is responsible for (see Essential

Planning Steps, Step 6, page 15). This will ensure that each group has a facilitator, that facilitators are not spread too thin, and will prevent different facilitators from giving conflicting suggestions to the same group. Facilitators can consult with each other about various groups, but it's best to have just one main facilitator per group.

While facilitating the investigations, your job is to find out what groups have already done and what they are thinking before offering comments or suggestions.

Make sure your comments and suggestions support the direction learners are taking. Let them know that they are free to ignore what you say if they choose to. By doing this, you will

## Materials Reminder

**During this part of the workshop, facilitators will need to:**

- Keep all previously posted charts in place
- Distribute 1 shake bottle per investigation group (see page 21)

STREAM TABLE INQUIRY
CHART

### Main Science Ideas for the Stream Table Inquiry (Content Goals of the Inquiry)

- When the flow of a stream increases, more erosion takes place.
- When the slope of a stream increases, more erosion takes place.
- Lighter particles (typically smaller or less dense) are deposited farther downstream than heavier particles.
- Stream flow is chaotic, yet regular patterns emerge. For example:
  - Certain shapes regularly form, including fans, streamlined [lens-shaped "( )"] islands, deltas, meanders, and canyons.
  - The main stream channel changes position, moving back and forth, especially on fans. This happens because, as material is deposited, it builds up high ground in the channel, so another channel becomes the most direct downhill route.

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exploratorium M11

**As you facilitate this section of the workshop, keep in mind the content goals shown in M11: "Main Science Ideas about the Stream Table Inquiry."**

be supporting learners in maintaining ownership of their investigations and in constructing knowledge with real understanding.

## 7 Steps ♦ 75 Minutes

### Steps 1–4, 20 Minutes

**1. Guide participants in the early stage of their investigations.** Participants begin their investigations in a number of different ways. Some groups take a long time refining their questions and getting started on a particular path. Some plan for a long time without using materials. Others quickly begin using materials and form and test hypotheses to explain their initial observations. But most, at this point, will be engaged in making close observations and refining their investigation plans.

Your facilitation role as the investigations begin is to help participants make observations, become engaged with ideas and questions that interest them, and refine their investigation plans.

During the first 20 minutes, the facilitator should:

- Observe what people are doing. Ask them what they are planning to investigate, and how they are

planning to do it. Make suggestions or ask questions that help them refine their plans.

- Help people get needed materials and set them up.
- Encourage people to make close observations and record what they try and what they observe. Say something such as:

► *Later in the investigation, there will come a time when you'll be asking yourselves "What did we see?" or "How, exactly, did we set that up?" You'll be happy to have recorded that information in your notebooks.*

**2. Circulate among the groups, observe what they're doing, and collect copies of all M9: "Starting the Investigation" sheets.** As investigations begin, collecting the sheets allows you to engage with each group, find out how they're doing, and provide help if necessary. It also gives you an opportunity to help the participants find materials and to suggest other potentially useful materials they hadn't thought of. Later in the investigation, these sheets can help you remember how each group started. This can be useful because if they are doing something very different, you can ask what caused them to change direction.

## Facilitation Hints for Focused Investigation: Beginning

### For Step 3

#### ■ Encourage Groups that Are Working Well

IF groups appear to be working well...

THEN encourage them by telling them they're doing fine and that you'll check in with them again soon. Just looking and not saying

anything can leave groups unclear about whether they're proceeding in an appropriate direction.

#### ■ Encourage Full Participation

IF one person seems to be making all the decisions and doing all the material manipulation...

THEN try asking the group to describe what people are doing

and why. After the dominant individual answers, turn to another group member and ask them for their understanding of what the group is doing.

It is sometimes necessary to pull the dominant person aside and make a gentle suggestion about leaving space for increased participation by other group members.

**3. Pay attention to group dynamics.** Pay particular attention to whether or not everyone is participating and whether group members seem to be working well together.

**4. Circulate to each of your groups a second time.** This allows you to stay connected to the people in all the groups and the direction of their investigations. Continue to encourage participants to record what they do and see.

- As groups are observing the stream table runs, you can make your own simply stated observations, such as:

► *The stream seems to keep changing directions.*

Such an observation might serve to interest people in what makes the course of the stream change. Mentioning your own observations in a casual way can help participants notice important features without distracting them from what they are most interested in at the time.

During this time, refrain from offering suggestions that might substantially change the direction of a group's investigation. Remember that you want the learners to experience ownership of the investigation.

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## Facilitation Hints for Focused Investigation: Beginning

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### **For Step 3, continued**

#### ■ **Help Resolve Conflicts**

IF group members don't agree about what to investigate or how their investigation should proceed...

THEN help resolve the conflict by trying to find common ground. Or, suggest pursuing one idea first, followed by another, or trying two things at the same time, in parallel.

#### ■ **Allow Incompatible Groups to Split Up**

IF individual differences in a group are getting in the way of their working well together...

THEN encourage the group to split up and work on separate (but possibly related) questions. They can check in with each other periodically to see what they can learn from each other.

Splitting up groups this way may

leave one person working alone. Encourage that person to try to find a group working on a similar question. If that isn't possible, let him or her work alone but encourage checking in regularly with a facilitator and, if appropriate, with former group members who may be working on a related question.

### **For Step 4**

#### ■ **Maintain Learner Ownership**

IF a group has devised a plan that has some problems...

THEN give them a chance to correct this for themselves early on. This way, they learn valuable lessons about planning, since they decide to make a correction rather than being told to do so.

#### ■ **Help Groups Avoid Overplanning**

IF a group is having trouble get-

ting started and spending a lot of time coming up with a plan...

THEN tell group members to keep talking with each other and let them know that you'll return. They may just need more time to think things through.

#### ■ **Help Groups Get Started**

IF they continue to talk without beginning to investigate for more than 10 minutes...

THEN encourage them to set up a stream table and get started on their plan. Mention that sometimes you can't tell if a plan will work until you actually try it out. Tell them they can refine their plan as they investigate. Actually trying something rather than spending time attempting to devise the ideal plan is usually more productive in the long run.

**5. Continue guidance throughout investigations (45 minutes).** You will find that after about 20 minutes, groups have gone in a number of different directions and will be at various stages of their investigations. Some will be just starting to collect data, some will be trying to make sense of data they've collected, and some might have already interpreted their results and are either feeling finished or are revising their plans and collecting more data.

Your first responsibility as facilitator is to determine where people are in their investigations by

observing them and asking questions. Once you have done this, offer suggestions as needed to help them decide what to do next. The facilitation hints below address many of the situations participants may find themselves in, along with suggestions for facilitators to respond. Overall, these suggestions are meant to encourage thinking, conversation, and debate within the groups, to help participants explain what they notice, articulate the evidence and rationale for their ideas, and generate plans for testing ideas by gathering more evidence to support or challenge their thinking.

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## Facilitation Hints for Focused Investigation: Beginning

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### **For Step 4, continued**

#### ■ **Help Groups Refine the Question**

IF a group is having trouble getting started...

THEN it may be because their question is too vague.

Encourage them to set up a stream table, and continue to explore and make observations about the kinds of things that made them want to investigate their question in the first place. Often a group will get interested in a particular area but need additional exploration to define specific questions in that area. People's observations during that exploration may help them find ways to focus their question.

#### ■ **Help Groups Focus**

IF groups have begun working but don't seem very focused...

THEN ask the group to explain what they are doing. This may be enough to help them figure out what they want to do next. You can help groups focus by asking about what people are planning to investigate, and how they are planning to do it.

### **For Step 5**

#### ■ **Help Groups Develop a Plan**

IF a group has an investigation question, but has not yet come up with a clear plan...

THEN help them decide what kind of things to look for that would help them answer their question. You might ask:

- ▶ *What can you observe or measure that could help you answer your question?*

#### ■ **Help Groups Plan to Collect Useful Information**

IF group members are beginning to record observations or collect data...

THEN you could ask:

- ▶ *How do you think the information you are gathering will help you to answer your question?*

#### ■ **Help Groups Record Useful Information**

IF you think groups would benefit from recording their observations or could be recording more useful information...

THEN you might say:

- ▶ *Try to think of ways to record your observations that include the most relevant features and your thoughts on those features. Being as descriptive as possible will help you make sense of your investigation when you look back at your notebook later.*



At this point, you are primarily trying to support participants in doing good investigations by helping them question, notice, express, and test ideas of interest. But, by keeping the content goals (the main science ideas) in the back of your mind, you can also look for opportunities to help participants make these ideas evident in their investigations. When you notice groups whose investigations

relate to the main science ideas, try to reinforce those ideas by encouraging the group to express, test, and discuss them, using the facilitation suggestions in this section.

**6. Introduce the Shake Bottle Thinking Tool (10 minutes).** With about 10 minutes left before the break, present this thinking tool, a device that can help people consider how lighter particles sink

## Facilitation Hints for Focused Investigation: Beginning

### **For Step 5, continued**

#### ■ **Discuss Controlling Variables**

IF groups are changing more than one variable at a time...

THEN talk the group through the idea of controlling variables. For example, a group may be interested in the effect of slope and plan to try side-by-side trials with different pans having slopes made by a different number of blocks. However, if one person keeps the drip container topped off throughout the trial while another lets her drip container empty out and then refills it, that will create an unfair comparison.

In this example, you could ask how they can tell whether it is the different slopes or the differences in how they poured water into the drip containers that caused the different effects they noticed. Suggest that they can identify the cause only if they change one thing at a time.

#### ■ **Encourage Groups to Generate Explanations**

IF groups are working on making

sense of their data in order to explain what they've observed...

THEN you might ask:

► *Can you think of any ideas that would explain what you've observed?*

#### ■ **Help Groups Test Explanations**

IF a group has formed a tentative explanation about what they have found...

THEN help that group test and support its explanation. Try to move groups toward being able to understand what they're investigating, and ultimately to be able to explain that understanding to the whole group.

You can ask:

► *Can you think of a way to test your ideas?*

Or

► *Is there something else you could do that would convince you that your explanation is correct?*

#### ■ **Encourage Simplicity**

IF a group's investigation seems too complicated...

THEN help them to simplify their plans.

Groups often become interested in very complex phenomena. Simplifying can help people better understand the underlying principles that can explain the phenomena.

For instance, groups might be intrigued by the fact that large grains of sand seem to be eroded from the stream beds in streams running through the "standard mix," which contain large numbers of sand grains of many sizes. But it is very difficult to observe what is happening to individual large grains when there are so many large grains in the mix. In this case, the group could simplify by creating a mix with only a small number of large sand grains, allowing them to more easily follow what happens to individual grains.

more slowly than heavier particles when suspended in water. At this point in the investigations, this phenomenon can apply directly to many investigations, helping groups explain what they are finding. For the other groups, it will serve later on to help them understand some of the explanations offered by their peers during the Sharing Understanding phase. The demonstration helps

people understand that, in the stream table, the heavier (typically larger) grains are deposited first and the lighter grains are carried farther before they are deposited (sometimes all the way out of the stream table). Tell participants:

- *This is another thinking tool, which may help groups make sense of their observations. If it doesn't seem to apply to your group's work,*

## Facilitation Hints for Focused Investigation: Beginning

### **For Step 5, continued**

#### ■ **Encourage Group Discussions**

IF a group has investigated sufficiently to be able to begin explaining what they've observed...

THEN encourage group members to discuss their ideas and the supporting evidence for the ideas. Hearing each others' viewpoints can prompt additional questions related to the group's initial investigations. These questions often lead to further explorations, which give the group more information from which to draw its final conclusions.

#### ■ **Suggest Checking with Other Groups**

IF different groups are working on similar investigations...

