Stream Course

A STREAM HEALTH STUDY

Respect Rule: Look, Listen, Learn, and Leave Alone (until instructed).

Overview

Streams in the Sierra Foothills support communities both natural and human. In this activity, students will select a local creek to study in-depth. The physical nature of the stream determines much of its overall character, the habitat that the stream provides and the organisms that can be supported by that habitat. The gradient of the stream, the presence of boulders or tree roots, the rocks, cobble and sand on the stream bed, even overhanging vegetation, contribute to a unique environment for aquatic organisms. Through this investigation, students will track the health of their stream.

Background

Rivers and streams in the Sierra Foothills play a rich role in the history of local communities. Towns established along sources of water. River water supported mines, foundries, vineyards, and ranching. The rivers and creeks also carried away the waste of communities and their mining activities.

Today streams continue to support communities through supplying drinking water and removing waste water. Streams often run directly through local communities and their natural course may be altered by bridges, culverts, and channelization.

The focus of this lesson is the physical structure of the stream. This lesson, used in conjunction with two other lessons on chemical and biological parameters, will give a complete picture of stream health. For chemical parameters, see the lesson: Teaming Up for Clean Water. For biological parameters, see the lessons on Aquatic Animals.

Perennial or Ephemeral?

Every stream is unique since the watershed it drains is unique. In the Sierra Foothills, perennial rivers, like the Mokelumne River, Tuolumne River, and Stanislaus River, drain large watersheds with their origins in high elevation and forested watersheds. Much of the runoff is held over the winter as snow pack. High spring runoff, as the snow melts, is characteristic of these rivers. These large rivers, that flow year around, are called perennial. Since flows of these perennial rivers may often exceed the ability to wade or cross them safely, the protocols in this lesson are unsuitable for studying them.

In contrast to large major rivers, the headwaters of smaller streams, like Jackson Creek, Murphys Creek, and Wood Creek, lie at lower elevations. Precipitation falls on the watershed primarily as rain. These creeks flow heavy in winter and early spring, often pooling up in the summer. Creeks that do not flow year around are called ephemeral or intermittent streams.

Stream Slope

The geology of the watershed dictates a stream's inherent nature. Streams that course through easily eroded sedimentary soils or decomposing granite carve through the landscape with less resistance than streams that course through granite bedrock. Over extensive periods of time, the stream channel is formed. The shape of the channel depends on the flow and the slope or gradient of the landscape. Very steep slopes may form waterfalls, as at Yosemite, or less dramatically and more commonly, small cascades within a stream. Watersheds with little slope, as in the Sacramento River Valley, have flat, low gradient rivers flowing through them.

Students can measure the slope of their stream using a surveying device called a clinometer. Holding the clinometer and viewing a subject downstream, allows the observer to determine the slope of the stream, in percent. Steep gradients range from around 4 to 10%, moderate gradients from 2 to 4%, and low gradients less than 2%. Along a stream, gradient will vary and the nature of the stream will change with it.

Objectives
Students will:
1. collect and record physical measurements of a stream;
2. analyze data to determine stream health.

Grade Levels
7–12

Adult/Student Ratio
Normal class size

Where
Creeks must have safe public access. Water should be flowing but low enough for several students to safely wade in (no deeper than calf deep). Students must be able to walk 150 meters along the creek at or above the bank on at least one side, so they can visually evaluate riparian vegetation and bank condition.

Skills
Analyzing, estimating, formulating hypotheses and questions, generalizing, graphing, predicting, researching

Key Words
Perennial stream
Ephemeral stream
Embeddedness

> **The care of rivers is not a question of rivers, but of the human heart.**
>
> —Tanaka Shozo, *Listening to Nature*, by Joseph Cornell

Instream Habitat

Within a stream, flows can vary substantially. As fishermen know, trout rest in the large deep pools of a river. As kayakers and canoeists know, fast moving white water occurs in areas where the stream narrows or where the slope increases dramatically. Healthy streams have a variety of habitats that support aquatic organisms. Fast moving water adds oxygen to a stream and is critical to aquatic insects and fish. Slow moving water provides refuge for fish.

