AgriLIFE EXTENSION
Texas A&M System

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Current Events

Watching How Streams and Rivers Flow

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Acknowledgments

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The stream and river photographs were provided by Christopher Mathewson of Texas A&M University, except for the braided stream photo on flip chart page 6, which was taken by Greg O'Beirne.

These materials were produced through the North Central Texas Water Quality Project.

The Texas Water Resources Institute and Texas A&M Agriculture are collaborating with the Tarrant Regional Water District to study water quality protection and improvements in reservoirs. They are focusing on the major problems of sediment and nutrient loading. Sediment loading affects reservoir capacity and water clarity; nutrient loading results in algae growth that affects water treatment and recreational use.

Using the stream trailer model

The stream trailer model is used to demonstrate stream processes and best management practices to protect and restore our streams and rivers. This program was created to help youths and landowners understand how stream channels form, how vegetation contributes to stream-bank stability, and how proper stewardship can help prevent erosion.

To check out a stream trailer in the College Station area, contact Susan Levien at *s-levien@ag.tamu.edu* or 979.845.7451; in the Dallas area, contact Dorothy A. Woodson at *d-woodson@tamu.edu* or 972.952.9688

Towing requirements and safety tips

Insurance

Before picking up the stream trailer with a vehicle that is not owned by the Texas AgriLife Extension Service, ensure that your vehicle insurance company will cover the stream trailer in the case of an accident.

Safety tips for driving with a trailer

(Excerpt from "Towing a Trailer: Being Equipped for Safety" by the National Highway Traffic Safety Administration, April 2002, pp. 17–19)

Take time to practice before driving with a trailer on main roads. Never allow anyone to ride in or on the trailer. Before you leave, remember to check routes and restrictions on bridges and tunnels.

Consider the following safety tips each time you drive with a trailer.

General handling

- Use the driving gear that the manufacturer recommends for towing.
- Drive at moderate speeds. This will place less strain on your tow vehicle and trailer. Trailer instability (sway) is more likely to occur as speed increases.
- Avoid sudden stops and starts that can cause skidding, sliding, or jackknifing.
- Avoid sudden steering maneuvers that might create sway or undue side force on the trailer.
- Slow down when traveling over bumpy roads, railroad crossings, and ditches.
- Make wider turns at curves and corners. Because your trailer's wheels are closer to the inside of a turn than the wheels of your tow vehicle, they are more likely to hit or ride up over curbs.
- To control swaying caused by air pressure changes and wind buffeting when larger vehicles pass from either direction, release the accelerator pedal to slow down, and keep a firm grip on the steering wheel.

Braking

- Allow considerably more distance for stopping.
- Always anticipate the need to slow down. To reduce speed, shift to a lower gear and press the brakes lightly.

Acceleration and passing

- When passing a slower vehicle or changing lanes, signal well in advance and make sure to allow extra distance to clear the vehicle before you pull back into the lane.
- Pass on level terrain with plenty of clearance. Avoid passing on steep upgrades or downgrades.
- If necessary, downshift for improved acceleration or speed maintenance.
- When passing on narrow roads, be careful not to drive onto a soft shoulder. This could cause your trailer to jackknife or go out of control.

Downgrades and upgrades

- Downshift to help with braking on downgrades and to add power for climbing hills.
- On long downgrades, apply the brakes at intervals to keep your speed in check. Never leave the brakes on for extended periods, or they may overheat.
- Some tow vehicles have specifically calibrated transmission tow-modes. Be sure to use the tow-mode recommended by the manufacturer.

Backing up

- Put your hand at the bottom of the steering wheel. To turn left, move your hand left. To turn right, move your hand right. Back up slowly. Because

mirrors cannot provide all the visibility you may need when backing up, have someone outside the vehicle at the rear of the trailer to guide you whenever possible.
- Use slight movements of the steering wheel to adjust direction. Exaggerated movements will cause more movement of the trailer. If you have difficulty, pull forward and realign the tow vehicle and trailer and start again.

Parking

- Avoid parking on grades. If possible, have someone outside to guide you as you park. Once stopped but before shifting into Park, have someone place blocks on the downhill side of the trailer wheels. Apply the parking brake, shift into Park, and then remove your foot from the brake pedal. It is important to follow this parking sequence to make sure your vehicle does not become locked in Park because of the extra load on the transmission. For manual transmissions, apply the parking brake and then turn the vehicle off in either first or reverse gear.
- When uncoupling the trailer, place blocks at the front and rear of the trailer tires to make sure the trailer does not roll away when the coupling is released.
- An unbalanced load may cause the tongue to suddenly rotate upward; therefore, before uncoupling, place the jack stands under the rear of the trailer to prevent injury.

Steps to hooking up the stream trailer

1. Make sure the receiver hitch has a 2-inch ball.
2. Back up to the trailer, lining up the ball with the tongue of the trailer. If someone is available to be a spotter, allow him or her to guide you back to the trailer. Always keep the spotter in sight and never allow that person to get between your vehicle and the trailer while backing up.
3. **Remember to apply the parking break when you exit your vehicle.**
4. Raise the trailer tongue to a height of just over the ball by using the trailer jack.
5. Back the vehicle up so that the ball is directly under the trailer hitch (Don't pinch fingers!) (Fig. 1.)
6. Lower the trailer hitch onto the ball using the trailer jack.
7. Lock the hitch onto the ball by sliding the collar forward and placing the pin in place to secure it (Figs. 2 and 3).
8. Hook the safety chain up to the vehicle and make sure to cross the chains for safety (Fig. 4).
9. Make sure the jack stand for the trailer is in the upright position or all the way up (Fig. 5).
10. Hook up the light connections to the vehicle using the proper adapters as needed to match the trailer wiring with the vehicle wiring (Figs. 6 and 7). Verify that the lights are working properly after you have connected the wiring harness.
11. Remove the blocks from the tires and place them inside the trailer.
12. Check to make sure the rear jack stands are up (Fig. 8).
13. Use bungee cords to ensure that the tarp covering the trailer is attached securely to the trailer.
14. Check to make sure that all water is drained from the water reservoir.
15. Check the air pressure in all tires, including the spare tire, to make sure the tires are full of air (20 to 25 psi).

Figure 1. Align trailer hitch over ball on vehicle

Figure 2. Lower trailer hitch on ball

Figure 3. Collar moved into place to hold hitch

Figure 4. Safety chains in a crossing pattern

Figure 5. Jack in an up position

Figure 6. Standard light wiring harness

Figure 7. Light wiring harness adapter

Figure 8. Rear jack stands in an up position

Steps to park or unhook from the stream trailer

1. Find a level space to park the trailer.
2. Once the trailer is where you want it, place blocks on each side of one tire.
3. Lower the jack stand until it hits the ground (Fig. 9).
4. Release the safety chain.
5. Unplug the light wiring harness.
6. Remove the pin from the trailer hitch.
7. Lift the lever to unlock the collar.
8. Raise the trailer jack stand until the trailer hitch is just above the ball hitch.
9. Pull the vehicle forward away from the trailer.

Hookup checklist

Before leaving for the pickup or lesson site, ensure the success of your demonstration by making sure that:

- The trailer is ready for transportation to and use at the demonstration site.
- The 12-volt battery is charged to provide power to the pumps.
- The screen leading to the pumps is clean.
- A water source is available at the demonstration site to use for filling the reservoir. Do not transport the trailer with a full water reservoir.
- A water hose is available at the demonstration site to use for filling the water reservoir.
- The tires, including the spare, have the appropriate air pressure (20 to 25 psi).
- The trailer lights operate when connected to the vehicle.
- Safety chains are attached and crossed.

Stream trailer model setup

To set up the trailer for a stream demonstration:

1. Park the trailer in the appropriate location (level as possible).
2. Block the trailer wheels and then disconnect the trailer from the vehicle.
3. Drop the rear jack legs, and adjust until jacks touch the ground.
4. Adjust the side-to-side level using the rear jack legs and a small bubble level. The back of the trailer should be level from side to side.
5. Adjust the front-to-back slope using the front crank and a small bubble level. Once the trailer is level front to back, crank up the hitch jack about five turns from level.

Figure 9. Rear jack stand in a down position

Demonstration checklist

These items, which are located in a tool box under the trailer, are needed for a successful demonstration:

Item	Use	Lesson
Flip chart	Introduces each lesson with learning objectives; shows actual situations being modeled by the stream trailer	1, 2, 3, 4
Leveling board	Levels the grit in the trailer pan and creates different scenarios	1, 2, 3, 4
Small bubble level	Helps level the trailer from side to side and front to back	1, 2, 3, 4, Optional Exercises A, B
Scoop	Moves and molds the grit in the trailer to create different streambed scenarios	1, 2, 3, 4
Flexible measuring tape	Measures the length of the stream on the stream channel board	Optional Exercises A, B
Ruler	Measures the distance from top of the stream channel board to the bed of grit	Optional Exercises A, B
Stream channel board	A wooden board with three grooves that guide rolling marbles in a predetermined pattern	Optional Exercises A, B
3 marbles	Rolled down the stream channel board to demonstrate the effect of channel meandering on stream velocity	Optional Exercises A, B
Stopwatch	Measures the amount of time it takes the marbles to roll down the stream channel board	Optional Exercises A, B
Vegetation mats	Portions of a window screen with plastic plants attached that simulate vegetative land cover	2
"Junk Cars" sign	Labels the toy cars used as erosion deterrents	2
Flat rocks	Small river rocks that simulate the armoring of the stream banks	2, 3
Toy homes and cars	Simulate residential buildings and development	2, 3
Bucket of water	Simulate a large flood	3
Square concrete slabs	Simulates a concrete embankment	3
Jar containing soil and water	Shows the interaction of soil and water in streams and the effect that excess sediment can have on aquatic life	4
Jar of gravel	Simulates the pore spaces in gravel, at the bottom of streams	4
Silt fence	A portion of a window screen used to show how silt fences decrease erosion and sediment loading to streams	4
Toy construction equipment	Placed on the "crop site" showing how filter strips are used	4
Filter strip	A toy fence with window screening that is placed on the "crop site" showing how filter strips are used	4
Toy tractor and farm implements	Placed on the "crop site" showing how filter strips are used	4
"Filter Strip" sign	Labels the filter strip area on the crop	4
Small stakes	Hold the silt fence in place	4
Mid-channel bar	Simulates the accumulation of sediment in the middle of a stream	4

Rivers Don't Run Straight

Lesson 1

Objectives Understand how channel slope and water velocity (speed) relates to erosion potential in streams and rivers.
Understand why streams meander.