THEN encourage participants to visit other groups who are investigating similar questions. You might say:

- *Your group is working on a very similar idea to another group. It might be useful at some point*

*to talk with them to compare to what they're doing and what they're finding out.*

#### ■ **Help Groups Work Efficiently**

IF you think a group is not working efficiently...

THEN make suggestions to help people make efficient use of their time. For instance, if a group has decided to test the effect of particle size on erosion and is going to do four runs, one at a time, you can encourage group members to do several runs simultaneously (depending on how many setups are available) to save time.

#### ■ **Help Groups that Finish Early**

IF a group feels that it has finished its investigation and there is still a good deal of time left...

THEN try to help the group find additional questions they are interested in by suggesting that they

- look at the posted questions
- reflect on their own investigation for questions that came up

- look at what other groups are doing to find something that might interest them

#### ■ **Help Groups Sorting Particles**

IF a group is trying to find a way to sort different-sized particles (for example, trying to find out the ratio of coarse to fine particles on a fan)...

THEN encourage them to use the graduated cylinder in the same way as the shake bottle thinking tool (see Step 6).

#### ■ **Help Groups Investigating Underground Streams**

IF a group is trying to investigate underground streams...

THEN suggest they consider using certain materials.

- One possibility is to use a clear tub as a stream table pan, so they can watch what's happening from the bottom.
- Another is to inject food coloring under the sand in certain places to find out where the water is flowing under the surface.

*that's OK. There's no need to try to invent a connection if there doesn't seem to be one. But for those groups who find it applicable, it may give you a useful common reference point.*

**Hold up the shake bottle and say:**

- *This bottle is filled with some of the sediment that we began with—a mixture of many different-sized particles and some water. When I shake the bottle to distribute the sediments evenly, and then hold it upright for about a minute, watch what happens. I'll pass out a shake bottle to each table and let*

*everyone look at it.*

**Pass out the shake bottles to each table and say:**

- *You'll have a few more minutes to consider what's happening in the shake bottle. Then, we'll take a break.*

**Give the groups a few minutes to examine the shake bottle.**

**7. Announce the break.** Let participants know when to be back in the room.

# Focused Investigation: Concluding

## Overview

During the final 35 minutes of their focused investigations, groups will have about 20 minutes to complete their work and another 15 minutes to decide how they will communicate what they have discovered about stream flow and erosion and how they found it out. All groups may not have answered their questions by the time they stop, but they should be able to explain their observations and articulate questions they might still have.

Near the end of the investigation you will be working to help learners reach some satisfactory level of understanding of the ideas with which they are working. At this point you should be clearer about the path each of your groups has taken and the way they are thinking about the phenomena they are investigating. To help groups bring their investigations to a resolution, provide direction based on this information and on what you've seen the group do to this point. As time runs short, you might give stronger hints to people. This might involve encouraging groups to do some final testing so they'll have more complete data to support their ideas. Or it might involve helping groups articulate what questions they still have, what they would do to try to answer them if they had more time, and what they actually have found out at this point.

## 6 Steps ♦ 35 Minutes

### 1. Let participants know how much time they'll have to conclude their investigations.

Tell the group:

► You'll have about 20 minutes to complete your investigations. Take this time to finish your experiments, to talk with your group and other groups, and to do whatever helps you understand what you've figured out so far about stream tables and what you still have questions about.

Then you'll have about 15 minutes to plan how you want to communicate to the other groups what your group has found so far. You can communicate your findings in words, with a chart or diagram, or by demonstrating something with your stream table setups.

We're not looking for formal presentations. We just want to hear a quick, 2- or 3-minute sharing of your group's understanding at this point.

**2. Visit each group to check in.** Find out what the groups are working on, and guide them toward having something meaningful to share with the other groups.

- If groups are close to a resolution point, and the results of one more stream table run or experiment could help them answer one of their questions, encourage them to complete their experiments.

## Materials Reminder

During this part of the workshop, facilitators will need to:

Keep charts posted:

- Schedule of the workshop
- M1: "Map of the Inquiry Structure"
- M2: "Take-Home Messages"
- M5: "Slope" with questions
- M6: "Flow" with questions
- M7: "QWWNDWATT" with at least one question
- M8: "Sand and Water Thinking Tool"

- If groups are not close to resolution, encourage them to think about what they do know, about what made their questions difficult to answer so far, and what additional questions they have. This way, they have something important to share besides an “answer.”

### **3. Tell participants to start preparing to communicate their findings.** After 20 minutes, say:

- *Please bring your investigations to a close and spend the next 15 minutes deciding how you will share your findings.*

*Remember that your notebooks can also provide a valuable resource to remind you of what you did and give you the evidence you need to support your conclusions.*

*Whether or not you answered your questions, share what you observed, what your difficulties were, and what questions you still have. Sharing questions, or explaining difficulties in figuring out how to answer particular questions, can be valuable.*

*As everyone shares a small bit of information, including questions, observations, and interpretations, you'll all have a chance to put the pieces together yourselves. One group's difficult questions might be answered by another group's observations, so all of your thinking is important for creating opportunities for learning from each other.*

*If you have ideas that explain what you saw, please share them—and the evidence that supports them—with the group.*

Let participants know that there are materials for preparing charts or posters to share their results (such as chart paper, pens, and tape) and where those materials are located.

### **4. Circulate among the groups, helping them decide how to share their findings.**

Some groups may think they haven't answered their particular question or found out anything important. However, they may have run into something significant in the course of their investigation, or even in the inquiry starters. If this is the case, you can remind them of what they have found and point out that it's actually an important idea. Ask them to mention it when they share their findings so that others can hear it and learn from it.

Groups may also need some advice on how best to communicate their ideas. Sometimes you can help “rehearse” people by asking them to sum up what they found out. As you help them clarify their thinking, let them know if you think a particular statement or diagram they used to explain their work to you was particularly clear, and encourage them to share that with the whole group.

### **5. Identify a group you'd like to have share first.**

As you move among the groups, identify one that has done something fairly simple that relates directly to one of the main science ideas. For example, groups that investigated how the amount of flow affected the width of the delta encountered the main idea that *when the flow of a stream increases, more erosion takes place*. Groups that investigated the varying depths of channels with different types of sands encountered the idea that *the smaller the particles, the farther they travel*. Typically, these kinds of investigations tend to involve single variables.

Once you have such a group in mind, ask if they'd be willing to report their findings first during the sharing period. Beginning with a group that reports a straightforward finding supported by evidence provides other groups with basic information they can build on.

You might even be explicit about what you want a

group to share by saying something such as:

- *Would you be willing to start us off by sharing your finding that a greater amount of flow tended to make bigger deltas?*

**6. Tell participants that they have one more minute to prepare their reports.** Then bring work to a close.

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## Facilitation Hints for Focused Investigation: Concluding

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### **For Step 2**

#### ■ **Point Out Findings to Share**

If a group is focusing on phenomena that explicitly relate to the main ideas about stream flow and erosion, which are the content

goals of this inquiry (see Step 5 on page 45), take note of that group. Later, when you help them plan to share their findings, you can encourage them to talk about the particular parts of their investi-

gation that are pertinent. Most participants respond favorably when you tell them that they've found something that demonstrates an important idea that everyone should know about.

# Sharing Understanding: Findings

## Overview

The Sharing Understanding phase of the inquiry has two sections:

- Sharing Understanding: Findings, during which participants from each group share their investigation findings, and
- Sharing Understanding: Synthesis of Findings, when a facilitator relates the group's investigation findings to the main science ideas about stream flow and erosion.

In this first section, each group will have 2 to 3 minutes to share what they learned from their investigation. Facilitators and other participants may ask the group some questions. After each group reports, the facilitator asks for any group whose investigation relates to or builds upon the previous one to volunteer to go next, until all groups have reported on their investigations.

As participants hear each others' findings and decide when to share their own, they construct an understanding of the main science ideas in several ways:

- They make sense of their own and others' ideas as they listen to the other groups.
- They build on each others' findings by choosing when to share in relation to other groups.
- They clarify their own ideas by putting their findings into words.

When groups share, they often make reference to previous groups' experiences, saying that they investigated or concluded similar things.

Listeners are likely to express that they, too, had similar experiences or thoughts. Participants reinforce each others' findings by sharing similar ideas, and complement each others' findings by sharing a variety of ideas. All groups learn from each other by building on what others found, leading to a deeper understanding than any one investigation group could achieve alone.

## 4 Steps • 50 Minutes

**1. Introduce the sharing of investigations (5 minutes).** Point to chart M1: "Map of Inquiry Structure" and explain that the workshop is shifting from the Focused Investigation phase to the Sharing

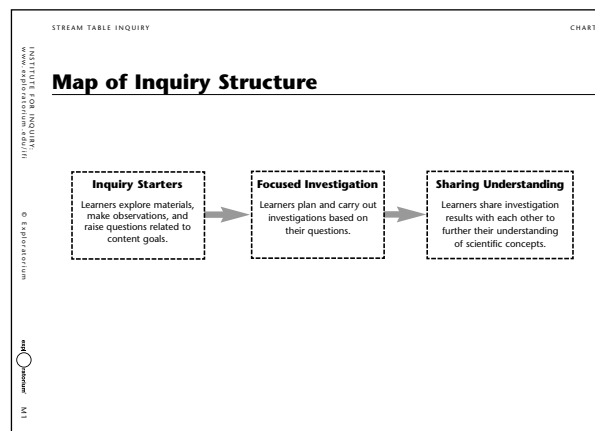
Understanding phase. Talk about the reason for sharing everyone's findings:

► *Everybody has become a bit of an expert about some of the ideas associated with stream tables. Some of you have become*

## Materials Reminder

**During this part of the workshop, facilitators will need to:**

- Keep previously posted charts in place
- Be sure the facilitator presenting the synthesis in the next section has copies of M10a&b: "Facilitator's Notetaking Sheet for Sharing Findings"



**Use M1: "Map of Inquiry Structure" to orient participants in different phases of the workshop.**

familiar with the effects of slope, others with particle size, still others with river shapes or other phenomena. We want to benefit from everyone's expertise so we can put together all these pieces into something much bigger than any one individual or group has done.

Putting your thoughts and ideas into words can help you to clarify your own thinking. And it gives you an opportunity to develop one of the critical science process skills—communication.

## 2. Guide participants in sharing their investigations (45 minutes).

As each group shares, the facilitator may need to ask clarifying questions (such as, “What did you mean by \_\_\_\_?”) if a point seems unclear, or to remind groups of important discoveries they made but haven’t mentioned in their reports.

It’s not necessary to ask each group a question. There’s only a little time built in for questions, so ask them only if they will add to everyone’s understanding. Also, because groups may feel put on the spot, try to ask questions you’re confident the group can answer. Then ask the participants if they have any clarifying questions for the group. Be aware of additional time spent on questions; if you start to fall behind schedule, limit yourself to essential questions. Begin by explaining:

► One group has agreed to go first. As you listen to groups share, if a group has done something that seems related to what your group did, then please volunteer to go next. This way, the groups have a chance to build on each others’ findings quite naturally. Each group has up to 3 minutes to share. This will leave enough time for everyone.

[Note that you’ll need to modify the sharing time according to the number of groups (see Essential Planning Steps, page 13).]

► Our timekeeper [refer to the facilitator whom you’ve determined to be the timekeeper] will let you know when the 3 minutes are almost up.