Aquatic scientists distinguish four types of habitat based on flow and depth. These are pools, riffles, runs, and glides. Particularly important for aquatic life are pools and riffles. Students will determine the relative percent of each type of habitat along a stream reach. Deep is defined as a meter or greater. Fast is defined as a flow greater than or equal to one foot per second.

Habitat	Depth	Flow
Pools	deep	slow
Runs	deep	fast
Riffles	shallow	fast
Glides	shallow	slow

While the flow and gradient determine the potential for a variety of habitats, pool formation depends on another critical factor—a physical element that blocks flow. Large boulders or fallen logs (referred to as large woody debris) help block flow. Removal of these instream structures is often done to reduce the risk of flooding in channels that flow through populated areas. In very extreme cases, river systems have been channelized and straightened for flood control so that only one type of habitat remains—fast and deep water. The Los Angeles River is an extreme example of this urbanization of a river course.

Stream Substrate

Travel to the upper reaches of the North Fork Mokelumne River at Salt Springs and view the large granite boulders and deep pools in this river. The water is usually clear, and sediment supply is low if the watershed is undisturbed. Boulders and fallen trees or large rocks may block flows, forming pools. The stream bed is covered with granite rocks from the size of small marbles to the size of houses. Following the river downstream through the foothills and into the Central Valley, the stream bed will change character. Large car-sized boulders in the upper reaches are replaced by sand and silt. The forces of water flow and gravity compete to transport and deposit these materials in a predictable fashion. On a smaller scale, these same forces interact to deposit large objects in the fast flowing sections of the river and smaller particles in slow moving sections. So even in the upper reaches of the Mokelumne River, fine sand and sediment will collect in deep pools.

The nature of the stream bed, the type and size of rocks, shapes the conditions for life at the bottom of the river. During spawning, steelhead and salmon use their tails to shovel depressions in the river gravel. Eggs from the female and milt from the male are deposited, then the fish cover the depression and mound silt and gravel on the downstream edge. Coarser gravel is placed upstream, creating an environment enhancing the flow of water and oxygen over the eggs. This spawning site is called a *redd*. Each species of salmon prefers a range of substrate size, ranging from silt to cobble (tennis ball size) on which to form its redds.

In many large rivers of the Sierras, dams retard the movement of gravel downstream to salmon spawning areas. Consequently, the river's substrate has changed, and in some cases, the substrate is too large to be moved by salmon, preventing the formation of redds. To remedy the problem, agencies have imported gravel and added gravel back in to rivers downstream of dams. On the Mokelumne River, EBMUD added significant quantities of gravel to the river to improve the spawning habitat for Chinook salmon. Results were encouraging. Oxygen levels in the gravel increased, water temperatures decreased, and insect populations grew, and the salmon were using the new gravel for spawning.

To measure substrate, standard size categories have been developed by the California Department of Fish and Game. These substrate classes range from bedrock (larger than a car) to silt/clay/muck. Students will determine the size of the substrate along cross sections of the stream reach.

Embeddedness

Fine sediment from natural and man-made sources deposits amongst the rocks along the stream bed. Measuring how much sediment covers rocks can tell a good deal about the health of the stream, since this sediment can smother insects and eggs, and clog fish gills. Embeddedness is a measure of this sediment load. It is measured by picking up cobbles (tennis ball to basketball sized rocks) and observing how deep they were buried. Often a line between the shiny buried portion and the exposed portion is clear. Students will estimate the percent that is buried, or embedded. This can be tricky because of the irregular nature of rocks, but estimating areas and semi-quantitative analyses are important components of field monitoring techniques. Fish and Game biologists use the same measure to evaluate undesirable levels of sediment (e.g. >50% embeddedness) for streams that support steelhead trout.

Riparian Corridor and Canopy Cover

Streamside vegetation plays a critical role in stream health. Trees close enough to the creek provide shade, moderating temperature extremes in the water. Leaves falling from streamside plants are an important food source. Partially broken down by bacteria and then eaten by aquatic insects, leaf litter is at the base of the food chain. Furthermore, root masses along the bank edge can armor the bank preventing erosion. Banks undercut around trees can provide refuge for fish.