Materials
Flip chart
Leveling board
Scoop
Small bubble level
Flexible measuring tape
Stream channel board
3 marbles
Stopwatch

Optional Materials
Copies of the "Stream Channel Worksheet," one for each participant
Pens or pencils, one for each participant
Ruler
Small bubble level

Time
15 to 20 minutes
10 to 15 minutes (optional activity)

Stream trailer model preparation

1. Use the leveling board to smooth and level the grit, making it a constant depth throughout the upper three-fourths of the trailer pan. Leave one-fourth of the lower end (the back of the trailer) of the pan empty.
2. At the upper end of the pan, excavate a "reservoir" from near the water inlet to the center line of the pan- about one-quarter the width of the pan.
3. Use the leveling board to create a 1-inch-wide, 1-inch-deep groove on the midline of the grit bed. Make the slot deeper at the outlet end.

Smooth out the grit with a leveling board.

Reservoir created with a channel sloping down the trailer.

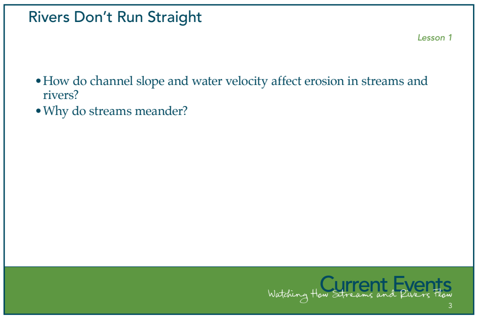
Presentation

Do
Show flip chart page 1.

Say
Hello, my name is ____________ and I work for _________________. Welcome to our program.

*Note: This would be a good time to acknowledge agencies and people who are cosponsoring this program.

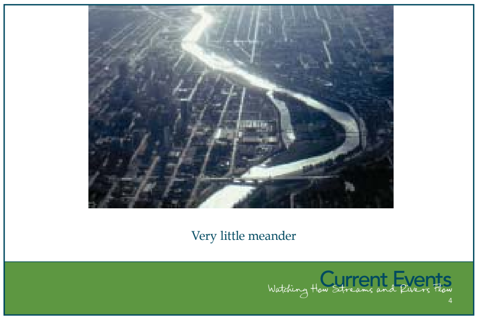
Do
Show flip chart page 3.



Say
Today we will discuss how the slope of a stream channel and the speed of the water, which is known as water velocity, affect erosion in streams and rivers.

We'll also discuss the reasons why streams are naturally crooked rather than straight.

Do
Show flip chart page 4.



Say
People who fly in airplanes often recognize that rivers and streams never run straight. Notice the little "wiggle" in this river? It has very little meander. Does anyone have an idea why?

Do
Allow time for the participants to answer.

Say
Keep thinking about it as we go and we will try and answer that question.

Do
Show flip chart page 5.

Typical meandering

Say
This river has a more typical meandering pattern. Over time, a bend has developed in the river. Notice the sand bar on the inside of the bend and the steep bank on the outside of the bend.

Do
Show flip chart page 6.

Many meanders: a braided stream

Say
This photo shows extreme meandering and many channels. This is called a braided stream. Some of the channels may be active only when a lot of water is flowing in the stream.

Do

Start the water flow in the stream trailer. Use one pump set at full flow to deliver the water to the channel.

Say

If the shortest distance between two points is a straight line, this stream should cut a straight path, right?

Let's watch what happens in the stream channel. After a few minutes ask, "Where is the water flowing the fastest: on the outside of the curve or the inside?

The water spreads out and then cuts unevenly to one side or the other. A clear meander is soon established.

Do

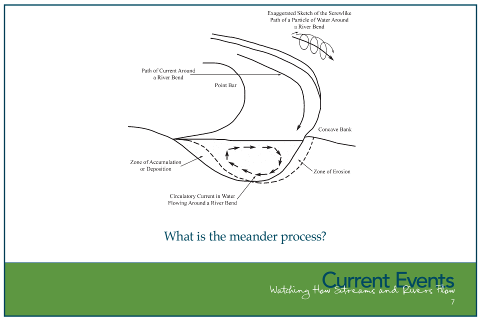
Sprinkle dry grit into the flow of water to show that the fastest flow is on the outside of the bend.

Say

The grit shows that the outside of the bend is where water flows fastest and cutting occurs. The inside is where the water moves more slowly and sediment is deposited, and the sediment starts forming a point bar.

Do

Show flip chart page 7.



Say

This drawing helps show why streams form bends instead of running straight. Why do rivers meander? One reason is that all the water in a stream does not flow at the same speed. Some parts flow faster than others.

As the water flows faster, it has more cutting power. When water flows a little faster on one side than the other, the water cuts—or erodes—the bank on that side.

In slower areas, the water deposits sediment, which builds up the bank. If you watch the model, you will see one side cut while the other builds up, forming a curve.

The process of erosion and deposition may change from one side of the creek to the other as banks collapse into the stream. This process might also be started by bedrock, boulders, or differences in the soil in the stream bed.

The outside of the bend is the cutting zone, and the inside is where sediment is deposited.

Look at the effect that a curved channel has on the flow of the water. When water flows around a bend, it starts to move in a spiral, flowing toward the inside of the bend and then back outward.

The cross section at the bottom of this drawing shows the circulation produced when some of the surface water flows toward the concave bank.

Let's see what happens when we speed up the water by increasing the slope.

Do

Crank up the front of the trailer by one turn to speed up the water flow. Point out the faster cutting of the outside curves or the streambed.

Say

Meanders are nature's way of overcoming the problem of water moving too fast and eroding the sides or bottom of the stream. When a channel meanders, it creates more stream bank to absorb the energy of the water. This reduces the slope of the channel, which slows the water flow.

Do

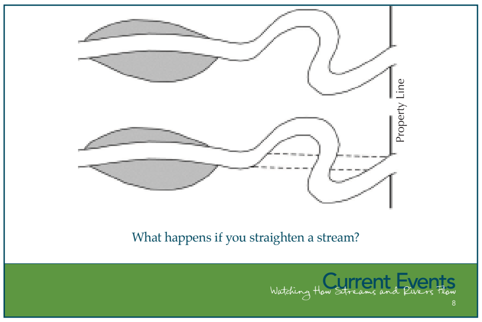
Reduce the trailer slope by cranking down the front of the trailer.

Say

Now that there is less slope in the stream, notice that the bank and bed cutting have been reduced.

Do

Show flip chart page 8.



Say

Mr. Jones owns some property with a creek running through it. He is worried about flooding on his land. He wants to move the floodwaters off his land more quickly.

What do you think will happen if he straightens the creek by cutting through this meander?

Do

Allow time for the responses.

Say

Let's see what happens in the model. I will make a meander in the stream and then cut through it. Watch closely to see what happens to the speed of the water, which is known as the water velocity.

Do

Form a meander in the stream and then cut through it. Use one pump set at full flow to deliver the water to the channel.

Cut through a bend to straighten the stream.

Say

Where does the water deposit sediment? Where is the bank being cut? How long do you think it will take for this new part of the stream to meander?

Do

Allow time for the participants to answer.

Conclusion

Cutting through a stream meander is a big mistake. It usually causes flooding and heavy erosion. River meanders are nature's way of slowing the water flow, which will help protect the flood plain from severe erosion problems. Flooding of cropland and housing developments can be alleviated by allowing for enough floodplain area along the banks of the river.

Optional Exercise A

For all ages

Materials Copies of the "Stream Channel Worksheet," one for each participant
Pens or pencils, one for each participant
Ruler
Small bubble level
Stopwatch

Time 10 to 15 minutes (optional activity)

The stream channel board has three grooves to show the difference in water flow in straight and curvy streams.

Do

1. Turn off the switch to the water pumps at the conclusion of Lesson 1.
2. Set the stream channel board in the trailer with one edge on the lip of trailer and other on the grit.
3. Increase the slope by placing a scoop or another object under the upper edge of the board.
4. At the lower end of the board, build small mound of grit for the marbles to hit.

Say

We will allow marbles to roll down the board on each of these grooves. Which marble will travel fastest and reach the bottom first—the ball in the straight groove, the slightly curved groove or the very curved groove?

Do

Allow time for the participants to answer.

Say

Which will have the most energy when it hits the grit?

Do

Pause to allow the participants to answer.

Set a marble in each groove at the top of the board. Use one of the signs as a starting gate to release all three marbles at same time.

Do

At 3, release the marbles.

Say

Now, give me a 1-2-3.

Say

Some landowners think a creek should drain floodwaters as quickly as possible. But this is actually not good. The fastest stream is harmful to the land because fast-moving water has more energy than does slow-moving water, and fast-moving water causes severe bank erosion. The more meanders a stream has, the less energy the water has for bank cutting.

The slope of the channel affects the speed of the water. We calculate slope as "rise divided by run"—the vertical distance from the highest point to the lowest point on the channel divided by the length of the channel.

Use a ruler to measure the height from top of the board to the bed of grit; this is called rise. Use the flexible tape measure to determine the length of the channel; this is called run.

Do

Allow time for the participants to take the measurements.

Say

To calculate the slope for each channel, divide the rise by the run.

Do

Allow time for the participants to make the calculations.

Say

Water flows more slowly in the meandering channel. Why?

Do

Allow time for the participants to answer.

Conclusion

It's similar to roads that switch back and forth in the mountains. The curves keep the car's brakes from being damaged. Meanders in the creek slow the flowing water, absorb the energy, and reduce bank cutting and erosion.

The stream trailer model shows us that with water, slow is good. We prefer slow rains, slow-flowing creeks and even slow floods because they all allow more water to soak into the ground, and they cause less soil erosion.

Optional Exercise B

For students in 11th and 12th grades

Materials Copies of the "Stream Channel Worksheet," one for each participant
Pens or pencils, one for each participant
Ruler
Small bubble level
Stopwatch

Time 20 to 30 minutes (optional activity)

Distribute a pencil and a copy of the "Stream Channel Worksheet" to each participant and lead them through the steps. The worksheet explores the effect of sinuosity on slope and provides a comparison of the erosion power of flowing water.