STREAM TABLE INQUIRY		FACILITATOR TOOL	
Science Idea and How Demonstrated	Group Names	Any Additional Details	
<b>Particle Size</b> Lighter particles move further than heavier ones. • fine particles eroded more • fine particles found in catchbasin • fine particles left in the streambed (exception) • other			
<b>Chaos</b> Stream flow is chaotic, yet regular patterns emerge • different results despite similar initial conditions • found particular landforms • channels move from place to place (especially on fans) • other			
<b>Other Ideas</b> (not mentioned in the Main Science Ideas) • effect of saturation • effect of channeling • other			

STREAM TABLE INQUIRY		FACILITATOR TOOL	
Science Idea and How Demonstrated	Group Names	Any Additional Details	
<b>Flow</b> When the flow of a stream increases, more erosion takes place. • moved more sand • dug deeper or wider channels • created longer or wider deltas • other			
<b>Slope</b> When the slope of a stream increases, more erosion takes place. • moved more sand • dug deeper or wider channels • created longer or wider deltas • other			

M10b

M10a

• Ask the group you identified in the previous section to go first.

• After the first group shares, ask any questions yourself and then ask participants if they have any clarifying questions for the group. The other facilitators can also ask questions, especially if there was something significant about the investigation that the group didn’t mention.

• While groups are sharing, the facilitator who will do the synthesis makes notes (using M10a&b: “Facilitator’s Notetaking Sheet for Sharing Findings”) of the main science ideas related to each group’s investigation. It can be helpful to use specific examples from their investigations to illustrate the concepts you will discuss in the synthesis.



- If more than one group volunteers to share at the same time, choose the group whose investigation is most clearly related to the previous group's work. Help them decide which investigation most appropriately follows. If no groups are volunteering to present, you might ask such questions as:

► *Are there any other groups that dealt with \_\_\_\_\_? [E.g., slope, flow, particle size—whatever idea has just been discussed.]*

- If any facilitator notices that a group didn't mention something significant that they found in their investigation, the facilitator should ask the group to say a few words about that finding.

**3. Have participants count off by 3s (or 2s, if there are only 2 facilitators) for the Making Meaning Discussions.** In the Making Meaning Discussions that take place later in the workshop, participants will break into three groups to reflect on their inquiry experiences. There should be no more than 12 people in each group, so that everyone has an opportunity to speak.

Now, when participants are still sitting in investigation groups, is the best time to count off by 3s, so that people from the same investigation groups will be in different discussion groups. Have people write down their numbers so they don't forget them. After counting off, they'll do a brief cleanup.

**4. Announce that in the next 15 minutes, participants will do a brief cleanup and take a quick break.** This is not meant to be a comprehensive cleanup, just a start to clear the tables for discussions and give facilitators an opportunity to get ready for the next part of the workshop:

- The facilitator doing the synthesis should review and integrate notes taken during this session, and use them to tailor the upcoming presentation so it addresses what the groups shared.

- Other facilitator(s) should use this time to take down charts. The only charts needed to begin the next part of the workshop are M1: "Map of Inquiry Structure," and M2: "Take-Home Messages."

## Sharing Understanding: Synthesis of Findings

### Overview

The purpose of this section is to support participants in building their understanding. Facilitators will introduce some main science ideas about stream flow and erosion, suggest some standard language for phenomena related to these ideas, and support these ideas with evidence drawn from the findings the groups shared. This synthesis helps participants organize the ideas and experiences they have just had or heard about from others into a conceptual understanding of the phenomena associated with stream flow and erosion.

The structure described here is meant to give facilitators a well-defined role in helping participants continue the process of constructing understanding of the main science ideas. The synthesis involves

making a 15-minute presentation, much of which is scripted.

Throughout the synthesis, the facilitator presents examples of evidence for each of the main science ideas, drawing from the notes she or he record-

ed earlier on facilitator tool M10a&b: "Facilitator's Notetaking Sheet for Sharing Findings."

### Materials Reminder

During this part of the workshop, facilitators will need to:

- Keep posted chart M1: "Map of Inquiry Structure"
- Keep posted chart M2: "Take-Home Messages"
- Post chart M11: "Main Science Ideas for the Stream Table Inquiry"
- Distribute handout M12: "Main Science Ideas for Stream Flow and Erosion"
- Distribute handout M13: "About the Process of Inquiry: Creating Paths Toward Understanding"

### For Experienced Facilitators

An alternate approach to the synthesis of findings involves assisting participants in doing their own synthesizing through facilitating a conversation rather than giving a presentation. It takes more time, and it requires a facilitator who is experienced in leading discussions and is comfortable with the science content.

Encouraging conversation and debate is a very powerful approach to helping learners develop understanding. When someone is trying to make sense of something, it is helpful to get language from the group, to discuss reasoning and evidence, and to hear alternative points of view. These are the kinds of conversations that facilitators were encouraged to support during the investigations in each small group, by asking people to express their ideas, gather evidence to test them, and debate the merits of their explanations. But at this point in the inquiry, it is much more difficult for a facilitator to guide a whole-group discussion where partic-

ipants distill the main ideas from all the different presentations and put them together in ways that lead to new understandings.

However, with ample time, an experienced facilitator who keeps the main science ideas and the group's presentations in mind can help shape such a conversation. This could begin with prompts such as "What do you feel you learned about stream flow and erosion based on the investigations? What evidence supports your ideas?"

Whether you choose to follow the step-by-step approach provided in this section or enhance it with more opportunities for conversation, the goal of each approach is to help teachers emerge from the synthesis with an understanding that by doing an investigation and then sharing and reflecting on their investigations, they developed a deeper understanding of the main science ideas about stream flow and erosion.

At the end of the synthesis, the facilitator concludes the inquiry and makes a transition into the Making Meaning Discussions section of the workshop.

## 7 Steps ♦ 15 Minutes

**1. Introduce the synthesis of findings.** Tell participants:

- *This inquiry was designed with science concepts in mind that could be learned through investigation.*

*The intention was not that each of you would individually arrive at an understanding of all the science concepts, but that all the groups collectively would arrive at an understanding of most, if not all, of these key ideas. When you shared your results, what you learned became part of everyone's understanding. You were, in fact, teaching each other, and learning from each other.*

*At the end of an inquiry, it's important to "synthesize"—to put together all the information you've found—in a way that highlights a few central scientific ideas. Doing this can be helpful because people may have found out some fundamental and important ideas but didn't realize that they were important.*

*During a synthesis, seemingly unrelated ideas can be brought together and standard scientific language for these ideas can be introduced.*

**2. Display chart M11: "Main Ideas about Stream Flow and Erosion," then describe the first idea about stream flow.** Say:

- *Let's talk about some of the main ideas associated with stream tables.*

*Many of the ideas have to do with erosion. Briefly, erosion occurs when natural materials are removed, or worn away.*

*The first idea is that **when the flow of a stream increases, more erosion takes place.** This may seem like a simple idea but actually it's an important one. The groups whose investigations supported this idea found that greater flows*

- *moved more sand*
- *dug deeper or wider channels*
- *created longer or wider fans.*

Try to reinforce the idea that greater flow leads to more erosion with examples that were mentioned when groups shared their findings (from M10a&b: "Facilitator's Notetaking Sheet").

For instance, if you heard a group report that they observed larger fans with greater flow, you can say:

- *Groups that investigated the effect of flow found that greater flow causes larger fans. This provides evidence that there has been more erosion.*

**3. Talk about slope.** Explain:

- *The next idea is that **when the slope of a stream increases, more erosion takes place.** Groups that supported this idea with their investigations found that greater slopes*
- *moved more sand*
  - *dug deeper or wider channels*
  - *created longer or wider fans.*

If no group explicitly addressed flow when they

STREAM TABLE INQUIRY

CHART

### Main Science Ideas for the Stream Table Inquiry

(Content Goals of the Inquiry)

- When the flow of a stream increases, more erosion takes place.
- When the slope of a stream increases, more erosion takes place.
- Lighter particles (typically smaller or less dense) are deposited farther downstream than heavier particles.
- Stream flow is chaotic, yet regular patterns emerge. For example:
  - Certain shapes regularly form, including fans, streamlined [lens-shaped "( )"] islands, deltas, meanders, and canyons.
  - The main stream channel changes position, moving back and forth, especially on fans. This happens because, as material is deposited, it builds up high ground in the channel, so another channel becomes the most direct downhill route.

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M11

**M11**

shared their findings, you can say that many groups noticed the effect of flow on erosion during the inquiry starters.

Again, try to reinforce this idea with examples that were mentioned in the presentations. For example, if you heard a group report that they observed deeper channels with steeper slopes, you can say:

- *Groups that investigated the effect of slope found that steeper slopes dug deeper channels. This provides evidence that steeper slopes cause more erosion.*

If no group explicitly addressed slope when they shared their findings, you can say that many groups noticed the effect of slope on erosion during the inquiry starters.

#### 4. Address particle size and weight. Say:

- *Next is the idea that, in general, **the lighter the particles (typically the smaller ones), the farther they move.** Once particles are swept up into the flow of water, the lighter ones take longer to settle out. We saw this in the shake bottles—the fine particles took a lot longer than the coarser sand to settle out. People may have noticed that the used water in your catch basins contained some fine sediment, which had been carried all the way out of the stream tables.*

Again, try to reinforce this idea with examples that were mentioned in the presentations. For instance, if you heard a group report that in a stream table with fine particles, the particles moved farther than those in a stream table with coarse particles, you can say:

- *Groups that investigated the effect of particle size found that finer particles moved farther than coarser particles.*

Point out a special case. Explain:

- *There is a special case about particle size that people often notice. After the water runs out, it appears that the streambeds contain only fine particles and that the larger particles have been swept away.*

If this has come up when groups shared their findings or during the investigations, you can refer to groups that noticed this phenomena. Then explain:

- *The idea that larger particles have been swept away and some finer particles have not may seem counterintuitive, but there's an explanation for it. The water flowing closest to the bottom of the streambed is slowed down due to friction. Large particles that stick up into faster-flowing water are swept away. In addition, the finest particles tend to stick to one another, so a relatively large force is needed to lift them. But if any of these tiny particles become suspended in the stream, they'll be carried the farthest.*

#### 5. Explain chaotic systems. Say:

- *The next idea involves what is called "chaotic systems." This is a complex idea that has to do with the interaction between the sediment and the flowing water. Some groups may have found that it was hard to get consistent results, no matter how hard they tried to make the starting conditions the same. In fact, **seemingly similar starting conditions can lead to very different results.** This occurs because of mutual interaction (feedback loops) between two variables that can accentuate an effect in particular ways that result in very different outcomes.*

Use an example to clarify:

- *For example, in the stream tables, the sediment affects how the water flows, which changes the*

position of the sediment, which changes where the water flows. This kind of feedback loop can amplify even very small differences. So even imperceptible variations in the initial starting setups can lead to very different results. It may have been hard to get consistent results, no matter how hard you tried to make the starting conditions the same.

**Another feature of chaotic systems is that there are some patterns and some predictability within the chaos.**

Mention some of the patterns:

- For example, some of you may have noticed that certain landforms frequently occur, such as fans, canyons, and islands. You may even have noticed that these islands have similar shapes—usually like lenses, or footballs. This happens because water can flow past these shapes without eroding them very quickly.

There are other recurring patterns, as well. For instance, while you can't predict whether a stream's course will flow left or right, you can predict that, under certain circumstances, it will change; that it won't stay the same.

On places like fans, where many particles are being moved, you may have noticed the stream's path changing from the middle to one side, and then back and forth. This happens because particles carried by the water sometimes drop to the bottom of the streambed, where they build up. Eventually, the water changes course, going around this higher ground, and the process begins again.

These channels keep damming themselves up, changing the direction of the flow, and forming new channels that dam themselves up again. Although you can't predict which way a stream will go, you can predict that it won't stay on the same path.

## **6. Address other ideas.** Some groups may have

mentioned ideas not listed on the “Main Science Ideas for the Stream Table Inquiry” chart (M11). Common examples of such ideas include the following:

- more saturated soils eroded more
- objects such as toothpicks or gravel pieces were effective in channeling the water, increasing the flow (and erosion) in certain places, and decreasing the flow in others.