There are several measurements of riparian cover in the habitat assessment. The density (in percent cover), size and age classes (e.g. seedlings, saplings, mature trees) are assessed along the bank. The amount of shade is measured in the middle of the stream with a handheld device called a densitometer. It looks much like the small convex mirrors placed on car mirrors. It reflects the view of the sky, and the observer determines how much of the view is sky versus shade.

Before-the-Field-Trip Activities

Activity 1: Imagine the River
Time: One class period
Materials: KWL Chart (see page 2 in Introduction), Lecture Notes Student Worksheet and Answer Key, paper, pencils

1. Using a KWL chart, discuss what students know about streams. Much of their knowledge may focus on biological components, so guide them towards the nonliving aspects of a stream.
2. Have them imagine standing next to a stream in the high Sierras, or on the Highway 49 bridge over the Mokelumne, or next to the local creek. Should all rivers look the same? Do they perceive one river to be healthier than another?
3. Have students identify factors such as slope, flow, and stream substrate. How do they think these factors affect stream organisms?
4. Provide students with the background information on physical factors and how they affect stream health. Use the Lecture Notes Student Worksheet to help them take notes.

Activity 2: Stream Changes
Time: One class period
Materials: KWL Chart (see page 2 in Introduction), Environmental Assessment Student Worksheet Watershed Map (in Appendix A), paper, pencils, map of the watershed (large scale available from the STE Lending Library)

1. Ask students to play the role of aquatic scientists that have been asked to evaluate potential projects proposed for their community (see below). Remind students that scientists should state potential effects objectively. Their conclusions will be weighed by community decision-makers to determine whether the benefits of the project outweigh any negative environmental impacts.
2. Students should take notes on whether the project will have an impact and how significant they think it will be.
3. Model how to complete the Environmental Assessment Student Worksheet of a

gravel mining operation adjacent to Dry Creek. Gravel will be extracted from a large pit next to an existing creek. Because the mining will remove large amounts of gravel and dirt very near the creek, there will be less water flowing underground to the creek, so the flow is likely to decline. That effect could be significant depending on the size of the operation. Since there will be less groundwater and flow, expect the stream vegetation to decline, reducing shade and increasing temperature. With less flow, expect there will be fewer fast habitats like runs and riffles.

4. Show students the Watershed Map indicating the proposed projects.
5. Discuss in groups how the physical factors of a stream would be changed based on several scenarios. Make sure they look at stream width, depth, slope, diversity of habitats, amount of woody debris, substrate size, embeddedness, and riparian cover.

Potential Projects

- Flood Control—Every year vegetation is chopped down above road crossings so that high flows don't cause flooding by woody debris backing up at the bridges.
- Creek Channelization—To prevent flooding, the stream course is straightened. Banks are armored with rocks to prevent erosion.
- Log After a Fire—A catastrophic fire has destroyed the forest on both sides of a creek. There is a choice to log. What would be the effects of logging?
- Not Log After a Fire—What would be the effects of not logging?
- Raising the Level of a Dam—To increase capacity for a growing city, an existing dam will be raised and outflow from the dam will increase. What is the effect on upstream and downstream portions of dam?

Activity 3: Practice Field Techniques
Time: One class period
Materials: CDFG's Channel/Riparian Transect Form Student Worksheet, STE Team member as lecturer, STE Team will provide field equipment, paper, pencils, clipboards, digital photos of stream

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1. Invite an STE team member to demonstrate the field techniques to the class in preparation for the field trip.
2. Find an outdoor location on campus that has some slope and some trees. If possible locate an area where river rock has been used in landscaping. This area will be used to measure substrate size.
3. Students will work in teams to measure:
   - Stream width and depth along a transect using a tape measure and stadia rod
   - Substrate size
   - Embeddedness
   - Canopy cover using a densitometer
   - Stream slope using a clinometer

Activity 4: Measure the Complexity of Instream Habitat
Time: One Class Period
Materials: Channel/Riparian Transect Form Student Worksheet, paper, pencils, computer and screen to project digital photos, digital photos of stream and stream bank (provided by STE Team)

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1. Students will view several digital photos of streams to measure complexity of stream habitat.
2. Have students rate their estimates of habitat complexity and then discuss results. Discuss with students how these measures are more subjective than ones taken with field equipment. What could be done to decrease the rate of error? For example, they could overlay the photo on a grid, or they could use GIS to more accurately estimate areas. Discuss whether they think the increased accuracy would be worth the time and money required.
3. Students will view several digital photos of stream banks to measure riparian cover and human influence.
4. Students record information on their Channel/Riparian Transect Form Student Worksheet.