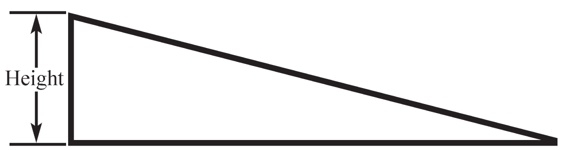
Follow steps 1 through 4 from Optional Exercise A, then release the marbles at the top of the stream channel board and have the participants record the times, distances and elevations to calculate slopes and velocities. Use the ruler and measuring tape in the box for Lesson 1.

Stream Channel Worksheet

Channel	*Height (inches)*	*Length (inches)*	*Slope (percent)*	*Time (seconds)*	*Velocity (inches/ second)*	*Relative Erosion Potential (velocity2)*
1: Gentle curves						
2: Straight						
3: Tight curves						

In the table above, write the answers to the following problems.

1. Measure the vertical height of the upper end of the board.



2. Measure length of each channel using flexible tape, string or a map wheel.
3. Calculate the slope. Slope = (Height ÷ Length) x 100.
4. With a stopwatch, measure the amount of time it takes for the ball to go from top of each channel to the bottom.
5. Calculate the velocity. Velocity = Length ÷ Time.
6. Calculate the relative erosion potential = Velocity x Velocity (erosion potential is related to the square of velocity).

Questions

1. Which slope is the steepest? ______________________
2. Which slope is the shallowest? ____________________
3. What three factors determine the velocity in each channel?__________________________________,

   ____ and _______________________________________.
4. If you straighten a channel, what will happen downstream? Why?

   ____

   ____

Stream Channel Worksheet

Extra credit

1. Sinuosity is the ratio of the actual channel length to the straight-line length from one end of the channel to the other. Calculate the sinuosity of each channel.

   Sinuosity = Actual channel length ÷ Straight-line length

   Sinuosity of Channel 1:____________________ **Sinuosity of Channel 2:**________________________

   Sinuosity of Channel 3:____________________

2. On a topographic map, you can calculate sinuosity as the ratio of average valley slope to average channel slope. How are these the same, and why?

   ____

   ____

   ____

   ____

Vegetation Protects Streams

Lesson 2

Objectives Understand the role and value of stream-side (riparian) vegetation.
Understand the effects of bank erosion on fish and other aquatic life in streams and rivers.

Materials Flip chart
Leveling board
Scoop
Small bubble level
Vegetation mats
Flat rocks
Toy homes and cars
"Junk Cars" sign

Time 15 to 20 minutes

Stream trailer setup

1. Use the leveling board to smooth and level the grit, making it a constant depth throughout three-fourths of the pan. Leave about one-fourth of the lower pan empty.
2. Set the slope of the trailer at eight turns above level, using the hitch jack.
3. Starting at one inlet, trace an S channel (two bends).
4. Using the scoop, excavate the channel all the way down to the pan.
5. Install the vegetation mats on one of the bends (you might ask the audience to tell you which one to protect with vegetation; it will work on either one). Place the lowest mat first and successively lap the mats as you work toward the inlet (higher) end of the trailer.

Trace an S-shaped channel.

Dig out the channel with a scoop.

Install the screen wire and insert the vegetation to hold both sides of the upper or lower bend.

6. At the upper end of the channel, scoop out enough grit to bury the leading edge of each mat and anchor the mat with a rock. Otherwise, the current will cut under the mat on the upper ends, especially on the outside of the channel. Note that some mats fit on the outside of the bend and others fit on the inside.
7. Sprinkle grit over the mats to make the wire screen less obvious.
8. Place one house on the outside of each bend to simulate desirable homesites overlooking the water.

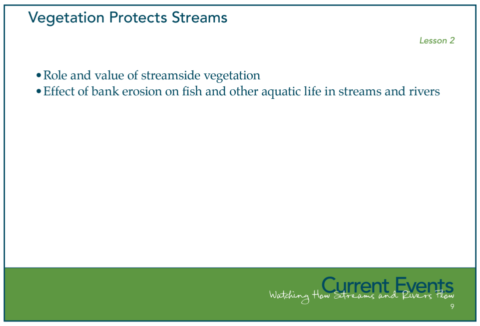
One home site has vegetation and the other does not.

Set one house near the stream with no vegetation.

Presentation

Do

Show flip chart page 9.



Say

Let's look at how plants growing along the stream bank affect erosion and wildlife.

Say

Two neighbors live along the same creek. One of the neighbors, Mr. Jones, has cut down all the trees and cleared the plants along his section of the stream.

Ms. Garcia, on the other hand, has left her land natural along the creek. Where would you rather live, on Mr. Jones's property or on Ms. Garcia's?

Do

Start one pump and open the valve to full flow.

Say

Look closely at Mr. Jones's property. See how the creek banks are beginning to be undercut? These banks do not have the deep root structure provided by trees and other vegetation to hold the banks in place. Too bad Mr. Jones did not leave the plants and trees in place as Ms. Garcia did.

Do

After significant bank cutting occurs, place toy cars along the creek to simulate a desperate attempt to stop the bank cutting. Place the "Junk Cars" sign near the cars. If you want the cars to be undercut faster, increase the water flow or crank up the hitch jack.

Do

Allow the cutting to continue until the bank collapse causes Mr. Jones's house to fall in the creek. If necessary, place rocks on the opposite side of the creek to focus the flow against Mr. Jones's bank.

Note: For a free-standing display, such as at a festival or fair, you do not need to rebuild the entire model when the house falls into the stream. Just rebuild the eroded bend and place one house on the site that previously collapsed. You could also impress the participants by moving the vegetation mats to the other bend and letting the previously stable bend erode.

Say

It is not a good idea to use junk cars or other homemade solutions to the problem of bank cutting. When water attacks the bank, the trash on the banks will become dislodged, turning into trash in the creek. Once it's in the creek, the trash may block the water flow, causing flooding and damaging the banks even more. If the junk cars deflect the flow of water, they will cause the banks to erode somewhere downstream.

Notice that Mr. Jones's part of the stream has become wider than Ms. Garcia's. When we started, they were both the same width.

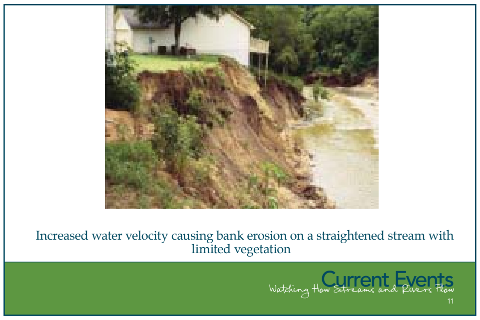
Mr. Jones has caused other problems in the creek as well. Now his part of the stream is shallower and there aren't any trees to shade the water, so it heats up. Game fish can no longer live or reproduce here because the water is too hot.

Do
Show flip chart page 10.

A cut bank developing on a stream channel

Say
Look at how much the stream has cut into this bank.

Do
Show flip chart page 11.



Increased water velocity causing bank erosion on a straightened stream with limited vegetation

Say
This serious erosion problem might have been prevented if more trees or brush had been left along the stream.

Do
Show flip chart page 12.

Vegetation on the stream bank helps stabilize the channel

Say
Here is an example of a stream that has vegetation on the banks.

If you clear the brush along a stream or let livestock graze too much along the creek banks, the banks become unstable. You need to preserve the plants' root structure by leaving the vegetation on the creek. The plants will help protect the banks against cutting.

Flooding is Natural

Lesson 3

Objectives Understand what a flood plain is and how it forms.
Understand how flood plains help with flood protection.
Understand the effect of new development on stream flows during rainfall.
Know how experts determine the predicted frequency and size of flooding events.

Materials Flip chart
Leveling board
Small bubble level
Flat rocks
Scoop
Toy homes and cars
Bucket

Optional materials Small concrete blocks

Time 15 to 20 minutes

The flat area alongside a creek or river is called a flood plain.

Stream trailer preparation

1. Fill the provided bucket about three-fourths full of water from the reservoir of the stream trailer.
2. Use the leveling board to move about three-fourths of the grit into a long "mountain" along one side of the trailer.
3. Create a large, flat bed of grit about half an inch deep in the center of the trailer. Use the excess grit to start making a smaller mountain on the other side of the trailer. Leave the space around the drain clear.
4. Use the hitch jack to set the front-to-back slope of the trailer at three turns above level.
5. Use the scoop to excavate a simple, arc-shaped channel from the inlet to the drain.
6. Form a steep-sloped mountain along one side of the creek and a flat flood plain on the other.
7. Set large flat rocks to anchor the larger mountain next to the water inlet. Shape the small mountain so that the flood waters can go nowhere but onto the flood plain.

Presentation

Say

You may have noticed that some areas along rivers and creeks are flat. These flat areas are formed over thousands of years by the natural flooding of the stream or by human activities in urban areas. The flat areas are called *flood plains.* A flood plain is the part of the river or creek that holds and absorbs the extra water during floods. How many of you have seen a flood plain near your home fill with water after a rainstorm?

Do

Allow time for the participants to answer.

Say

Most creeks and rivers come out of their banks every few years. But this overflow happens more often in cities than in the country. Why?

Do

Allow time for the participants to answer.

Say

The pavement in cities and suburbs cause more runoff and frequent floods. Natural and agricultural land absorb about 90 percent of rainwater, but land in urban areas absorbs less than 40 percent.

Do

Start a moderate flow of water to establish a natural channel.

Engulf the flood plain by increasing the flow for 5 to 10 seconds. You may try temporarily damming the water from the inlet by setting an obstacle in the stream path and then removing it to cause a mini-flood.

Say

In most rainstorms, the water stays inside the channel. But occasionally, there are periods of heavy rains that are above the average for that area. This causes water to rise above the channel banks and flow onto the flood plain.

Advanced lesson

Do

Continue the moderate flow of water through the stream channel.

Say

The average annual flow is the highest level of water that occurs about once every 1 or 2 years. From historical records, hydrologists, or water experts, can predict how often water will come out of the banks of a stream and onto the flood plain.

Larger flows occur less often. The 10-year stream flow occurs on average once in 10 years, and the 50-year flow (or flood) occurs on average once in 50 years. The 10-year flood is larger than the average annual flow, and the 50-year flood is bigger than the 10-year flood.