If ideas not included on the chart have been mentioned, you could say:

- In addition to the ideas on the chart, a number of other ideas were mentioned, including... [list the ideas mentioned, such as the effect of saturation or the effect of channeling, etc., and briefly describe what the groups did to investigate these ideas and what they found out].

One characteristic of inquiry is that it's possible to convey a core of particular science ideas, while also allowing for additional discoveries. This happens through supporting people in asking and pursuing their own questions.

## **7. Conclude the synthesis.** Tell participants:

- This brings us to the end of our inquiry. It's a bit of an arbitrary ending place, but now that we've had the opportunity to hear about each others' investigations, and the synthesis of those ideas, any one of us could probably get out the materials, investigate further, and find out even more.

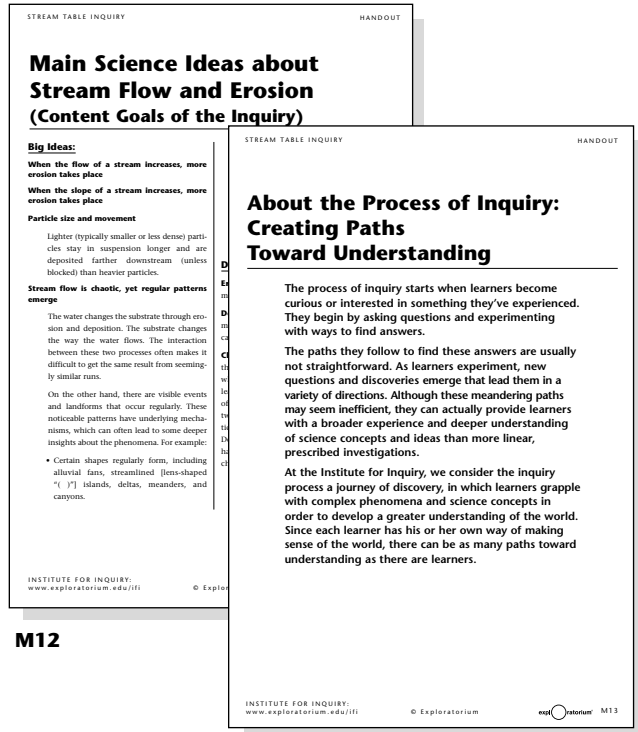
But even stopping here, I hope we can all acknowledge that—from the many questions we started with, and from the many directions our investigations took—each person has arrived at a deeper understanding of the main science ideas this inquiry was intended to address.

In fact, arriving at similar ideas through a wide variety of investigations is one of the unique qualities of inquiry.

Distribute handouts M12: “Main Science Ideas about Stream Flow and Erosion,” and M13: “About the Process of Inquiry: Creating Paths Toward Understanding.” Explain:

- *This first handout describes the main science ideas about stream flow and erosion. The second one addresses the idea that in an inquiry, there can be a great many pathways toward similar content goals.*

Tell participants that in the next part of the workshop, they’ll be breaking into groups according to how they counted off earlier. In those groups, they will reflect on their inquiry experiences.



# PRESENTING THE WORKSHOP

## Part 2: Making Meaning of the Inquiry Experience



- **Making Meaning Discussions**
- **Concluding the Workshop**

# Making Meaning Discussions

## Overview

The Making Meaning discussion is a critical part of this workshop. It helps participants identify—and elaborate on—what they valued about their inquiry learning experience. By expressing and comparing their reactions, participants also deepen their understanding of the inquiry process. The plan for this section is given in the Making Meaning at a Glance box, below.

The Making Meaning discussion has two parts. It begins with participants reflecting on and sharing what they valued about the inquiry experience. When participants articulate what they valued, it helps make those values more concrete, and opens up issues for analysis later, in the second part of the discussion. By beginning with an articulation of what is valuable about their experience of inquiry learning, the stage is set for a discussion of the positive aspects of the inquiry experience.

In the second part of the discussion, participants have a 30-minute conversation about their inquiry learning experience. This

discussion gives people a chance to build and deepen their own understanding by hearing others' perspectives. During the conversation, people are eager to express their reactions, get their ideas out, and hear what other people thought of the inquiry experience. The aim is to share genuine insights about what the process meant to them as learners. As one person's ideas build on another's, new insights arise, affirming the value of inquiry from a diverse set of perspectives. Participants leave the conversation with a deeper understanding of the benefits inquiry learning can offer.

## Materials Reminder

During this part of the workshop, facilitators will need to:

For each discussion group:

- Post chart and distribute hand-out M14: "What I Valued about the Inquiry Experience"
- Post your filled-out chart M15: "Discussion Guidelines" (3 copies)

## Making Meaning at a Glance

**Total Time: 55 minutes**

- 1. Set the context.** One facilitator briefly explains to the entire group the purpose and structure of the discussion. **3 minutes**
- 2. Break into groups.** **2 minutes**
- 3. Elicit personal reflections.** In their smaller groups, participants are given the chance to jot down their thoughts in writing before engaging in discussion. **5 minutes**
- 4. Review discussion guidelines.** The facilitator reviews discussion guidelines, which are meant to create an atmosphere conducive to the open exchange of ideas. **2 minutes**

- 5. Have participants share what they valued about the inquiry experience.** Participants state what they valued about the inquiry experience they just had, as the facilitator records responses on a chart. **10 minutes**

- 6. Have participants discuss the inquiry learning experience.** Participants discuss their inquiry learning experience. **30 minutes**

- 7. Summarize the discussion, then reassemble the entire group.** In each group, the facilitator summarizes the discussion, reminding participants of the main ideas discussed, then everyone returns to the larger group. **3 minutes**



The discussion format is designed to give participants ownership of the conversation—to let them be expansive and to hear from others and share insights. However, the facilitator will need to shape the discussion as necessary, making continual judgments about when it's useful to explore an idea further and when to move things along.

The most productive discussions occur when participants express what they found to be important about their inquiry experience, and with the facilitator's encouragement, to elaborate on these topics. The inquiry learning experience often brings up strong feelings about teaching and learning, and participants need to be the ones to highlight important points about inquiry and discuss their significance. These ideas become important when they come from people's own thoughts and conversations. Although there's not enough time for a deep analysis of all of the aspects of inquiry in this discussion, by discussing some of the key aspects of inquiry that engaged the group, participants come to understand the depth and strength of inquiry teaching and learning.

Note that for Step 4 of this section, you'll need

three copies (one for each discussion group) of M15: "Discussion Guidelines," the chart you filled out as part of your planning process. (See Essential Planning Steps, Step 9, page 16.)

## 7 Steps ♦ 55 Minutes

**1. Set the context (3 minutes).** One facilitator sets the context for discussion for the entire group. Tell the whole group:

- *You've just experienced inquiry as a learner. Now it's time to reflect on that experience. For the next 55 minutes, you'll have the opportunity to think and talk in small discussion groups and begin to make sense of what you experienced in the stream table inquiry. In these groups, you'll reflect by discussing your experience and writing about it. You'll begin by focusing on what you valued, and why you valued it.*

Talk about why the discussion won't be about classroom implementation. Tell the group:

- *This stream table inquiry was designed for adult awareness. But as teachers, many of you may already be thinking about implementing inquiry in the classroom. However, it is vital to build a strong base of understanding about inquiry learning*

### Leading the Conversation about Participants' Inquiry Learning Experiences

As you facilitate the discussion in Step 6 (page 59), it's important to shape the conversation around participants' insights and the topics the group has enthusiasm for. To help the facilitator lead the discussion, we provide the following tools within this section:

- suggestions for an open-ended prompt to start the conversation

- a general description of a typical conversation
- suggestions for handling some specific situations in a typical conversation
- general facilitation strategies for handling challenges during the discussion

Use your judgment in applying these tools. As facilitator, you are in the best position to gauge how much leeway to give your participants to take the conversation into topics unrelated to their immediate experience.

*before considering classroom inquiry. The first step in building this understanding is to examine and understand the experience of learning through inquiry. We can help you best do this by focusing the discussion on the experience you just had.*

Since many teachers will be concerned about how to implement inquiry in the classroom, it's important to let them know if and when you will address classroom applications. If you're having another workshop that focuses on moving toward inquiry in the classroom (such as *Subtle Shifts: Adapting Activities for Inquiry*, the fifth workshop in this curriculum) mention that you will address classroom implementation in that workshop.

Talk about why it's important to begin by discussing what participants value about inquiry. Tell the group:

- *Your small group discussions will begin by sharing what you value about inquiry. This will create a foundation on which to build the remainder of the workshop. In your discussions, you'll have the opportunity to reflect on individual aspects of the overall inquiry experience that were important to you. This can help make the whole experience more understandable.*

*Also, although we did not focus on classroom inquiry in this workshop, when you do consider inquiry in your classroom, it will be helpful to think back to what you personally valued about your own inquiry learning experience. This can provide both inspiration and direction for your efforts.*

**2. Break into small groups (2 minutes).** Send people off into the small groups that you identified earlier, when participants counted off, indicating where each group meets. **One facilitator goes with each group, and then guides their group through Steps 3–8, below.**

**3. Elicit personal reflections (5 minutes).** In each small group, distribute handout M14: "What I Valued about the Inquiry Experience" and tell participants:

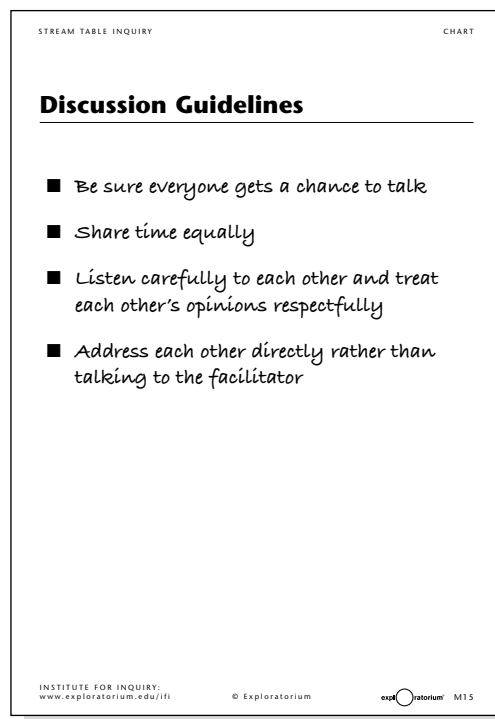
- *Let's start with a brief time for personal reflection.*

Tell participants to take five minutes to jot down on the handout some thoughts about the following prompt:

- *In the inquiry experience that you just completed, what did you value? Why?*

**4. Review discussion guidelines (2 minutes).**

After giving participants a chance to write their personal reflections, post M15: "Discussion Guidelines," which you filled out as part of your planning (see the Essential Planning Steps, Step 9, page 16). Go over the guidelines with participants.



**M15, with examples of typical guidelines**

**5. Have participants share what they valued about the inquiry experience (10 minutes).** In this step, participants are usually excited to share, and they have a lot to say. Collecting many comments is valuable for the large number of perspectives they provide for later discussion.

Tell the group:

- *Now we'd like to hear what you valued about the inquiry experience you just completed and why you valued it. We'll start with brief statements; later we'll have a chance to discuss your ideas in more depth. Let's go around the room and take one response from each person. After everyone gets a chance to respond, I'll take additional comments.*

As participants speak, record their responses on chart M14: "What I Valued about the Inquiry Experience." Ask them to state the reasons for their comments if they don't mention them. (You don't need to record the reasons they give.) After everyone has had a chance to speak, expand your list by asking the group:

- *Are there any other things you valued about the inquiry experience that should go on this chart?*

Record these additional responses.