Activity 5: Create the Teams
Time: One-half class period
Materials: Transparency of CDFG's Channel/Riparian Transect Form Student Worksheet

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1. Prior to class, contact STE team member to set date for field activity.
2. Prior to class, contact local officials/property owners to gain access to field site.

3. Prior to the field trip discuss safety precautions around flowing water.
4. Students must be aware of their jobs for the day to run smoothly.
5. Assign teams. See Field Trip Activity
6. Record team assignments.

Field Trip Activity

Activity: Collect Stream Data
Time: Half a day
Materials: Field clothes, appropriate shoes, equipment, data sheets as for Before-the-Field-Trip Activity 2, pencils, clipboards

1. Discuss appropriate field trip behavior. Make sure students know their assignments and are dressed appropriately.
2. At the field location, divide class into different teams to collect data. Teams include:
   - Instream Teams (2)—measure stream, width, depth, substrate size, and embeddedness.
   - Densitometer Team (2 individuals)—record the densitometer meetings along transects provided by the Instream Team.
   - Habitat Complexity Team—measures instream habitat values.
   - Visual Riparian Team—measures the size and class of trees. (A good job for students who don't want to get wet.)
   - Human Influence Team—measures human influence. (A good quick job for students who do not want to get wet. This team could be the trash pick-up team, or the photo record team.)
   - Habitat Diversity Team—walks the length of the "reach" and measures number of riffles and lengths for each habitat type, and pools information to complete habitat assessment. Students should uniformly and accurately identify their locations.
   - Slope Team—Assign to the team who gets done first. This will probably be the Human Influence Team.

After-the- Field-Trip Activity

Activity: Stream Course Follow-up
Time: One class session and homework
Materials: Data from field trip

1. Discuss the results of the field trip. What did the students learn about the stream course?
2. The students should write a quick field report. It should include the parts of a scientific report based on accepted protocols—abstract, introduction, materials and methods, results, and discussion.
3. Guide the reporting process as needed for students and assign completion for homework. Remind students that the discussion section is the appropriate place to discuss possible follow-up investigations.

Source

"Bioassessment for Citizen Monitors." *A New Era for Water Quality.* Jim Harrington and Monique Born. 1999. Sustainable Land Stewardship International Institute.

"California Rivers and Streams." *The Conflict between Fluvial Process and Land Use*. Jeffrey F. Mount. 1995. University of California Press.

Resources

For the Teacher and Student

For *Updates on the Habitat Assessment* approved by California Department of Fish and Game, visit their web site at http://www.dfg.ca.gov/cabw/cabwhome.html.

For more information on fish and habitat assessment inventories visit CalFish at www.calfish.org.

For stream monitoring projects around the nation, read the *Volunteer Monitor* online at http://www.epa.gov/OWOW/monitoring/volunteer/vm_index.html.

"Bioassessment for Citizen Monitors." *A New Era for Water Quality*. by Jim Harrington and Monique Born. 1999. Sustainable Land Stewardship International Institute.

"California Rivers and Streams." *The Conflict between Fluvial Process and Land Use*. by Jeffrey F. Mount. 1995. University of California Press.

EBMUD's websites provide additional information on their Salmon Spawning Habitat Improvement Project. Go to their website www.ebmud.com and search for gravel enhancement project.

Name ______________________________ Date ______________

Lecture Notes

Student Worksheet

1. Perennial stream is ______________________________
2. An example of a perennial stream is the ______________________________
3. Ephemeral stream is ______________________________
4. An example of an ephemeral stream is the ______________________________
5. Why do ephemeral streams flow intermittently? ______________________________

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6. Draw a picture of what slope measures:

7. The instrument used to measure slope is called a ______________________________.
8. Fill out the following table using the words "deep" or "shallow," "slow" or "fast."