The 100-year flood occurs about once in 100 years. In any given year, that area has a 1 percent chance of having a 100-year flood. Accordingly, the 10-year flood has a 10 percent chance, and the 50-year flood has a 2 percent chance. A 100-year flood is slightly larger than a 50-year flood—not twice as large.

Some people mistakenly believe that their house is safe from flooding if it is located outside the 100-year flood plain shown on a local map. They think the area cannot flood. Such an area does have less than 1 percent chance of flooding. But flooding can occur wherever a drain or an outlet is blocked. Also, a small error in the maps could mean that the house is actually in the flood plain.

Do

Reduce the water flow to a minimum.

Say

A flood plain is part of the river: It helps reduce downstream damage by allowing the water to spread out and slow down.

Floodwater carries sediment. What happens to the sediment when the floodwater spreads out onto a flood plain?

Do

Allow time for the participants to answer.

Do

Place the toy houses on the flood plain.

Building on a flood plain is a bad idea.

Say

The water flows more slowly over the floodplain, which allows the sediments to deposit.

Say

Why do some people build houses on flood plains? Why have some whole towns been built on flood plains? Often, it is because the residents think that if an area has not flooded for a long time, it will never flood. But they are wrong!

Why is more flooding likely to occur after new parking lots are built in town?

Do

Allow time for the participants to answer.

Say

It's because rainwater does not seep into the pavement; instead, it runs off, which could cause flooding.

Why might an area flood if there is a road crossing or bridge downstream?

Do

Allow time for the participants to answer.

Say

Flooding can occur wherever debris or sediments block a stream.

Do

Increase the water flow to high, or dam and release the water to partially flood the houses.

Say

What can the residents do now? They invested a lot of money when they built their homes and neighborhood here. Maybe they would be able to rest easy if the government built a levee to prevent flooding here.

Do

Reduce the water flow to a minimum. Using your hands, create a levee on the edge of the flood plain.

Use the scoop to shape the levee; slide the scoop slowly along the line of the levee while tapping the scoop to compact the grit.

Place the square concrete slabs along the outside of the levee to simulate a concrete embankment.

Say

Can this levee hold up during the next big flood? Maybe or maybe not, depending on how much water flows and where the levee's weak spots are.

Do

Increase the water flow to the maximum. Also pour water from the bucket into the stream until the levee fails.

Say

Levees are not the solution to the problem of flooding. Large floods will still occur, and they could weaken or spill over the levees. Sometimes the authorities breach levees on purpose to prevent flooding in other areas.

If a river cannot use its flood plain to hold or absorb the floodwater, downstream areas will be flooded more. Another drawback to levees and dikes is that they are expensive to build and maintain.

Do
Show flip chart page 14.

What is a flood plain?

Say
What is a flood plain?

Do
Allow time for the response.

Say
As we mentioned earlier, a flood plain is a flat area near a creek or river that carries the extra storm water during floods.

Do
Show flip chart page 15.

A floodway along a stream with man-made levees and dikes defining the flood plain

Say
This photograph shows a floodway along a stream. The man-made levees and dikes define the flood plain.

Do
Show flip chart page 16.

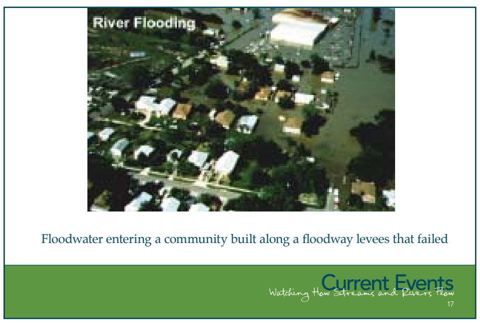
A defined floodway carrying flood water; levees can fail or make floods worse downstream

Say
Why do people build in a flood plain?

Do
Allow time for the participants to answer.

Say
People who build in a flood plain either do not know that the area is likely to flood or they think they are safe from flooding.

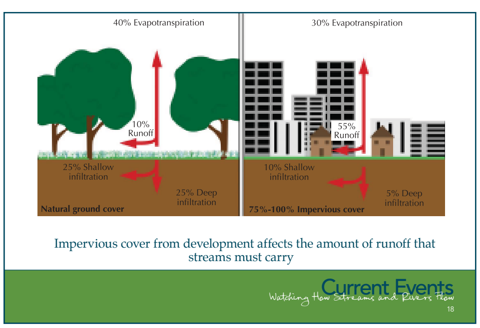
Do
Show flip chart page 17.



Say
But levees can fail or make floods worse downstream. People who live in a flood plain should consider buying flood insurance. But in the long run, we'll all be better off if we don't build houses in flood plains.

Sometimes flood plains can be used for parks, athletic fields and other uses that will not endanger lives or be damaged by flooding. Athletic fields damaged by floods are less costly to restore than are homes and businesses.

Do
Show flip chart page 18.



Say
Impervious cover includes the roads, buildings and parking lots built on the land. These drawings show how impervious cover affects water runoff. As a watershed has more impervious cover, the amount of surface runoff also increases.

According to the U.S. Environmental Protection Agency, water problems can be caused by as little as 10 percent of impervious cover in a watershed.

Conclusion
People need to know where the 100-year flood plain is in their communities. Do you know where it is in your city? If you do not live in the 100-year flood plain, are you completely safe from flooding?

Will the flood plain change if a levee is built upstream from you? Downstream? What if new parking lots and streets are built? These are important factors to consider when you are deciding where to live or how your area should be developed.

Sediment: Too Much is Harmful

Lesson 4

Objective: Be able to explain what sediment is.
Understand how vegetation affects the amount of sediment in streams and rivers.
Understand how the sediment in streams and rivers affects aquatic life.

Materials: Flip chart
Leveling board
Small bubble level
Scoop
Jar with soil and water
Jar with gravel
Silt fence
Toy construction equipment
Filter strips
Toy tractor and farm equipment

Time 10 to 15 minutes

Stream trailer preparation

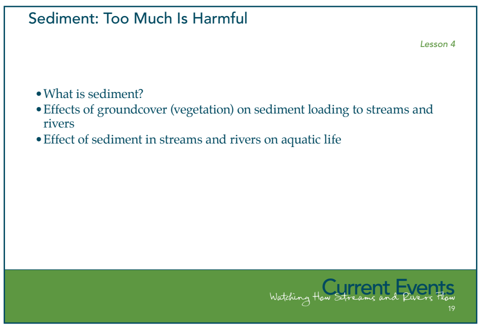
1. Create an S channel with two bends as in Lesson 2, "Vegetation: It's Doing a Job."
2. Dig out the channel with a scoop.

Trace an S-shaped channel.
Dig out the channel with a scoop.

Presentation

Do

Show flip chart page 19.



Say

Let's look at what sediment is and how it affects our streams and rivers. We'll talk about how plants and trees along the bank affect the amount of sediment in streams. We'll also discuss the effects that sediment has on the living things in the stream.

Do

Show flip chart page 20.

Say

Sediment is soil or rock material that is carried or deposited by water. A particle of sediment can vary in size from tiny clay particles—too small to see—to rocks as big as a house. Water must be flowing very fast to carry large sediment particles such as boulders.

Sediment is the primary pollutant of our surface water. Surface water is water that collects on the ground or in a creek, river, lake, wetland, or ocean. If there's too much sediment in the water, it can smother the aquatic organisms that fish eat. Sediment also makes rivers and lakes muddy.

Do

Start a moderate flow of water in the stream trailer.

Say

Look at the particles being carried along by the water. Notice that some of the sediment is being deposited in point bars, and deltas are beginning to form.

How far does the sediment usually move? Do all the particles just follow the flow all the way from one end of the pan to the other?

Do

Allow time for the participants to answer.

Say

Sediment particles usually do not all flow to the end of a stream. They usually are captured in a point bar or elsewhere for a while.

Do

Shake up the jar of water, sand, and silt. Hold it still to let the sand and silt settle.

Jar of soil and water.

Say

When sediment is carried by water, it usually settles out according to the particle size, just as it does in this jar. The bigger particles settle first.

Can you identify which particles are the sand, silt and clay? Which type of particle settles first?

Do

Allow time for the participants to answer.

Say

Sand particles are the largest particles of soil, so they settle to the bottom first. Silt is smaller; these particles settle very slowly. The smallest particles are clay, which takes the longest to settle.

How long does it take for each to settle to the bottom?

Do

Pause to allow the participants to respond.

Say

How far does flowing water move sand? How about silt? Clay?

Do

Allow time for the participants to answer.

Say

The finer clay can move all the way to a lake. If the lake gets too much clay, the lake becomes ugly and less productive. Silt and sand take longer to travel. But they can clog streams and rivers.

Do

Show flip chart page 21.

Say

The main source of sediment is bare soil from the watershed. When a lawn does not have plants, rain pounds on the soil.

The impact of a rain shower on the soil is like millions of tiny explosions per acre. Each raindrop blasts the loose soil particles and washes them into nearby streams.

Do

Show flip chart page 22.

Say

Just as in cities, range and pasture sites need proper vegetation cover to limit erosion.

Do

Show flip chart page 23.

Say

When too much soil erodes into streams, the sediment smothers the aquatic insects and other animals that fish need for food. It also smothers fish eggs and newly hatched fish.

Some fish that are popular for people to catch include white bass and smallmouth bass. These fish must live in clear streams to be able to spawn. When streams are clogged with sediment, there are fewer fish to catch.

Do

Show the jar of gravel.

Do

Place the toy construction equipment on the upland area of the trailer, and surround it with the silt fence. Install the fence along the contour. Be sure to bury the bottom of the fence to prevent the sediment from going under it.

Installing a silt fence.

Do

Show flip chart page 24.

Do

Set the tractor and farm implements on a different site in the trailer and place the filter strips on the downhill sides of the "crop field." Place the "Filter Strip" sign nearby.

Say

Creeks that have rocky bottoms are great places for insects and newly hatched fish to live, because they can hide and find shelter in the spaces between rocks and gravel. But if sediment fills these spaces, it's good-bye to good fishing.

Say

At building and road construction sites, silt fences are installed along the downhill side to slow down the water running and trap sediment.

Do
Show flip chart page 25.

Say
You can prevent sediment from moving out of plowed fields into the creek by using filter strips. The strips of grass along the edge of this field capture the sediment. The grass slows down the water runoff and allows the sediment to settle out.