**6. Discuss participants' experiences (30 minutes).** Refer to chart M14: "What I Valued about the Inquiry Experience" and tell the group:

- *This list provides a good foundation for further discussion. It seems clear that there are a number of things about your inquiry experiences that stood out for you. Remember that we asked you to experience the stream table inquiry as learners. As learners, what was this experience like for you? What was important about the inquiry experience for you?*

Since this initial prompt is very open, it usually draws a number of responses. Your primary job is

to listen to your group to get an idea of what members seem interested in discussing. Keep an ear open for topics that people express interest in, or that you as the facilitator think are important and feel you could facilitate well (see Typical Discussion Topics, page 60).

Sometimes a participant will make an important comment that strikes a chord with the group. Others may add to or respond to the comment and the conversation will take off of its own accord. This is exactly what you want to happen. When it does, you may need to do little more than encourage some people to talk.

STREAM TABLE INQUIRY
CHART AND HANDOUT

### What I Valued about the Inquiry Experience

---

- the discussions I had with my investigation partner
- being able to choose which question to investigate
- the feeling of accomplishment when our group finally figured out what was going on
- that we all started in different places but ended learning about the same things
- the way the facilitator stepped in with a suggestion at just the right time

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**M14, with examples of typical responses**

At other times, the discussion will not generate momentum as easily. Comments may address a series of unconnected topics, without building or going very deep. The conversation may stray onto unrelated topics such as classroom application, or

participants may make unconstructive or negative comments. At these times, you'll need to take more of a role in focusing the discussion.

The facilitation hints on page 61 will help you keep conversations focused and on track. They address

some of the most common challenges that come up in facilitating this section of the workshop. In addition, the box on page 62 offers a model for a typical discussion, based on one of the topics shown in the box below.

### **Typical Discussion Topics and How Participant Comments Fit Within a Topic**

#### **Ownership of Learning**

##### *Learners making choices*

- "We were able to choose which question to investigate."
- "We got to decide what to do next during the investigation."

##### *Learners figuring out concepts for themselves*

- "We had a feeling of accomplishment when our group finally figured out what was going on."
- "We each had our own way of thinking about what was going on."
- "We got to form groups based on our own interests."

#### **Social Aspects of Learning**

##### *Groups working together*

- "The discussions I had with my investigation partner were valuable."
- "We learned from each other's different ways of thinking."
- "My investigation group made me slow down and think about what I was doing."

##### *Groups sharing results*

- "I learned from listening to the other groups' presentations."
- "Getting ready to share helped our group solidify what we learned."

#### **Structure of Inquiry**

##### *Recognizing inquiry's identifiable structure*

- "Inquiry isn't just random."
- "There was a time to bring all our ideas together and share them."
- "We were told when we were shifting from one phase of inquiry to another."
- "The QWWNDWATTs and the idea of limiting questions that can be investigated is a useful technique."

#### **Use of Process Skills**

##### *Questions driving investigations*

- "It helped to see everyone's questions posted."
- "We were able to change our question as we went along."

##### *Using particular process skills during investigations*

- "We got to practice all of the process skills during the inquiry."
- "We saw that we needed to do a fair test (i.e., control variables) in order to understand our experiment."

##### *Connecting process and content*

- "We learned content through using the process skills."

#### **Role of the Facilitator**

##### *Matching assistance to learners' backgrounds and ways of learning*

- "The facilitator stepped in with a suggestion at just the right time."
- "The facilitator didn't talk down to me."

##### *Providing help without taking away ownership of learning*

- "The facilitator really listened to us."
- "We were given enough help to make progress on our own."

#### **Science Content Learning**

##### *Achieving content learning goals through inquiry*

- "We all pretty much learned the target science content and then some."
- "I really understood the science that I learned."
- "The inquiry starters lead to content goals."
- "We all started in different places but ended up learning about the same things."

**Making Meaning discussions generally center around one or more of the six major topics shown above. As you facilitate the conversation, listen for topics that a number of people express interest in. Then you can elicit further discussion. Groups that discuss one or a few of these topics at length are likely to have the most substantial conversations. Attempting to address all of these topics usually results in conversations that only skim the surface of the issues involved.**

## Facilitation Hints for Making Meaning Discussions

### For Step 6

#### ■ Help Focus Conversations

IF comments are not building on each other after a number of people have had an opportunity to talk...

THEN help focus the conversation by referring to several people who have mentioned a particular topic, and ask for additional thoughts about it.

#### ■ Encourage Deeper Discussion

IF someone addresses a topic you'd like people to discuss in more depth...

THEN mention that it's an important idea and you'd like to hear what others have to say about it. You can encourage continued and deeper discussion by asking:

- for more description or elaboration
- for examples from other people's stream table inquiry experience
- how people think the topic being discussed contributed to their learning experience
- why people think what they think (i.e., for rationales of their opinions)
- for each individual's reaction to what others have described (i.e., whether their experience was similar or different from what they are hearing).

#### ■ Keep Conversations Moving

IF a discussion starts to flag...

THEN give it some time to see if it picks up again. If not, it may be

time to go on to another topic. Try:

- referring to other topics that people have mentioned
- asking if there are other things that stood out for people
- referring back to what people valued to find new topics of interest (i.e., you can ask how a particular point contributed to the learning experience).

#### ■ Keep Focused on the Immediate Experience

IF, during the discussion, teachers begin talking about how they teach science, how they'd like to implement what they've just experienced, or why inquiry would be difficult in their circumstances...

THEN help them refocus on the goals of the workshop. While it's natural for participants to relate workshop activity to classroom practice, they risk losing touch with their own immediate experience.

Acknowledge that you value their starting to think about how to do inquiry with their students, but tell them it's critical to first think deeply about why they want to do it. Tell participants that the more they understand about their own inquiry experience, the better prepared and motivated they'll be for addressing ways to move toward inquiry in the classroom.

#### ■ Deal with Participant Concerns

IF someone expresses a concern,

doubt, or problem with the process of inquiry or their own inquiry experience...

THEN acknowledge the issue while keeping focused on what people valued. More than likely, what concerns some people will have worked well for others. If one person had a hard time working in a group, for example, others are likely to have worked productively together and can provide alternative viewpoints. You might ask for responses from the group, or turn the discussion into a group problem-solving session by saying:

► *What do others think about \_\_\_\_\_?*

*Was this also an issue for you or did you view this differently?*

*How would you suggest handling \_\_\_\_\_?*

It's more important to get a range of views on the table than to present a definitive opinion. Discussing different viewpoints can broaden everyone's thinking.

After a short discussion of a concern, you can say that you understand how someone might see a problem, and acknowledge that inquiry teaching can be challenging. But for this conversation, the more participants can reflect on what they think is valuable about inquiry and why, the better prepared and motivated they'll be for addressing any potential difficulties.

### Example of Leading a Discussion on a Typical Topic

There are a number of topics that regularly arise in these discussions. These topics, and the types of comments that relate to them, are listed in Typical Discussion Topics on page 60.

As you facilitate the conversation, listen for a topic that seems to catch people's interest. Then encourage more discussion around that topic. For example, if you notice that several people express interest in ownership of learning, you could prompt a discussion like this one:

- *There are a number of comments here connected to ownership of learning. (Give specific examples from the list you heard.) It seems as if this topic is important for people. We'd like to hear from a number of people about ownership of learning and the related area of learner choice.*

*Where did you have choices in the stream table inquiry? How were these choices important for you? Why?*

- If you need to encourage conversation after one or two people have talked, ask for reactions or comments on the experience presented. You might ask:

- *What do others think about this?*

- If you want more detail from an individual, ask:

- *What contributed to the feeling that you "owned" the learning? What made you feel less ownership?*

*Did you feel that you figured something out yourself?*

In discussing ownership and choice, participants often talk about:

- choice of the question
- choice of the way you approach the investigation (choice of path)
- choice of investigation partners
- how choice builds confidence and competence

- If you want to extend the conversation, ask:

- *How do you think learner ownership contributed to your learning?*

**7. Wrap up the discussion (3 minutes).** At the end of the conversation, summarize by highlighting some of the more important comments about what people valued about inquiry, as well as

particular topics you discussed further. Remind people what subjects seemed to be especially important to the group. Then send participants back to join the larger group.

# Concluding the Workshop

## Overview

At the close of the workshop, the three small discussion groups come back together to form one large group. It's helpful at this point to go back to the "Map of Inquiry Structure" and the "Take-Home Messages" charts introduced at the beginning of the workshop (M1 and M2). This review helps participants summarize what they did in the workshop and reinforces the pedagogical ideas considered in the inquiry.

## 5 Steps ♦ 5 Minutes

**1. Review the inquiry.** Distribute handout M16: "Inquiry Structure for Learning Science Content." Tell participants:

- *We just did an inquiry and discussed what we valued about the experience. The learning that took place and the experience of those things that you valued did not happen by accident. The learning happened within a carefully designed structure.*

Refer to chart M1: "Map of Inquiry Structure" and continue:

- *The "Map of Inquiry Structure" gives a broad structural overview. Each of the phases in that structure has a definite purpose.*

Refer to the first box on the chart and talk about the Inquiry Starter phase. Say:

- *The Inquiry Starters phase introduces learners to interesting material and phenomena and stimulates questions from the learners. The Focused Investigation phase lets learners concentrate on a particular question that they investigate. The Sharing Understanding phase provides a structure*

*for learners to share their investigation findings with each other to further everyone's understanding of scientific concepts.*

*Looking more closely, you will see that there are many sub-*

*structures within these phases. During the Inquiry Starters, mini-activities with a limited collection of carefully selected materials were used to introduce phenomena. Materials were arranged to get people to work in groups of two or three. Sentence strips were used to collect questions to be displayed to the whole group.*

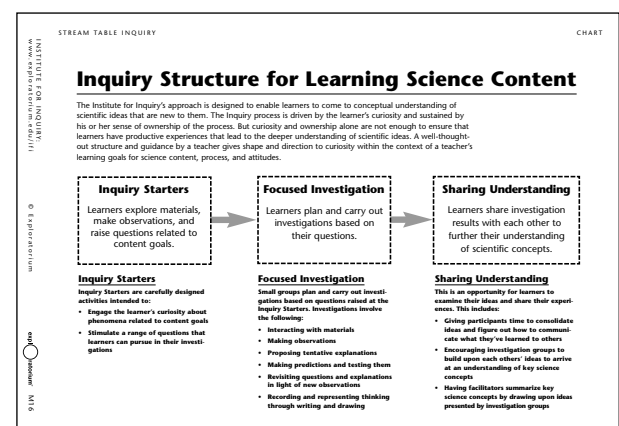
Refer to the second box on the chart and talk about the Focused Investigation phase. Say:

## Materials Reminder

**During this part of the workshop, facilitators will need to:**

**Keep charts posted:**

- **M1: "Map of Inquiry Structure"**
- **M2: "Take-Home Messages"**
- **Distribute handout M2: "Take-Home Messages"**
- **Distribute handout M16: "Inquiry Structure for Learning Science Content"**
- **Distribute any additional resources you have chosen for participants**



- In the *Focused Investigation*, groups self-organized based on learners' interests. "Thinking tools" were introduced at strategic times to help point to science content learning. Facilitators continually monitored group progress but intervened only minimally, keeping the learning in the hands of the learners.

Refer to the third box on the chart and talk about the *Sharing Understanding* phase. Say:

- In the *Sharing Understanding* phase, sharing time was kept short, compelling groups to summarize and identify the main ideas of what they learned. The findings were synthesized to make sure all of the main science ideas were discussed in standard scientific language and to connect the learners' investigations directly to those ideas.

