STREAM RESTORATION LESSON PLAN

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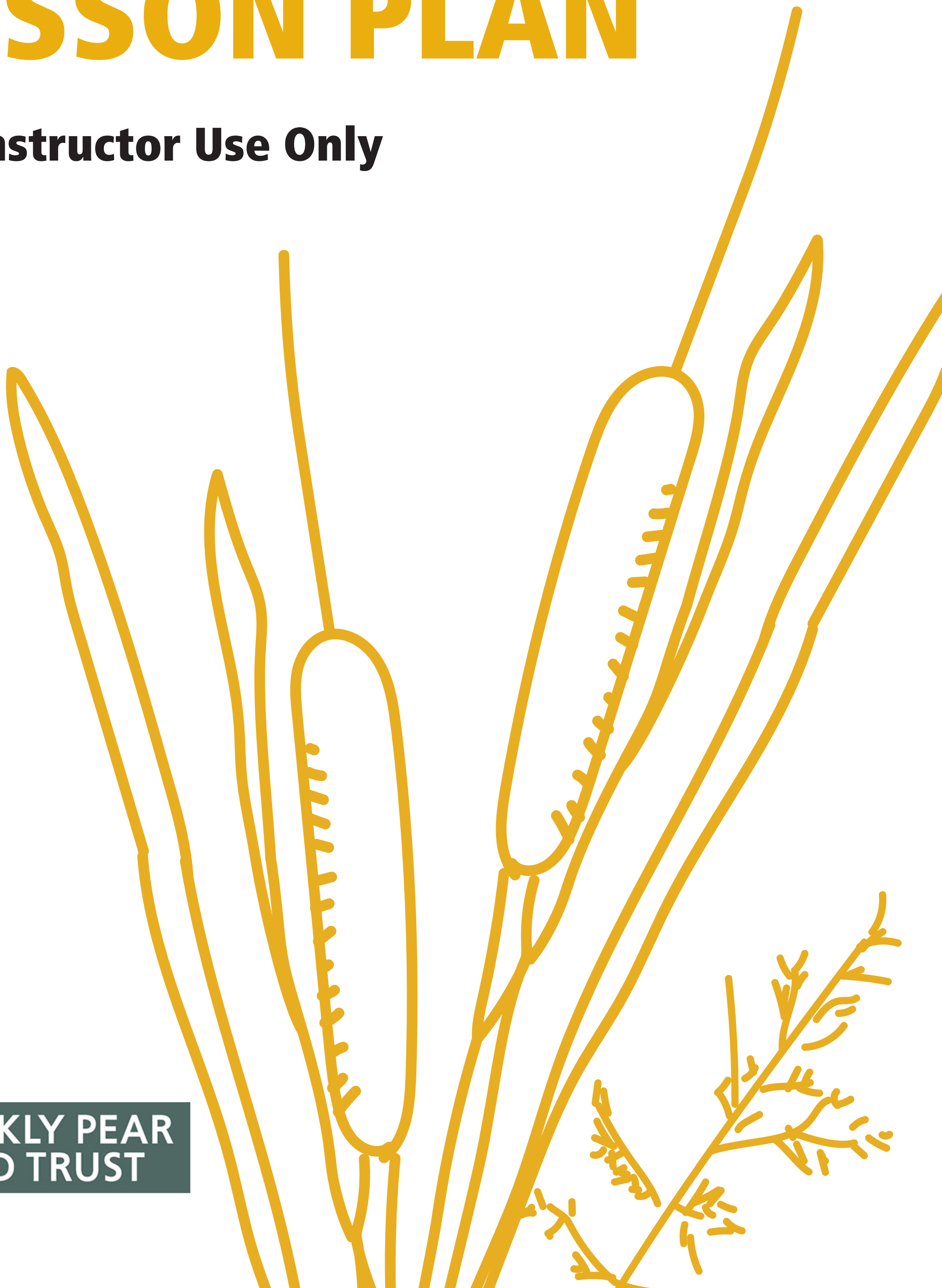


PRICKLY PEAR LAND TRUST

Stream Restoration

Location: Sevenmile Creek Property

Aim: What factors contribute to making a stream and floodplain unhealthy and why are stream restoration projects important?

Time: 1.5-2 hours

Next Generation Science Standards:

HS-LS2-6, HS-LS2-7, HS-ESS2-2, HS-ESS2-5, HS-ESS3-1, HS-ESS3-4

Guiding Questions:

Historically, how have human uses impacted healthy riparian ecosystems?
How does rerouting a stream from its historic stream bed affect the health of the ecosystem?
What needs to be done to restore a stream? What steps need to be taken?
Is a stream restoration complete as soon as the stream is rerouted?