What happens if too much sediment settles in the filter strip?

Do
Pause to allow the participants to respond.

Say
If too much sediment gets into the filter strip, water cannot flow through it. The strip will divert the flow of water, which will cause erosion in another direction. We use this example scenario to highlight the need for maintenance in all management practices. For example, a filter strip that has performed its job of collecting sediment needs to be maintained. Because it is full of soil, the soil needs to be collected and carried back to the field, which will reestablish the strip a functioning filter strip.

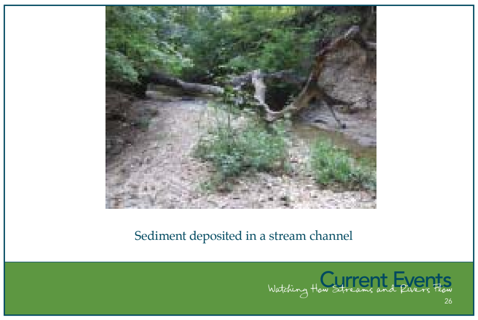
Say
What if too much water flows from the field into the filter strip?

Do
Pause to allow the participants to respond.

Say
If too much water flows across the filter strip, the strip will erode.

Do

Show flip chart page 26.



Say

When there is too much sediment in the stream, the sediment settles out in the channel. This happens when there is erosion occurring somewhere in the watershed. In what part of the stream will the sediment settle out?

Do

Pause for the participants' responses.

Say

On the inside of a bend in a stream, the flow is slower than at the outside of the bend. Settling occurs on the inside first. It may also occur directly upstream of any obstruction in the stream, such as at a bridge, a culvert or a dead tree.

Sometimes a stream contains a lot of extra sediment because of erosion problems upstream or in the watershed. When that happens, the sediment settles in the middle of the stream. This forms mid-channel bars and even islands. Any obstruction in the channel will cause the development of a mid-channel bar.

Mid-channel bars are a sign that too much sediment is entering the stream.

Do

Place a mound of grit in the middle of the stream to serve as a mid-channel bar. This works best if the streambed is bare or nearly so.

A mid-channel bar in a stream.

Say

Notice what happens to the banks around the mid-channel bar. The bar directs the water against the banks. This causes the banks to erode more. Anytime there is a mid-channel bar, it is a sign that too much sediment is entering the stream.

Any obstruction, including mid-channel bars, will cause the banks to erode.

Conclusion

Bulldozers and farm tractors are powerful tools. People need to use them with care to keep sediment out of streams. Otherwise, we can say goodbye to good fishing and hello to serious bank erosion.

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#M, New

Natural Stream Restoration and Enhancement

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Introduction

Streams change over time, both naturally and from human interference. Changes can alter the natural balance of the stream corridor, resulting in reduced water quality, wildlife habitat and increased erosion. When streams are restored to a more natural state, these detrimental effects can be reversed, or at a minimum their negative impact reduced. Stream corridors can be restored in several different ways, but the most beneficial to the environment is natural stream restoration. Natural stream restoration is a multi-step process in which objectives are defined, the stream is assessed, the best course of action is determined, and restoration design and construction occurs. Following this process while incorporating natural materials and native vegetation into the design will help bring the essential services of the stream back in balance.

This Fact Sheet will describe the make-up of a stream corridor, common conventional stabilization techniques, the natural stream restoration and enhancement process with specifics of the design component, and an example of natural stream restoration in Oklahoma. See the glossary at the end for definitions of the words in bold.

Stream Corridor Properties

The stream corridor consists of the carved out **channel bottom** that contains flowing water at least part of the time, the **floodplain** and the **transitional upland fringe** (Figure 1). The water level and **velocity** will vary as a result of slope, rainfall and snowmelt. An increase in the amount of water can exceed the carrying capacity of the channel and results in water spilling onto the floodplain. The transitional upland fringe is a higher elevation area that separates the floodplain from the surrounding landscape.

Trees and vegetation play an important role in the stream corridor and offer many services to the stream **ecosystem**. Trees and their roots help stabilize the bank, reduce erosion and provided needed shade; vegetation serves as a filter for pollution and sediments carried into the stream. The stream corridor also provides essential habitat to both aquatic and terrestrial species. Woody debris in the stream provides a place for **macroinvertebrates** to feed, which in turn serve as a food source for many fish species. Small pools in the channel bottom and rocky formations serve as breeding grounds for fish. The floodplain and upland area provide forage and

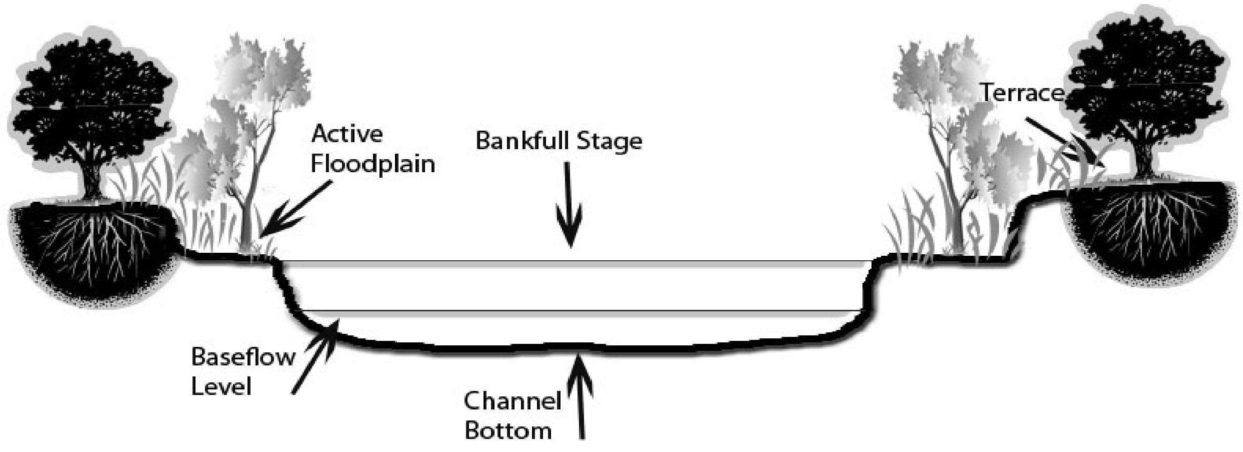

Figure 1. Cross-section of stream corridor with major components labeled.

habitat for mammals and reptiles. Streams provide many benefits to humans as well — recreational opportunities and add aesthetic value to the landscape. Good fish habitat will bring out the anglers; sufficient flow and cool, inviting water means canoes and rafts will abound. A healthy riparian area with trees for shade can serve as campground or picnic areas. All of this together provides an economic benefit to the communities along the corridor.

For more information on streams and their functions see Extension Fact Sheet NREM-9208 *Understanding Streams.*

Stream Corridor Degradation

While humans derive many benefits from a stream corridor, they can also be the major cause of a corridor's degradation. Human impacts to the stream corridor include land development for both urban and agriculture use. Clearing the **riparian** area allows more pollutants to flow into a stream from either manicured and well fertilized lawns or plowed fields. Allowing cattle access to the stream for water can degrade the stream bank, loosen soil and increase bank erosion. Use of concrete and asphalt on the landscape increases runoff into the stream rather than seepage into the ground. This increases the amount of debris and pollutants flowing into a stream. Improper grading of dirt roads and lack of vegetation in the ditches allow more sediment to flow into a stream, increasing the **turbidity** (cloudiness) of the water. An increase in the amount of nutrients entering a stream can increase algae growth, which in turn can decrease the amount of oxygen in the water and the variety of organisms the stream can support. The introduction of non-native plant species can cause native species to die off and limit natural food and habitat for the areas wildlife. They can also increase bank instability if their root systems are not deep or sturdy enough to help stabilize a bank. All of these issues decrease the value of the stream corridor. Figure 2 is an example of bank erosion and land loss on the Illinois River.

However, not all changes to a stream are caused by human interaction. A stream naturally changes with time. Sediment gets washed in and the stream channel reshaped. The difference between natural changes to a stream and those caused as a result of human interference is the time span of the change and the ability of the stream system to adapt to the changes. Since streams are normally in a state of **dynamic equilibrium,** the stream is able to rebalance itself as these changes occur.

Figure 2. An example of bank erosion and land loss on the Illinois River.

One of the biggest problems resulting from the degradation of the stream corridor is the increased amount of **sediment** going into a stream system. The sediment can be large or small and will either continue to flow downstream or settle into the stream bed. Sedimentation is the number one water quality issue in the U.S. Oklahoma has more than 4,012 stream miles of impaired waters based on turbidity and 151 miles are impaired due to sedimentation/siltation.

Once soil or other solid material enters a stream, it often becomes suspended in the water. The material is referred to as suspended sediments or solids and causes the water to be turbid. **Sedimentation** occurs when the solids begin to settle out of the water to the stream bed, changing the level of the stream bed. What does not settle out in the stream will ultimately settle in the water body the stream feeds, resulting in faster siltation of lakes, thereby reducing the lakes' holding capacity.

Water Velocity and Sedimentation

The velocity and type of sediment will determine what the sediment does. As the velocity of the water increases, so does the ability of the stream to carry sediments. Once the water slows, heavier sediments settle out of the water and drops to the stream bed. With time, this can change the form of the bed and the biological makeup of the stream. Figure 3 shows the slope of a stream and the pools and **riffles** that form in the deep and shallow areas of the bed. As the velocity increases, more sediment is pulled into the water and carried downstream. As the velocity decreases, the amount of sedimentation increases.

One way sediment enters a stream is from bank erosion. This can result in large amounts of soil, rock and other debris either falling or being washed into a stream. Bank erosion happens when changes occur to the bank's slope from raising or lowering the stream bed, redirection of stream flow around obstructions in the channel, or from removal of stabilizing vegetation. Often the bank becomes more vertical and loses almost all vegetation, resulting in destabilization.

Bank erosion happens in two ways, bank scour and mass failure. Bank scour occurs when the speed of the water and its erosive power increases along the bank, removing bank

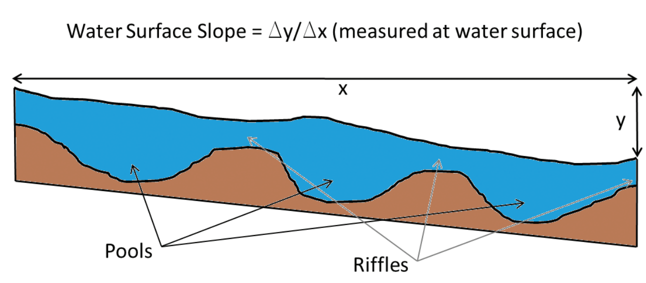

Figure 3. Longitudinal view of stream slope and bed with pools and riffle.