Habitat	Depth	Flow
Pools		
Runs		
Riffles		
Glides		

9. Why are riffles important to aquatic life?______________________________

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10. Why is gravel size important to salmon populations? ______________________________

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11. What human activity could increase silt in a stream? ______________________________
12. What human activity could increase substrate size in a stream? ______________________________

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13. Embeddedness is ______________________________
14. Why is embeddedness an important measure of stream health?______________________________

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15. How do riparian trees influence the health of a stream? ______________________________

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Lecture Notes

Answer Key

1. Perennial stream is *a stream that flows year around.*
2. An example of a perennial stream is the *Mokelumne River, Sacramento River, American River, Cosumnes River, etc. (Answers will vary)*
3. Ephemeral stream is *a stream that doesn't flow year around.*
4. An example of an ephemeral stream is the *Dry Creek, Jackson Creek, Sutter Creek, etc. (Answers will vary)*
5. Why do ephemeral streams flow intermittently? *They are fed primarily from low elevation watersheds that receive winter rain, but not snowmelt.*
6. Draw a picture of what slope measures. *Answers will vary.*
7. The instrument used to measure slope is called a *clinometer.*
8. Fill out the following table using the words "deep" or "shallow," "slow" or "fast."

Habitat	Depth	Flow
Pools	*deep*	*slow*
Runs	*deep*	*fast*
Riffles	*shallow*	*fast*
Glides	*shallow*	*slow*

9. Why are riffles important to aquatic life? *Riffles add oxygen to a creek which is essential for most aquatic organisms.*
10. Why is gravel size important to salmon populations? *Salmon construct their nests in specific-sized gravel beds. If gravel is too large, they can't move the stones. If gravel is too small or covered with silt, their eggs will not have sufficient oxygen to survive.*
11. What human activity could increase silt in a stream? *Erosion from construction, logging, mining, road-building.*
12. What human activity could increase substrate size in a stream? *Dams halt the downstream movement of gravel, so substrate size increases downstream of a dam.*
13. Embeddedness is *a measure of the silt surrounding the rocks in a stream.*
14. Why is embeddedness an important measure of stream health? *Embeddedness indicates the sediment load in a stream. Too much silt can harm benthic insects and fish eggs.*
15. How do riparian trees influence the health of a stream? *Tree litter is a source of food for aquatic insects. Roots stabilize banks and prevent erosion. Roots can also slow water, increasing physical habitat diversity. Tree canopy shades a stream reducing temperature extremes.*

Name Date

Environmental Assessment

Student Worksheet

Project Name ____________________

Project Location ____________________

Location description (Name the stream(s) that might be affected by the project.

Brief project description. What will the project do? ____________________

Potential Impacts. Describe the effect of the project on each factor, and give your best professional judgment on whether it is significant or not significant.

Stream width and depth ____________________

Stream slope ____________________

Habitat diversity (pools, riffles, runs, glides) ____________________

Stream substrate and substrate size ____________________

Amount of woody debris ____________________

Name ____ Date ________________

Environmental Assessment
(continued)

Embeddedness ____

Riparian Cover ____

Mitigation. For significant impacts, briefly describe ways the impacts may be reduced.

Stream width and depth ____

Stream slope ____

Habitat diversity (pools, riffles, runs, glides) ____

Stream substrate and substrate size ____

Amount of woody debris ____

Embeddedness ____

Riparian Cover ____

Name Date

Channel/Riparian Transect Form

Student Worksheet

Site Code:	Date: ____/____/ 20____	Transect:

Substrate Cross-Sectional Information

Dist LB XX.XXm		Depth XXXcm	Size Class Code	Cobble Embed. 0–100%*
Left				
LCtr				
Ctr				
RCtr				
Right				

Substrate Size Class Codes
RS = Bedrock (Smooth)—Larger Than a Car
RR = Bedrock (Rough)—Larger Than a Car
RC = Concrete/Asphalt
LB = Larger Boulder (1000 to 4000 mm)—Meter stick to Car
SB = Small Boulder (250 to 1000 mm)—Basketball to Meter stick
CB = Cobble (64 to 250 mm)—Tennis ball to Basketball
GC = Coarse Gravel (16 to 64 mm)—Marble to Tennis ball
GF = Fine Gravel (2 to 16 mm)—Ladybug to Marble
SA = Sand (0.06 to 2 mm)—Gritty up to Ladybug
FN = Silt/Clay/Muck—Not Gritty
HP = Hardpan—Firm Consolidated Fine Substrate
WD = Wood—Any Size
OT = Other (write comment below)
* Cobble Embeddedness on first 25 cobbles only.