Then talk about the general structure of the process. Tell people:

- This inquiry structure, and its detailed substructures, provides a means for learners to use their own questions and the experiments they plan themselves to learn science content. Designing and carrying out these structural elements is one of the

primary roles of the teacher in inquiry teaching.

## 2. Distribute handout M2: "Take-Home Messages" and refer to the corresponding chart. Say:

- From your experience during the stream table inquiry and your discussions following that experience, I think that everyone has seen evidence of these statements.

Read each take-home message aloud. Then add:

- These are the ideas that we would like you all to carry with you as you leave this workshop.

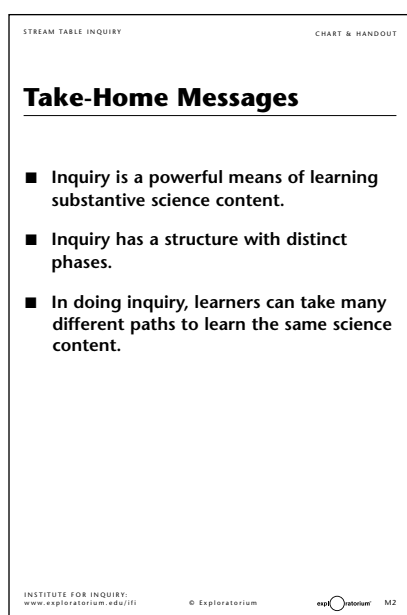
## 3. Make a closing comment and explain what comes next. Tell participants:

- Inquiry is a complex process that can provide powerful learning experiences. The stream table inquiry you just did illustrates this. To do something like this with students would require a number of modifications, such as changing the schedule, having more support for carrying out certain skills, and preparing the students in advance to handle the increased independence.

This workshop may have inspired you to want to move your own teaching toward those aspects of inquiry that you particularly value. This does not mean that you are expected to go right back to your classroom and start teaching using inquiry. Most teachers who do inquiry in their classrooms have moved there gradually, step-by-step, building their own skills as well as their students' over time.

## 4. Pass out copies of any additional resources you've prepared. Encourage participants to continue the conversation with each other about hands-on science.

## 5. As appropriate, let participants know about upcoming workshops.



M2



# REVIEWING THE WORKSHOP

- **Facilitation Review**

# Facilitation Review

## Overview

It's a good idea to set aside some time after the workshop to get together with your co-facilitators and reflect on what worked and what didn't work. You can think and talk about your own facilitation, and consider what adjustments you can make for subsequent workshops.

You'll also want to consider how the group's understanding of the power and value of inquiry developed during the workshop, and where you would like this group to go next in exploring the teaching of science.

## 4 Steps ♦ Time as Needed

**1. Acknowledge what you did well, and reflect on the goals.** Start by taking a few minutes to talk about what went well during the workshop. Share any insights you gained about good facilitation strategies. Identify some things you did that helped groups get over difficult spots. Also, ask yourselves what you might do differently next time to improve the workshop.

**2. Go through the workshop from beginning to end.** Discuss not only how you facilitated different parts of the workshop, but also what participants did, and what they learned in each part of the workshop:

- Were all participants fully engaged in all parts of the workshop? Were there some steps that seemed particularly difficult for any of them? What could you do to encourage more active participation or help participants through difficult spots?

- Did participants develop their own understanding of the take-home messages? If so, how did they demonstrate their understanding? If not, what could you do differently to help them arrive at an understanding?
- Were participants inspired to consider applying some of their new ideas in their own classrooms?

## 3. Review the logistics of the workshop.

- Did you remain on schedule?
- Did you ever feel rushed to complete a step or did you finish early?
- What adjustments could you make that would be helpful?
- How did the distribution and cleanup of materials go?
- Is there anything you could do next time to make the workshop run more smoothly?

## 4. Consider how you and your co-facilitator(s) worked together.

- Were you able to transition smoothly from one part of the workshop to the next?
- Were you able to transition smoothly between the roles of primary and secondary facilitator?
- Did you communicate effectively with each other during the workshop?
- What could you do to improve transitions and communication?

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- **About the Exploratorium Institute for Inquiry**
- **More Workshops on the Web**
- ***Stream Table Inquiry and the National Science Education Standards***

## About the Exploratorium Institute for Inquiry

The Exploratorium is San Francisco's innovative museum of science, art, and human perception. Here, hundreds of interactive exhibits engage visitors in seeking answers to the questions that emerge as they play and experiment with all kinds of intriguing phenomena.

The process of asking questions and seeking answers is at the foundation of the Exploratorium Institute for Inquiry (IFI), a group of scientists and educators dedicated to developing and promoting inquiry-based science learning.

For more than thirty years, we have been educating teachers, administrators, and professional developers about the theory and practice of inquiry-based learning. Our workshops emphasize both the

importance of engaging learners in firsthand experience with materials and phenomena and the necessity for learners to play an active role in building new knowledge. Our work is shaped and refined by our own knowledge and experience as science educators, and by the invaluable input of teachers and professional developers working in the field.

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**Since 1969, the Exploratorium has been bringing hands-on learning to visitors from around the world. Filled with hundreds of interactive exhibits, the museum offers programs for the public as well as for science and education professionals.**

## More Workshops on the Web

In addition to the five-part FUNDAMENTALS OF INQUIRY curriculum, Institute for Inquiry staff have also developed the ASSESSING FOR LEARNING curriculum. Created with noted British researcher and educator Wynne Harlen, this five-part curriculum covers topics in both formative and summative assessment for teachers and professional developers. It's available online at [www.exploratorium.edu/ifi/workshops](http://www.exploratorium.edu/ifi/workshops).

### **ASSESSING FOR LEARNING**

#### **Workshop I: Introduction to Formative Assessment**

Participants discover the purpose of formative assessment and find out how it differs from summative assessment. (about 2 hours)

#### **Workshop II: Assessing Process Skills**

Participants learn how to observe and interpret students' use of the process skills of science. (about 3 hours)

#### **Workshop III: Effective Questioning**

Participants identify questions that are useful for eliciting students' ideas and for encouraging the use of science process skills. (about 2 hours)

#### **Workshop IV: Assessing Science Ideas**

Participants create indicators of development for specific scientific ideas and consider the nature of feedback that helps student learning. (about 2 hours)

#### **Workshop V: Student Self-Assessment**

Participants investigate the value of students assessing their own and their peers' work and explore ways to communicate goals and criteria to students. (about 2 hours)

# Stream Table Inquiry and the National Science Education Standards

The *National Science Education Standards* states that “inquiry into authentic questions generated from student experiences is the central strategy for teaching science.”<sup>1</sup> Therefore, it strongly advocates inquiry both as science content and as a way to teach and learn science. The *Standards* describe inquiry as follows:

Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.<sup>2</sup>

But learning science this way demands that students have the abilities to understand and engage in all aspects of this multifaceted activity. And as the authors of *Inquiry and the National Science Education Standards* state, “Developing the ability to understand and engage in this kind of activity requires direct experience and continued practice with the processes of inquiry. Students . . . must experience inquiry directly to gain a deep understanding of its characteristics.”<sup>3</sup>

To gain a deep understanding of inquiry, teachers must also experience it directly. The *Stream Table Inquiry* workshop provides teachers with that direct experience. Teachers get to explore interesting materials, raise their own questions, investigate those questions, analyze and draw conclusions

## Content Standards Science as Inquiry (K–12)

Abilities to do scientific inquiry.

Understanding about scientific inquiry.

*National Science Education Standards*, p. 105.

from their results, share their learning with others, and—through this process—learn science content.

The *Stream Table Inquiry* provides an experience of a model of inquiry teaching that works within the constraints of a classroom. Teachers see how, through careful design and facilitation, specific science content, process, and attitudinal learning goals can be addressed through inquiry. The *Stream Table Inquiry* serves to support teachers in progressing toward the national teaching standards, and by doing so assists them in helping their students move toward the content standards.

## Teaching Standards

### Standard A

Teachers of science plan an inquiry-based science program for their students.

### Standard B

Teachers of science guide and facilitate learning. In doing this, teachers

- Focus and support inquiries while interacting with students.
- Encourage and model the skills of scientific inquiry.

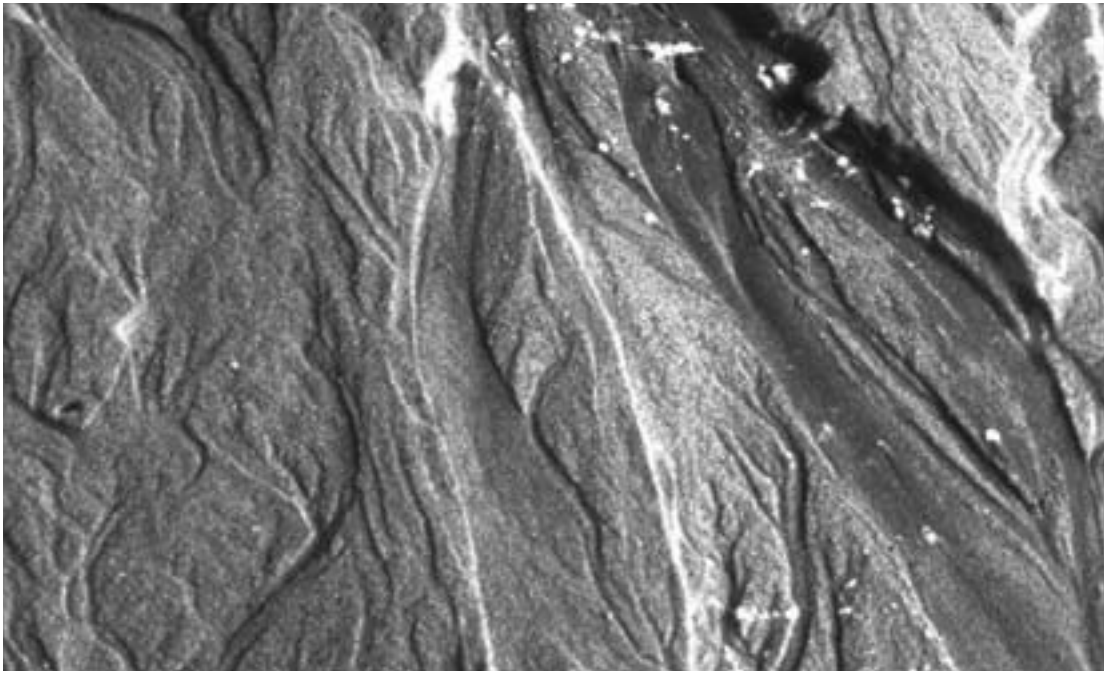
Excerpts from *National Science Education Standards*, p. 30 and p. 32.

1. National Research Council. *National Science Education Standards*. (Washington, DC: National Academy Press, 1996), p. 31.

2. Ibid., p. 23.

3. National Research Council. *Inquiry and the National Science Education Standards*. (Washington, DC: National Academy Press, 2000), p. 14.

# TUTORIAL



- **Stream Table Tutorial for Facilitators**

# Stream Table Tutorial for Facilitators

## Overview

This tutorial was developed to help prepare facilitators to lead the Institute for Inquiry's *Stream Table Inquiry*.

Even if you've worked extensively with stream table materials in the past, it's important to go through this tutorial in its entirety, as it will allow you to gain familiarity with this particular inquiry experience.

In the course of this tutorial, you'll work with the same materials participants will use during their investigations, and you'll familiarize yourselves with the phenomena and concepts participants will encounter. Your firsthand experiences will help you support participants in their work and in understanding their findings.