Figure 4. A tree toppling into a river is a sign of a mass bank failure.

material. Mass failures occur when large chunks of the bank collapse into the stream. Figure 4 shows a mass failure, resulting in a tree and section of land toppling into a river.

To mitigate some of these issues, several techniques have been developed to stabilize banks, reduce erosion and mitigate the effects of flooding.

Common Conventional Stream Stabilization Techniques

Some commonly used stream stabilization techniques include lining channels with concrete, stabilizing the bank with riprap (graded stone or crushed rock) and the use of gabions (metal cages that hold stabilization material in place). Tires and broken concrete have also been used as a rip rap material along a stream bank. The benefits of using rip rap to stabilize banks include relatively low costs, simple construction and ease of repair. Vegetation planted between the rocks provides increased stability and wildlife habitat. Rip rap can help decrease sediment loads and improve water quality. However, it does have limitations. The addition of rip rap can harm an area that has a healthy riparian vegetative community and habitat that includes shade, some stable undercut banks and large woody debris. It can alter the habitat, negatively impacting the flora and fauna. In addition, rip rap is not aesthetically pleasing.

Lining a stream channel with concrete is another method used to manage water flow and stabilize banks. Many cities across the U.S. use these channels to move stormwater quickly away from developed areas to help reduce flooding. This method is effective; however, it too has limitations, and while solving one problem, may create another. Everything that is washed into these channels is carried to the stream, lake or ocean that serves as its outlet, increasing water pollution. Since these channels are impervious, water cannot seep into the ground. They are often not aesthetically pleasing and limit the amount of wildlife in the area, as they typically have water in them for only a short time after a storm event. See Figure 5 for examples of common conventional stream

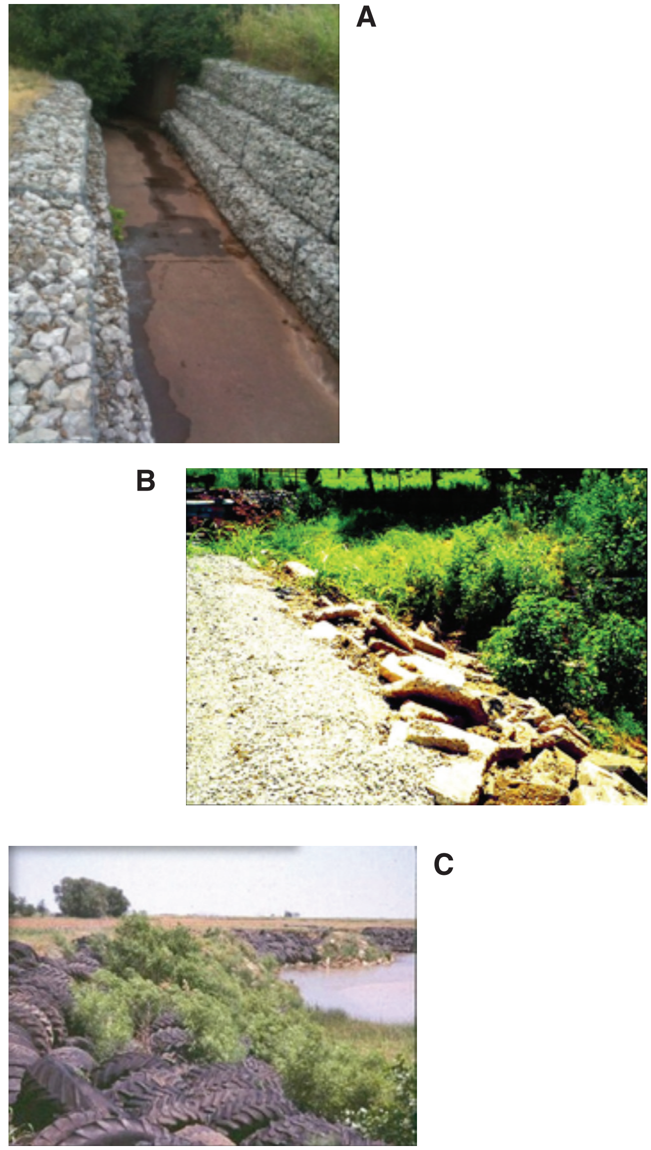

Figure 5. Concrete channel lined with riprap held in place with gabions in Stillwater, OK (A). Tire riprap along the Red River and concrete chunk riprap (B and C).

stabilization techniques. While these techniques can reduce bank erosion and move water rapidly out of a localized area, they are not always beneficial to the environment and reduce the natural beauty of an area. Their use can actually increase water quality problems rather than decrease them.

Natural Stream Restoration Process

Natural stream restoration techniques can improve water quality, enhance aesthetic value, improve wildlife habitat and enhance floodplain function. A successful natural stream restoration project requires following a multi-step process to ensure thorough consideration is given to the planning and design stage before any work in the stream corridor occurs. The first step is to define the objectives. These may vary, but commonly are a combination of goals including; flood control, improving recreation, improving habitat, or reducing bank erosion. Once the objectives are determined, the current condition of the stream should be assessed. The assessment step involves noting any downcutting or widening; the amount, type, and condition of bank vegetation; changes in the watershed upstream; or features downstream that are constricting flow. Defining the goal and assessing the stream are two essential steps of the natural stream restoration process to provide the foundation for decision making during the final two steps.

The third step is determining the best course of action. Not all restoration work requires extensive manual labor or costly construction. A potential solution is to allow the stream to fix itself. This option may include doing nothing or removing stressors such as livestock or mowed stream banks. Fencing cattle away from the stream or developing a grazing plan allows vegetation to stabilize the banks and restore balance. Allowing the vegetation near the bank to grow wild instead of mowing it short will increase bank stability. A buffer between mowed areas and the stream can achieve this. If the minimal course of action is not enough, then a re-vegetation plan should be considered. A re-vegetation plan should include a list of native plants to be used, planting locations and timeline, and a monitoring and maintenance strategy. When leaving the stream alone or adding vegetation is not enough to achieve the objectives, then the stream needs to be redesigned and construction should occur.

The stream restoration design and construction involves reshaping the stream channel and floodplain, building in-stream structures, and protecting the bank. Dirt and rock are moved to reshape the channel to a natural form that includes a connected floodplain and adding an appropriate amount of meanders (a bend in the stream) and stream features such as riffles and pools. Invasive vegetation is removed during the dirt and rock stage. An example of a reshaped bank with invasive vegetation removed is presented in Figure 6.

In-stream structures include various types of rock vanes and toe wood. Each of these techniques not only relieves stress on the banks, but creates scour pools for habitat enhancement. Rock vanes are in-stream structures that stabilize the stream slope to prevent erosion caused by downcutting and widening. They also shift the flow of water away from the bank to the center of the stream, where a scour pool is developed that dissipates energy and provides fish habitat. Several variations of rock vanes exist; examples include constructed rock riffles, cross-vanes, and J-hooks. Constructed rock riffles are diagonally placed rocks that go less than halfway into the stream, while a Cross-Vane extends from bank to bank (Figure 7). They can also be designed as a J-Hook which is a rock structure built in the shape of a J (Figure 8). The material used in the hook portion is spaced apart to allow sediment to flow through and can increase the enjoyment of recreational boaters in larger streams by creating or enhancing riffles. Each technique provides a slightly different benefit and can work together down the stream channel to repair the corridor to its natural state.

Figure 6. A bank that has been re-sloped. Vegetation will be added once construction is complete.

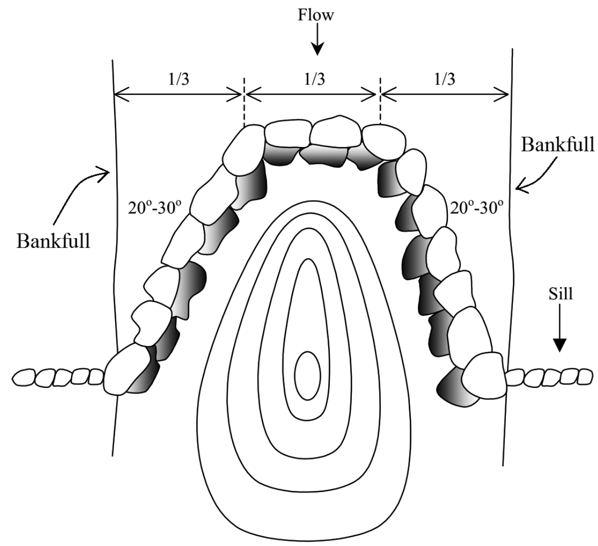

Figure 7. Constructed rock riffle and rock cross-vane.

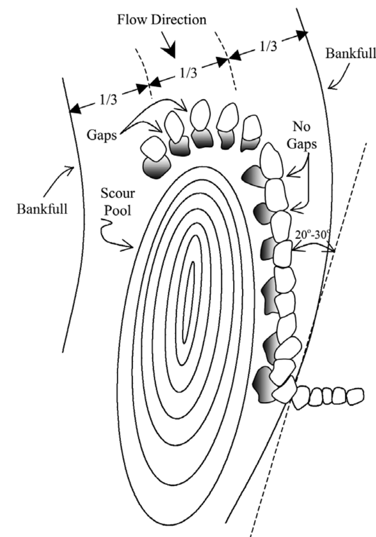

Figure 8. J-hook rock vane.

Placing a rootwad or bundles of woody vegetation at the toe of a bank, also called toe wood, is another way natural materials enhance aquatic habitat and reduce stream bank erosion. A rootwad consists of a tree's root mass and 10 to 15 feet of trunk. Its purpose is to create habitat and serve as a barrier between the stream bank and the stream flow. Several rootwads can be used together and are often placed on the outside bend of a meander. Rootwads are installed with the trunk portion entrenched in the stream bank with the root ball exposed to the stream. The trunk is anchored in place using large boulders and soil. Vegetation is added on top of the structure for erosion protection and habitat. The root ball serves as fish habitat and mimics natural root scouring that occurs in a stream. They can be used when stream bank sloping is not an option, typically on vertical banks. The tree in Figure 4 can be used to help stabilize the bank it fell from by using a portion of the trunk and the rootwad.