Habitat Complexity

Cover in Channel Estimate channel features for the stream section 5m above and 5m below transect.	0 = Absent (0%) 1 = Sparse (<10%) 2 = Moderate (10–40%) 3 = Heavy (40–75%) 4 = Very Heavy (>75%)				Circle one
Filamentous Algae	0	1	2	3	4
Macrophytes	0	1	2	3	4
Woody Debris >0.3 m (Big)	0	1	2	3	4
Brush/Woody Debris <0.3 (Small)	0	1	2	3	4
Live Tree Roots	0	1	2	3	4
Overhanging Vegetation </= 1 m of surface	0	1	2	3	4
Undercut Banks	0	1	2	3	4
Boulders	0	1	2	3	4
Artificial Structures	0	1	2	3	4

Name Date

Channel/Riparian Transect Form
Student Worksheet (continued)

Densiometer (0–17 Max)	
Left Bank	
Center Up	
Center Down	
Right Bank	
Center Left*	
Center Right*	
*Center Left and Center Right Optional	

Visual Riparian Estimates	0 = Absent (0%) 1 = Sparse (<10%) 2 = Moderate (10–40%) 3 = Heavy (40–75%) 4 = Very Heavy (>75%) Circle one

Visual Riparian Estimates made 5m above and 5m below the transect and 10m to the side starting at the bank. Orientation is looking downstream.

Vegetation Cover	**Left Bank**					**Right Bank**				
Canopy (>5m High)										
BIG Trees (Trunk >0.3m DBH)	0	1	2	3	4	0	1	2	3	4
SMALL Trees (Trunk <0.3m DBH)	0	1	2	3	4	0	1	2	3	4
Understory (0.5 to 5m High)										
Woody Shrubs and Saplings	0	1	2	3	4	0	1	2	3	4
Non-Woody Herbs, Grasses,Forbs	0	1	2	3	4	0	1	2	3	4
Ground Cover (<0.5m High)										
Woody Shrubs and Saplings	0	1	2	3	4	0	1	2	3	4
Non-Woody Herbs, Grasses,Forbs	0	1	2	3	4	0	1	2	3	4
Barren, Bare Dirt or Duff	0	1	2	3	4	0	1	2	3	4

Comments:

Name Date

Channel/Riparian Transect Form

Student Worksheet (continued)

Human Influence	0 = Not Present B = On Bank C = Within 10m of Channel P = > 10m of Channel CH = Within Channel								
	Left Bank					**Right Bank**			
Wall/Dyke/Rip-rap/ Revetment/Dam	O	B	C	P	CH	O	B	C	P
Buildings	O	B	C	P	CH	O	B	C	P
Pavement/Cleared Lot	O	B	C	P	CH	O	B	C	P
Road/Railroad	O	B	C	P	CH	O	B	C	P
Pipes (Inlet/Outlet)	O	B	C	P	CH	O	B	C	P
Landfill/Trash	O	B	C	P	CH	O	B	C	P
Park/Lawn	O	B	C	P	CH	O	B	C	P
Row Crops	O	B	C	P	CH	O	B	C	P
Pasture/Range/Hayfield	O	B	C	P	CH	O	B	C	P
Logging Operations	O	B	C	P	CH	O	B	C	P
Mining Activity	O	B	C	P	CH	O	B	C	P

Inter-Transect Substrate Cross-Section Information			
Taken 7.5m above Transect			
Dist LB XX.XXm		**Size Class Code**	**Cobble Embed. 0–100%**
Left			
LCtr			
Ctr			
RCtr			
Right			

Comments: ____