Working through this tutorial involves doing seven experiments and takes about two hours. Additional time would help you become familiar with a greater range of phenomena participants might encounter, but

## A Note about Stream Table Modeling

This tutorial is meant to help you become familiar with the phenomena and concepts participants will encounter during their stream table investigations. While geologists use similar stream tables to model real-world phenomena, there are some special cases that cannot be modeled with these materials. For instance, in very wide, shallow rivers (which cannot be modeled here), there can be more flow but less erosion.

You may have participants with geology backgrounds who have experience with these phenomena. If so, you may want to tell them that these materials can provide useful models for many real stream-related phenomena, and the main science ideas offered in this guide explain the phenomena related to these materials. However, it's not a perfect model, and in real-world special cases, there are exceptions to these ideas.

two hours should be enough to experience phenomena that relate to the main science ideas of the inquiry.

Try to pace yourselves by allowing 15 to 20 minutes for each experiment. If you run short of time, the final two experiments are the least critical. Set up for the tutorial after all the materials have been gathered (see page 23). It's important for all

the facilitators to

work through the tutorial together, coming to a shared understanding of the main science ideas (the content goals of the inquiry) and of how the evidence from the experiments supports these ideas.

Each experiment is made up of three sections:

- What to do
- What to observe
- Relation to main science ideas

The first two sections ("What to do" and "What to observe") suggest various experiments and point out relevant features. There are also some questions

## Materials Reminder

For this tutorial, you'll need:

- Chart M11: "Main Science Ideas for the Stream Table Inquiry" (no need to enlarge; for your reference only)
- 4 stream-table setups (pans, rulers, catch basins, wood angle scrapers, shims, pitchers)
- 1 level
- 1 box toothpicks
- 1 five-gallon bucket of water
- 12 wooden blocks (to prop up stream tables)
- 2 each of the  $\frac{3}{32}$ ",  $\frac{5}{32}$ ", and  $\frac{3}{16}$ " drip containers
- 4 each of the  $\frac{1}{8}$ " drip containers
- 10 quarts of the "standard mix" sand (see page 22 for details)
- 4 quarts each of coarse sand, fine sand, and very fine sand (baking soda)
- 1 quart gravel



## Common Terms

### canyon

A deep, narrow, often V-shaped valley, usually cut by a stream.

### delta

A deposit of sediment, approximately triangular in shape, formed where a stream enters a lake or ocean.

### fan

A fan-shaped deposit of sediment (called an “alluvial fan” by geologists) formed when the slope of a stream is suddenly reduced.

### flow

To a geologist, refers to the amount of water flowing past a point in a given amount of time: Normally, increasing flow results in increasing erosion because the speed of water is also increased.

### meander

A bend in the course of a stream, often wide and loop-like.

### streamlined (lens-shaped) island

Islands with a characteristic lens shape “( )” formed when a shallow stream divides and reconnects.

meant to encourage the kinds of conversations participants will have with each other. The third section (“Relation to main science ideas”) connects the relevant features of the experiment to the appropriate science concepts.

In some cases, an “Additional background information” section is provided that goes beyond what is immediately observable. It’s not intended that you should communicate this additional background information directly to participants. Rather, the intention is to help you develop additional confidence in your own understanding by providing a bit more insight into the phenomena encountered.

We also have provided a short list of terms relating to stream flow, erosion, and deposition. Again, this is background information to help you see the relevant phenomena. It’s not intended that you teach these terms to participants.

As you work, carefully observe what happens when water runs down the stream table, and what happens when you make various changes. Point out what you see to each other, and ask each other questions. Keep in mind that the inquiry is designed to teach the concepts outlined in chart M11:

“Main Science Ideas for the Stream Table Inquiry.”

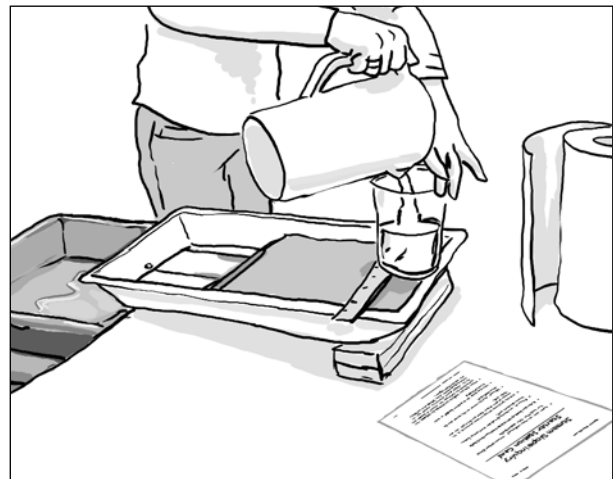
STREAM TABLE INQUIRY
CHART

### Main Science Ideas for the Stream Table Inquiry (Content Goals of the Inquiry)

- When the flow of a stream increases, more erosion takes place.
- When the slope of a stream increases, more erosion takes place.
- Lighter particles (typically smaller or less dense) are deposited farther downstream than heavier particles.
- Stream flow is chaotic, yet regular patterns emerge. For example:
  - Certain shapes regularly form, including fans, streamlined [lens-shaped “( )”] islands, deltas, meanders, and canyons.
  - The main stream channel changes position, moving back and forth, especially on fans. This happens because, as material is deposited, it builds up high ground in the channel, so another channel becomes the most direct downhill route.

INSTITUTE FOR INQUIRY:  
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exploratorium M11

**M11**



**Standard stream table setup**

## Experiment 1: Observing Flow with the Standard Setup

**What to do:** Set up a stream table using the standard setup, as described here (and on page 20), and shown in the illustration above.

- Prop up a pan on two blocks and fill it with about two quarts of “standard mix” sand (sand that has all

the particle sizes mixed together; see page 22 for details).



**Using the wood angle scraper to smooth the sand**

- Wet the sand completely until the water runs off, and then use the wood angle scraper to smooth and spread it two-thirds of the way down the pan, so it forms a “cliff” where it stops (see illustration above and on the previous page).

- Place a ruler across the width of the stream table, about 4 or 5 centimeters (2 inches) from the back edge of the pan. Then balance the container with the 1/8” drip hole between the ruler and the back edge of the pan.

Fill the container with water and watch what happens as the water flows out. Read the “What to observe” section below, and then pour in more water. As your catch basin begins to fill, use an empty pitcher or measuring cup to scoop the water back into the five-gallon bucket.

**What to observe:** When you do this experiment, you may see one or more of the following:

- You may see the water form a stream, erode some sand as it flows (particularly as it goes over the cliff), and then deposit the eroded sand in a fan shape when it reaches the flatter area near the bottom of the pan.

- You may see a section of the cliff slip forward and downward. (This process, called “slumping,” is mass movement rather than stream erosion.) Once slumping has occurred, though, you may see a stream move across the slump.

- You may see more than one stream form.

When the water stops flowing, look at the stream channels. What shape are they (straight, curved, S-shaped)? How deep and wide are they? How far has the sand moved beyond where the cliff originally was?

Pour more water in the container and observe closely where the particles erode and where they are deposited. Notice where particles of different sizes end up. Watch to see if the stream changes course, drying out in old channels and flowing in a new ones. One place where this tends to happen is on the fan. Where this happens, look for particles forming “high ground” in the channel, causing the stream to change course.

**Relation to main science ideas:** It’s difficult to predict the path a stream will take. Often, the only thing that’s predictable is that a stream consistently changes course. One reason is that some of the particles transported by the water are deposited in the channel, creating “high ground,” and the water will no longer flow in that direction. This supports the main science idea that stream flow is chaotic, yet regular patterns emerge. Here, the stream flow is called chaotic because it’s difficult to predict where it will go. The regular pattern that emerges is that the stream channel will consistently change course.

**Additional Background information:** One reason the stream changes course often on the fan is because the water speed decreases on the fan as the slope flattens out near the bottom of the pan. As the water speed decreases, more particles are deposited in the channel, causing the stream to change course.

## **Experiment 2: Changing the Slope**

**What to do:** To most quickly and effectively observe the effects of changing slopes, set up two or three stream tables side by side, propped up to different levels with different numbers of blocks (1–4). Saturate the sand in each and then run them at the same time.

**What to observe:** Notice that when the slope is steeper, the cliff collapses faster because the water gets to it more quickly. While subtle and often difficult to observe, see if you can tell if the water in the steeper stream tables is moving more quickly (sometimes you can see particles moving in the channels).

After the runs have been done side by side, compare the effects and notice the following:

- More sediment has been moved in the steeper pans.
- The channels are often deeper and straighter in the steeper pans.

Scrape the sand back up and smooth it out. Try to repeat these runs several times so you can begin to see the kinds of effects that are consistent and those that are not.

**Relation to main science ideas:** More sediment moves in the steeper pans because the streams flow faster, which increases the “push” that the water can exert on the particles in the channel. The faster speed also keeps particles in the streamflow longer. Because the particles in the steeper pans tend to keep moving and don’t settle out to build “high ground” in the channels, the channels are often straighter and deeper. These observations are related to the main idea that when the slope of a stream increases, more erosion takes place.

## **Experiment 3: Changing the Amount of Flow**

**What to do:** Scrape the sand back up the slope in

each stream table. Prop up stream tables on two blocks, so they are all sloped the same, and then try containers with different-sized drip holes. Fill each drip container and watch each run closely. Then talk to each other about the differences you notice that might relate to the amount of flow, and what seems significant.

**What to observe:** After the water has flowed out completely, notice what happened in all the stream tables. In general, the greater flows will have moved more sand downstream (caused more erosion) and created wider or longer fans. The greater flows also tend to “scour” the streambeds, leaving only very fine, smooth sediment on the bottoms of the channels while sweeping bigger particles downstream. Some of the very fine particles are also carried downstream, however, and they often get swept all the way into the catch basin.

**Relation to main science ideas:** In general, when there is a greater volume of water, the water flows faster. Water that moves more quickly can move more particles in a period of time, enabling more sand to be removed from larger channels and deposited into bigger fans. These events relate to the main science idea that when the flow of the stream increases, more erosion takes place.

**Additional background information:** When there’s a greater amount of flow, the streams tend to be deeper, and deeper streams flow faster than shallower streams. In order to understand this, picture water flowing in layers. The layer in contact with the bottom slows down due to friction. But layers above the bottom flow over water, and because there is less friction, flow faster.

It may seem strange that some of the very fine particles remain on the streambed, while larger particles are eroded. There are a couple of reasons why this

happens. First, the layer of water flowing in contact with the bottom (called the boundary layer) moves more slowly than the water above it. But if a large particle sticks up out of the boundary layer, it will be hit with moving water that may have enough force to erode it. In addition, the tiniest particles tend to stick to each other, so a stream needs a relatively high speed to lift them. Once they're in suspension, however, they're carried farther than larger particles.

### **Experiment 4: Changing Particle Size**

**What to do:** Set up four stream tables side by side, each with different kinds of sand—coarse, fine, very fine (baking soda), and the standard mix. Saturate each kind of sand by mixing in enough water for some water to run off. (When excess water runs off, you know the sand is completely saturated). Then run water through each pan. You can try this with flow holes of different sizes and with different slopes, but you might want to start with the standard 1/8" flow hole and two blocks.

**What to observe:** Notice how conditions in the four setups differ. The finer particles tend to erode more, creating deeper, narrower channels, with the sediments carried all the way into the catch basin. The coarser particles barely budge.

It's likely that in the stream table with the finest particles (and possibly in others), you'll see a very deep canyon cut as the stream hurries over the cliff. When that section of the cliff is eroded, the land just upstream becomes the steepest part of the channel, and it's eroded next. Effectively, the cliff gradually retreats upstream and is eroded again and again.

**Relation to main science ideas:** The lightweight particles (typically, the finer ones) are deposited farther downstream than the heavier (typically larger) particles. This happens because they require less force to trans-

port them. Once the lighter particles are swept up into the flow of water, they take longer than heavier particles to settle out and so are carried farther.