Immediately following construction, temporary bank protection is installed. This may include coir matting and short-term fast-growing plants. Banks and floodplain are then re-vegetated with native plants. Vegetation in the floodplain slows water during flooding events and protects the soil from erosion. The added vegetation reduces the amount of pollutants flowing into the stream and serves to provide essential habitat both to aquatic and terrestrial species. Trees along the bank provide shade which can keep the water temperature at a healthy level for aquatic organisms. The vegetation also provides a food source from plant debris and falling insects for the aquatic community of the stream.

Each of these methods uses natural materials, some of which can be found within or close to the stream corridor itself. The cost of doing natural stream restoration may be higher than conventional methods, even though materials may be easily obtained. One of the issues with cost is that these techniques are not in widespread use, and there are a limited number of companies with the needed expertise to design and construct natural stream restoration projects. However, those increased costs should be balanced with the benefits to the natural and human communities within the corridor, and beyond. Decrease in sedimentation and other pollutants in the stream will result in lower costs of drinking water treatment. By adding aesthetic and recreational value, an increase in tourism can impact the economy of the entire region by creating jobs and bringing in tax dollars from out of state. Decreased pollution, coupled with increased economic benefit can reach beyond the corridor and have a long-term impact that can outweigh the initial costs.

Safety in Design and Construction

To ensure a restoration project is successful, both in achieving the projects goals and ensuring the safety of users, the combination of an experienced design, and construction team should be a requirement. Flowing water in streams, especially during flooding events, can be dangerous; therefore, the design of structures and streambank slopes should consider the safety of the users. Extremely steep banks should be avoided when possible and in-stream structures must be properly designed and installed to remain stable during flood events. Additionally, if a stream or river has heavy recreational use, an appropriate plan should be put in place to ensure the public does not enter the restoration area during construction.

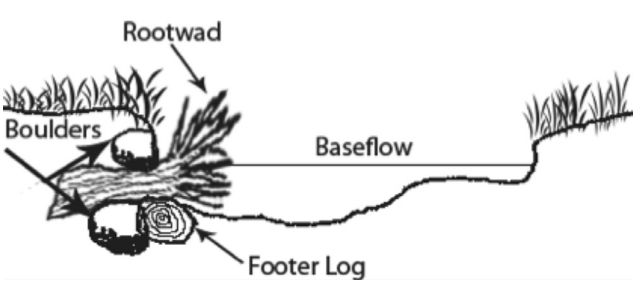

Figure 9. Stream cross-section with rootwad.

Permitting Requirements

Before any restoration project begins, it is important that the responsible party ensures all required permits are approved. This can include permits from the U.S. Army Corps of Engineers, the state's environmental protection agency, the U.S. Fish and Wildlife, and any other state agency that may have requirements. It is important to research what information and permits are needed in the state where work is being proposed. Section 404 of the Clean Water Act requires a permit to be obtained from the U.S. Army Corps of Engineers if any dredge or fill material is discharged into the waters of the U.S. Since stream restoration involves adding or removing material and can result in material being discharged into the stream or an alteration of the waters, a Section 404 permit is required.

The U.S. Army Corps of Engineers has two different permits: Nationwide Permits (NWPs) and Individual Permits. The purpose of the NWPs is to allow regulation of a general permit for projects that will have minimal impacts with little, if any delay or paperwork. The most common NWPs for stream restoration activities include the NW 13 – Bank Stabilization which allows up to 500 linear feet of bank to be repaired under the NWPs, though a waiver can be obtained for slightly longer areas. The other is NW 27 – Aquatic Habitat Restoration, Establishment, and Enhancement Activities, which includes activities that restore and enhance non-tidal streams.

Individual Permits apply to those projects that exceed the limits and thresholds of NWPs. The review process for Individual Permits is more extensive and requires additional details on the project. Public notice is required on an individual application to allow the public the opportunity to comment on the project and scope of work. The applicant is given the opportunity to respond and that response can be used in the review of the application. For additional information on Section 404 permits visit http://www.usace.army.mil/CECW/Pages/cecwo_reg.aspx and select a state.

In Oklahoma, the Oklahoma Department of Environmental Quality (DEQ) requires a Section 401 water quality certification if an individual Section 404 permit is required. Certification requirements include a written statement clearly stating that a 401 water quality certification is being requested; a copy of the corresponding federal permit application or license; copies of any draft federal permit or license if available; copies of plans, studies, drawings, maps, environmental impact assessment and information regarding endangered, rare or threatened species; project location legal description; description of potentially affected surface water, groundwater or natural resource; if a federal entity requires a mitigation plan, then a copy must be included and a $100 application fee. Other information may be required by the DEQ. A complete list of all requirements can be found on at www.deq.state.ok.us under their rules at Subchapter 3 Sections 252:611-3-1 through 252:611-3-6.

Monitoring

To determine the success of the stream restoration project, monitoring must be done. This should be done in two stages, pre- and post-construction. One indicator of the health of a stream is the macroinvertebrate population. Some macroinvertebrate species are considered sensitive, while others are more tolerant to changes in water quality. It is likely that you will find a larger population of tolerant macroinvertebrates in a stream with impaired water quality and fewer of the sensitive species. Samples should be taken prior to beginning construction to establish a baseline to help measure the success of the project on the stream's health.

Once construction is complete and vegetation has been reestablished, samples should be taken again. If the stream's macroinvertebrate population was not balanced, i.e. more tolerant than sensitive species present, that balance should begin to return post-construction. This in turn will help balance the presence of other aquatic species and wildlife, since macroinvertebrates are toward the bottom of the food chain.

Example of Stream Restoration in Oklahoma

Examples of natural stream restoration in Oklahoma is presented in Figures 10 through 12. Before photos show cut banks that are not stable. As the banks continue to erode, land is lost and high levels of sediment enter the stream. The restoration plan for these sites involved reshaping the bank and adding native vegetation. The new banks are stable and have improved habitat compared to the original bank.

Conclusion

Restoring streams using these and other natural methods have several benefits. Natural stream restoration not only

Figure 10. Honey Creek Restoration Project in Northeast Oklahoma (before, top; after, bottom).

Figure 11. Illinois River Restoration Project near Tahlequah, Oklahoma (before, top; after, bottom).

enhances the natural beauty of the stream corridor, it can reestablish the natural balance of the terrestrial and aquatic communities within it. It can reduce contaminants and decrease the sediment load in the stream resulting in improved water quality. Habitat improvements and additional riffles and pools enhance recreational opportunities that translate into economic benefits for the surrounding communities.

Glossary

Channel bottom – bottom of the stream channel, usually containing rock, sand or silt channel beds.

Dynamic Equilibrium – a system in a steady state since forward reaction and backward reaction occur at the same rate.

Ecosystem – the living organisms and the nonliving environment interacting in a given area.

Floodplain – flat area alongside the stream channel that receives floodwaters and sediment when the stream overflows.

Macroinvertebrates – organisms without a spine and large enough to be seen without a microscope.

Riffle – a rapid, as in a stream.

Riparian Area – area adjacent to a stream channel that is occupied by water loving trees, shrubs, or other plants.

Scour Pool – a type of slow-water habitat unit. Scour pools are formed by scouring, or removal through hydraulic forces, of substrate from the stream channel and deposition of that material elsewhere.

Sediment – sand, silt, clay, gravel, or larger rocks that have been moved by water or wind.

Sedimentation – deposition or accumulation of sediment.

Transitional upland fringe – upland area on one or both sides of the floodplain that delineates the floodplain from the surrounding landscape.

Turbid – not clear or transparent because of stirred-up sediment or other material.

Velocity - speed of something in a given direction.

Further Information and Resources

Oklahoma Cooperative Extension Service Fact Sheets:
Riparian Buffer Systems for Oklahoma BAE-1517
Riparian Forest Buffers BAE-5034

References

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North Carolina Stream restoration Website, http://www.bae.ncsu.edu/programs/extension/wqg/srp/index.html

Rosgen, D. L. The Cross-Vane, W-Weir and J-Hook Vane Structures…Their Description, Design and Application for Stream Stabilization and River Restoration, http://www.wildlandhydrology.com/assets/cross-vane.pdf

What causes bank erosion? Queensland Natural Resources and Water. http://www.derm.qld.gov.au/factsheets/pdf/river/r2.pdf

Figure 12. Tahlequah Creek Restoration Project in Tahlequah, Oklahoma (before, top; after, bottom).

The Oklahoma Cooperative Extension Service
Bringing the University to You!

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of the Cooperative Extension system are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and research-based information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
- It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
- Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.

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Understanding Streams

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This discussion aims to give landowners the essential information needed to understand how streams work. Further information, including a deeper look at the underlying principles, can be found in the references listed at the end. See the glossary at the end for detailed descriptions of the underlined words.

What Streams Do

Streams have two mechanical functions. The first is to transport water from higher to lower elevations. The second is to transport sediment - earthen materials better known as rock, sand, silt, and clay. In a healthy stream, the amount of sediment being picked up and moved downstream is equal to the amount being deposited in the stream. In unhealthy streams, this balance is lacking; either too much sediment is being deposited or too much erosion is occurring. Excess deposition is usually indicated by the presence of unstable islands or mid-channel sediment bars. Excess channel erosion is indicated by rapid deepening or widening of the channel. Tell-tale signs are high, freshly eroded banks with exposed roots, or deeply incised channels. Both excess deposition and excess erosion may occur in the same channel reach (Figure 1).

Energy

The movement of water and sediment through a stream system involves kinetic energy. The faster the stream flows, the greater the power it has to erode and carry sediment. As children, many of us played with a flowing garden hose to dig holes in the ground, so we have an intuitive understanding of the cutting power of flowing water. Nature provides four ways of keeping this erosive power in check.

The first way streams protect themselves is the growth of deep or densely rooted, water loving plants along the stream channel. This streamside area is known as the riparian zone (Figure 2). These deep and dense root networks hold the riparian soil together. Although this protective zone of vegetation may be damaged from time to time, one of the great benefits of this network of riparian trees, shrubs and grasses is that it is self-repairing. When some plants are lost, others grow in their place.

The second way streams act to dissipate the erosive energy of flowing water is by changing their pattern or meandering (Figure 3). By forming curves the distance the water travels is increased, the slope is decreased, and the water's velocity slows as a result. It is normal for stream and river channels to slowly move over time. If one could watch a stream from the air over a period of several lifetimes, it would appear as if it were a writhing snake. This is one reason why construction of homes and other structures close to streams should be discouraged.

Figure 1. A high cut bank in the background and a mid-channel sediment bar in the foreground indicate that this stream is out of balance. The undercutting and collapse of streambanks contributes excess sediment to the stream. As that sediment forms mid-channel bars, stream flow is directed against the banks causing more undercutting and collapse. (Photo credit: Mike Smolen)

Figure 2. Healthy riparian zones are alive with trees, shrubs or other deep-rooted plants that resist the cutting power of the flowing water and protect streambanks from erosion. (With permission by Wendy Kroeker, artist, and Manitoba Association for Community Arts Councils Inc.)

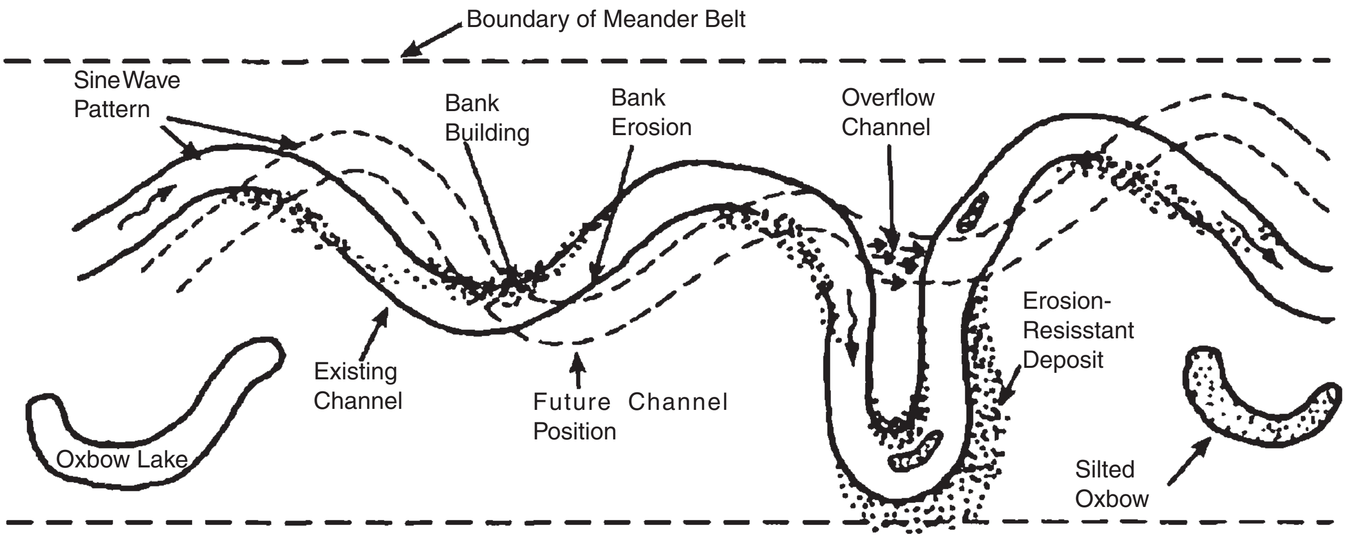

Figure 3. Over time it is normal for a healthy stream channel to move, or meander. Rivers which carry high sediment loads typically develop a braided pattern of multiple crisscrossing channels, instead of the single channel shown here. (Image credit: Ohio Department of Natural Resources)

Flooding is the third way in which erosive energy is reduced (Figure 4). During and after rainstorms, the water rises above the streambank and spreads on the floodplain. The velocity of the water outside the channel is very much reduced and, as a result, sediment is deposited. Flooding is a beneficial process as long as people avoid building houses and other structures in the floodplain. Local groundwater tables benefit from the increased infiltration of water, and the deposition of new sediment helps form and maintain productive soils. Flooding is a natural occurrence and is part of normal stream functioning.

The fourth way of lessening the erosive energy of water is the presence of live trees, plants, rocks, or woody debris within the stream channel, particularly the larger streams and rivers. By increasing the resistance to flow, such objects slow the water's velocity. Down trees, or snags, can also benefit fish populations by creating habitat, such as root wads and scour holes. In smaller streams, down and dead trees may need to be removed to avoid unnecessary flooding. To determine if a logjam or beaver dam should be cleared to maintain flow, seek advice from the Conservation Commission or Department of Wildlife Conservation.

Figure 4. It is important to recognize floodplains and understand how they work. See "Further Information" for sources of floodplain maps for your area. Always check a floodplain map before buying or building a home or other structure close to a waterway. (Photo credit: USGS)

Common Causes of Stream Problems

The failure to understand and respect how nature allows streams to resist erosion can lead to serious problems. While there may be engineering methods for solving these problems, the costs are quite high and almost always beyond the reach of the private landowner. It is far better to understand and respect the ways in which nature regulates stream erosion and avoid such problems (Figure 5).

Figure 5. This high cut bank is the sign of an unhealthy, unraveling stream channel. The channel is being widened as the stream seeks to meander. Once a stream has been degraded this severely, there is little a landowner can do about it. (Photo credit: Mitch Fram)

Along with the benefits of stream ownership, there are some dangers and pitfalls for the uninformed landowner. Whether your stream is a large one that flows year round or a small one that is dry more often than not, take heed of the following warnings:

- **Don't** "clean up" a stream by clearing off the brush, trees and other deep rooted plants from the banks. Their deep root network is all that holds the creek bank together against the cutting power of the water.
- **Do** learn to recognize floodplains and don't build a home or other structure in one. As long as floodplains are left undeveloped, flooding provides the natural benefits of replenishing soil moisture, recharging local water tables, and reducing downstream flooding and erosion.
- **Don't** let heavy cattle traffic, vehicles, or equipment damage streambanks. The soils are soft and easily disrupted, setting in motion serious erosion.
- **Don't** attempt to straighten a stream channel or cut across a meander. Although the intention may be good, generally it is illegal without a permit from the U.S. Army Corps of Engineers. It can seriously damage downstream areas due to increased water velocities and sediment.
- **Be aware** that stream problems on your land may be the result of upstream problems. If the watershed above your land is eroding, then there will be excess sediment entering your stream. If your channel bed is a rocky one, this sediment can silt in the spaces between the rocks needed by small fish, crawfish, and insects. A different problem occurs when the upstream watershed is covered by buildings, roads, and parking lots. The increased runoff from these impervious surfaces will increase the flow your stream must handle, resulting in deepening or widening of the stream channel.

Streams have an amazing ability to handle the erosive energy of flowing water, but can be made vulnerable to severe damage when a landowner doesn't appreciate how they work. By the time most stream owners notice a problem, it is usually too late for an affordable solution. Take time to enjoy and understand your stream and do what you can to protect its health.

If you are blessed with a stream, you have something of value that can greatly add to the enjoyment of a property. There is nothing quite like sitting beside a stream and taking in the sights and sounds. Both children and anglers can get a kick out of collecting crawdads, stream insects, and other stream critters. In general, streams with rocky beds and overhanging trees provide the best habitat for fish, but any stream with well vegetated banks and a riparian zone provides a tremendous benefit – they are a durable, self-repairing means of handling high flows that would otherwise erode adjacent land (Figure 6).

Figure 6. This small creek is in healthy condition with a well-vegetated riparian zone. If brush and trees are cleared, bad consequences will follow. Like most Oklahoma streams and rivers, its fate is in the hands of landowners. (Photo Credit: B. Hoagland, Okla. Biological Survey)

Glossary

Channel Bed – The bottom of the stream channel. Streams will usually have rock, sand, or silt channel beds.

Floodplain – The flat area alongside the stream channel that receives floodwaters and sediment when the stream overflows.

Habitat – The specific type of usable space, shelter (cover), food, and water required by a particular animal species. Scour holes created by woody debris and the spaces between rocks in the stream bed are important forms of usable space and shelter for fish and the insects they consume.

Kinetic Energy– The energy produced by motion. Kinetic energy is proportional to the square of velocity. Water flowing at 1 foot per second has only 1/16th of the kinetic energy of water flowing 4 feet per second.

Meander – A bend in a stream or river. Streams naturally form meanders due to erosion and deposition in the stream channel.

Mid-channel Sediment Bar – An unstable island formed by the deposition of sediment. It differs from a point bar, which is attached to an inside bank in a meander curve.

Riparian Zone – The area adjacent to a stream channel that is occupied by water loving trees, shrubs, or other plants. It generally has a greener appearance than surrounding areas.

Sediment - Sand, silt, clay, gravel, or larger rocks that have been moved by water or wind.

Sediment Deposition – The dropping of sediment from suspension whenever velocity decreases to the point that the water no longer has the kinetic energy required to transport the particle.

Silt – Sediment that is larger than clay and smaller than sand.

Snag – A dead tree. These are often valuable as habitat for fish or wildlife.

Watershed – The area of land that catches rainfall and funnels surface water and groundwater to the stream.

Further Information and Resources

Riparian Area Management Handbook, E-952 http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-2251/e-952.pdf

Riparian Forest Buffers, NREM-5034 http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-2245/BAE-1517web%20color.pdf

Riparian Buffer Systems for Oklahoma, BAE-1517 http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-2245/BAE-1517web%20color.pdf

Ohio Stream Management Website www.dnr.state.oh.us/water/pubs/fs_st/stfs03/tabid/4159/Default.aspx

North Carolina Stream Restoration Website www.bae.ncsu.edu/programs/extension/wqg/srp/index.html

Stream Corridor Restoration: Principles, Processes, and Practices By the Federal Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US government). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3. Available on-line at www.nrcs.usda.gov/technical/stream_restoration

The official website of the Federal Flood Insurance Program: http://www.floodsmart.gov/floodsmart/

Free on-line floodplain maps: http://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1

floodplain maps ($): http://www.myfloodzone.com/fema-flood-maps.htm

Stream Hydrology Models – By flowing water through a bed of plastic grit, these teaching models demonstrate normal stream functioning and then degradation under the influence of bad management practices. Six trailers are available for classroom and public event audiences. Contact your County Extension Service office at http://www.oces.okstate.edu.

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