The cliff gradually retreats upstream because erosion increases on steeper slopes, and the steepest part of the channel is right over the edge of the cliff. (Niagara Falls has migrated upstream in a similar way, creating the Niagara Gorge). This relates to the main idea that when the slope of a stream increases, more erosion takes place.

**Additional background information:** Note that some of the baking soda, unlike the other kinds of sand, will dissolve in the water, which will flow away into the catch basin. Despite being slightly soluble, baking soda is still a good material for demonstrating that lighter (typically smaller) particles move farther than heavier (typically larger) particles because the undissolved baking soda will be transported farther than the fine sand. The baking soda also models conditions in real streams, where some sediment is soluble. A stream can transport particles in three ways: most particles are suspended in the stream flow, but some dissolve, while others, the largest, are skipped or rolled along the bottom of the channel.

### **Experiment 5: Comparing Dry and Wet Sand**

**What to do:** Run water down a stream table filled with dry sand. Refill the drip container as necessary to saturate the sand.

**What to observe:** Notice that, as the water flows, no sand moves until the sand is wet, and this takes quite a long time. It's interesting to watch the sand become damp as a "shadow" spreads across it. Only when the sand becomes thoroughly wet does it start to erode.

**Relation to main science ideas:** This experiment doesn't illustrate one of the main science ideas, but it's something participants sometimes try. If people investigate this, you can honor their findings during the synthesis by connecting it to the idea that streams will erode saturated soils more than unsaturated soils.

**Additional background information:** When the water encounters dry sand, it soaks in, so no erosion takes place. When the sand is saturated, the water flows over the surface, causing erosion to take place.

### **Experiment 6:** **Changing a Channel's Direction**

**What to do:** Make a wall with gravel, or set up toothpick "trees" or centimeter-cube "houses" at a 45-degree angle partway across the sand. Use a  $\frac{3}{16}$ " drip hole or prop up the tray on three blocks to have a substantial flow of water.

**What to observe:** Placing objects in the channel directs the water in such a way that its flow increases in some places and decreases in others. You'll notice that sand is eroded more from places where water is moving more quickly (such as where the wall ends), and is deposited more in places where the water is moving more slowly.

**Relation to main science ideas:** Channeling the water can increase its speed in places by making the stream deeper or steeper. For example, where a diagonal wall ends and the water turns straight downhill, the slope of the streambed increases, so more erosion takes place.

### **Experiment 7:** **Observing Chaotic Phenomena**

**What to do:** In your trials, you may have noticed that the streams typically don't take the same path every time, even though all the starting conditions seem similar. If you want to test this, set up two

stream tables side by side as much the same as possible, and run them at the same time to compare similarities and differences.

**What to observe:** You are likely to find differences in the ways the streams flow, such as the direction the water goes, the number of channels, the width or depth of the channels, and where the sand eventually ends up. You are also likely to see similar features and events, such as the formation of fans and islands, and changes in the direction of the stream.

**Relation to main science ideas:** In their investigations, participants sometimes try to recreate particular effects. But what they find most often is that it is very, very difficult to get the same effects, even from seemingly similar starting conditions.

While participants can become frustrated by unsuccessfully trying to repeat an effect, their frustration can be alleviated when a facilitator acknowledges the situation. The difficulty in replicating a result can be characterized by the term "chaotic phenomena," which describes situations where similar starting conditions can generate different ending conditions. This relates to the main science idea that stream flow is chaotic, yet regular patterns emerge.

**Additional background information:** Chaotic phenomena are caused when feedback amplifies small differences between conditions. In the case of a stream table, the water affects how the sand moves, but the sand also affects how the water moves. So even a slight difference at the start can make the sand end up in a very different place. There are some patterns you can find within the chaos, however. Regular patterns are exemplified by the creation of landforms in certain shapes (such as fans and streamlined islands), and in characteristic patterns of erosion, such as stream channels flowing first in one place and then another (especially on fans).

# REPRODUCIBLE MASTERS

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# Map of Inquiry Structure



# Take-Home Messages

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- Inquiry is a powerful means of learning substantive science content.
- Inquiry has a structure with distinct phases.
- In doing inquiry, learners can take many different paths to learn the same science content.



# Stream Slope Inquiry

## Starter Station Card

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- Start with an even surface of sediment extending from the top to about two-thirds of the way down the stream table.
- Raise the back of the stream table on two blocks.
- Place a ruler across the stream table about 2 inches from the back wall.
- Fill the  $\frac{1}{8}$ " drip container and support it in the center of the stream table tray, on the ruler and the back wall.
- Observe what happens to the water and to the sediment.
- You can keep the container topped up so it drains steadily.
- When you are ready to try varying the slope of the stream table by changing the number of blocks, use the L-shaped piece of wood to prepare an even surface of sediment about two-thirds of the way down the stream table again.

# Stream Flow Inquiry Starter Station Card

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- Start with an even surface of sediment extending from the top to about two-thirds of the way down the stream table.
- Raise the back of the stream table on two blocks.
- Place a ruler across the stream table about 2 inches from the back wall.
- Fill the  $\frac{1}{8}$ " drip container and support it in the center of the stream table on the ruler and the back wall.
- Observe what happens to the water and to the sediment.
- You can keep the container topped up so it drains steadily.
- When you are ready to try varying the flow of the stream table by using a drip container with a different sized hole, use the L-shaped piece of wood to prepare an even surface of sediment about two-thirds of the way down the stream table again.

# Slope

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# Flow

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# QWWNDWATT

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# Sand and Water Thinking Tool

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- Consider what the sand does to the water as well as what the water does to the sand.

# Starting the Investigation

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Once you have formed your group and have chosen your investigation question, answer the following questions. Make two copies, one for yourself and one for the facilitator.

- Your names
  
  
  
  
  
- What question(s) will you try to answer?
  
  
  
  
  
- What materials will you need?
  
  
  
  
  
- What will you do first?

# Facilitator's Notetaking Sheet for Sharing Findings

This sheet is meant to help the facilitator who will present the synthesis of ideas to take notes when groups share investigation findings. Examples from the groups can be used to provide evidence for the main science ideas during the synthesis.

As you listen to each group share, note any of the main science ideas (flow, slope, particle size, and chaos) that are addressed. Also note additional science ideas (such as the effect of saturation) so that these can be mentioned during the synthesis.

When you find that a group's investigation addressed a science idea, write one or more of the participant's names in the box next to the science idea (e.g., greater flow, more erosion). Then, indicate how they demonstrated this idea by drawing an arrow to the appropriate description of what they found (e.g., if they found that greater flow caused wider fans, draw an arrow from their names to the words: "created longer or wider deltas." Use the "Any Additional Details" column to note any interesting details or quotes.

Science Idea and How Demonstrated	Group Names	Any Additional Details
<b>Flow</b> When the flow of a stream increases, more erosion takes place. <ul style="list-style-type: none"> <li>• moved more sand</li> <li>• dug deeper or wider channels</li> <li>• created longer or wider deltas</li> <li>• other</li> </ul>		
<b>Slope</b> When the slope of a stream increases, more erosion takes place. <ul style="list-style-type: none"> <li>• moved more sand</li> <li>• dug deeper or wider channels</li> <li>• created longer or wider deltas</li> <li>• other</li> </ul>		



Science Idea and How Demonstrated	Group Names	Any Additional Details
<p><b>Particle Size</b></p> <p>Lighter particles move farther than heavier ones.</p> <ul style="list-style-type: none"> <li>• fine particles eroded more</li> <li>• fine particles found in catch basin</li> <li>• fine particles left in the streambed (exception)</li> <li>• other</li> </ul>		
<p><b>Chaos</b></p> <p>Stream flow is chaotic, yet regular patterns emerge</p> <ul style="list-style-type: none"> <li>• different results despite similar initial conditions</li> <li>• found particular landforms</li> <li>• channels move from place to place (especially on fans)</li> <li>• other</li> </ul>		
<p><b>Other Ideas</b></p> <p>(not mentioned in the Main Science Ideas)</p> <ul style="list-style-type: none"> <li>• effect of saturation</li> <li>• effect of channeling</li> <li>• other</li> </ul>		

# **Main Science Ideas for the Stream Table Inquiry**

## **(Content Goals of the Inquiry)**

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- When the flow of a stream increases, more erosion takes place.
- When the slope of a stream increases, more erosion takes place.
- Lighter particles (typically smaller or less dense) are deposited farther downstream than heavier particles.
- Stream flow is chaotic, yet regular patterns emerge. For example:
  - Certain shapes regularly form, including fans, streamlined [lens-shaped “( )”] islands, deltas, meanders, and canyons.
  - The main stream channel changes position, moving back and forth, especially on fans. This happens because, as material is deposited, it builds up high ground in the channel, so another channel becomes the most direct downhill route.

# Main Science Ideas about Stream Flow and Erosion

## (Content Goals of the Inquiry)

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### **Big Ideas:**

**When the flow of a stream increases, more erosion takes place**

**When the slope of a stream increases, more erosion takes place**

### **Particle size and movement**

Lighter (typically smaller or less dense) particles stay in suspension longer and are deposited farther downstream (unless blocked) than heavier particles.

**Stream flow is chaotic, yet regular patterns emerge**

The water changes the substrate through erosion and deposition. The substrate changes the way the water flows. The interaction between these two processes often makes it difficult to get the same result from seemingly similar runs.

On the other hand, there are visible events and landforms that occur regularly. These noticeable patterns have underlying mechanisms, which can often lead to some deeper insights about the phenomena. For example:

- Certain shapes regularly form, including alluvial fans, streamlined [lens-shaped "( )"] islands, deltas, meanders, and canyons.

- The main channel that runs down a fan does not stay in the same place. It moves back and forth because, as material is deposited, it builds up high ground in the channel. As a result, the water forms a new channel where it can flow more directly downhill. The water eventually deposits enough sand in the new channel that yet another route becomes more direct.

### **Definitions**

**Erosion:** The process of removing natural sediments.

**Deposition:** The process by which eroded earth materials settle out of the wind, water, or ice that carried them.

**Chaotic phenomena:** Chaotic phenomena are those where outcomes are difficult to predict—where seemingly similar starting conditions can lead to very different results. This occurs because of mutual interactions (feedback loops) between two variables that can accentuate an effect in particular ways that result in very different outcomes. Despite being hard to predict, chaotic systems have an underlying order and regularly occurring characteristics.

# About the Process of Inquiry: Creating Paths Toward Understanding

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The process of inquiry starts when learners become curious or interested in something they've experienced. They begin by asking questions and experimenting with ways to find answers.

The paths they follow to find these answers are usually not straightforward. As learners experiment, new questions and discoveries emerge that lead them in a variety of directions. Although these meandering paths may seem inefficient, they can actually provide learners with a broader experience and deeper understanding of science concepts and ideas than more linear, prescribed investigations.

At the Institute for Inquiry, we consider the inquiry process a journey of discovery, in which learners grapple with complex phenomena and science concepts in order to develop a greater understanding of the world. Since each learner has his or her own way of making sense of the world, there can be as many paths toward understanding as there are learners.

# **What I Valued about the Inquiry Experience**

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# Discussion Guidelines

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# Inquiry Structure for Learning Science Content

The Institute for Inquiry's approach is designed to enable learners to come to conceptual understanding of scientific ideas that are new to them. The Inquiry process is driven by the learner's curiosity and sustained by his or her sense of ownership of the process. But curiosity and ownership alone are not enough to ensure that learners have productive experiences that lead to the deeper understanding of scientific ideas. A well-thought-out structure and guidance by a teacher give shape and direction to curiosity within the context of a teacher's learning goals for science content, process, and attitudes.