Learning Objectives:

Understand what it takes to reconstruct a stream

Discuss why people alter riparian zones and what the alternatives are

Lesson Timeline

Note: The introduction to the topic should take no more than 45min. The students will then play the salmon game, which will demonstrate the barriers to fish passage. The class will end with a discussion on the challenges fish face moving through a river, as well as measures that can be taken that aid fish passage around dams.

10 MIN

Students arrive, greet them and introduce yourself

Try to be as engaging as possible. The introduction with the students is what sets the tone for the rest of the lesson. This does not require you to have any special skills, just be friendly and be yourself. It would be great if you included some information about what you do, or did, for work. It is a good opportunity to introduce the students to different careers and does not need to be related to the lesson you are leading.

Ask the students to introduce themselves. Up to you how you want to do this.

10 MIN

Where you meet the students, introduce them to the topic for the day and ask them if they can think of reasons a stream might become degraded. In a discussion or if the students can't come up with any reasons, talk about:

Humans altering streams to prevent them from flooding surrounding areas
People moving streams to new locations without taking into consideration substrate or vegetation has consequences
Downcutting
Undercutting
Increased velocity from straightened stream

15 MIN

Walk the students to the stream and talk about the consequences of degraded streams (if you can walk and talk great, otherwise you can just talk at the stream). Ask the students if they can think of consequences to a degraded stream.

Ask if they can think of consequences for people and for wildlife.

Disconnect from floodplain
Undercutting decreases vegetation
High velocity and its effect on fish reproduction
High turbidity and its effect on:
- Gill-breathing macroinvertebrates
- Fish and fish eggs
- People - drinking water and processing facilities

Lesson Timeline Cont.

45 MIN

In an open area play the salmon game with the students (an easy transition is to just ask the students if they would like to play a game or do an activity) Discuss the effects of human changes and ask the students the difference having human interactions made. Was it harder to make it back to the spawning grounds?

25 MIN

Walk the students to a place where they can see Reach 3 and discuss the stream restoration

History of the property - why the stream was moved, top soil mining, vegetation removal

Stream restorations need experts in biology, hydrology, ecology, engineering, and construction, as well as others, to create a sustainable stream

Briefly discuss reaches 1&2 and the measures PPLT took to restore them

Ask the students if they can figure out why reaches 3&4 could not be restored using the same methods as reaches 1&2. (Hint: it's because the stream had downcut too much and was too far below the floodplain zone)

Discuss the in-progress restoration of reach 3 and the planned restoration for reach 4

Ask the students if they can come up with some characteristics of a natural stream or river. Discuss riffles, runs and pools.

If there is time, discuss the permitting and financial side of the stream restoration

15 MIN

On the walk back to the vehicles or at the vehicles, discuss conservation vs restoration

Easier to conserve than to restore
Important to take into consideration ecological aspects when planning infrastructure

Background Info

How a Stream Degrades

Stream restorations become necessary after a waterway has been altered to accommodate human uses and the stream quality has degraded as a result. A common stream alteration is to change the stream or river in a way that prevents it from flooding the surrounding area. Cities built around a river will often channelize the river in concrete to prevent it from overflowing its banks and flooding the city. In more rural places like Montana, the alterations people make tend to not be as drastic, but can still have devastating consequences for the stream quality. In our example, past owners of the Sevenmile Creek property dug a new channel away from the flat grasslands and against the hills presumably to access more of the property for farming and ranching. By digging a new channel, they straightened a portion of the creek and removed important ecosystem habitat. Moving a creek can seem harmless but, without taking into consideration the biological and hydrological factors, relocating a creek can severely degrade the creek quality, hurting both the natural ecosystems and human systems.

When a stream is relocated, a few major things change. Vegetation that relied on the stream and seasonal flooding is lost. Important substrate that contained gravel and larger rocks in the original channel is abandoned and soils from the new stream can erode quickly. And, depending on the structure of the new stream, the stream menergy can increase.

Vegetation loss on stream banks is a major concern because vegetation plays a major role in stabilizing stream banks. The root systems of plants create a web that holds soil and rocks in place and maintains the stream bank. When that root system is lost, the water is able to erode the bank much more easily, which leads to undercutting of the bank and increases the amount of fine sediment sloughing into the water. People who attempt to move streams without understanding all the factors that make up a riparian ecosystem often do not think about what the substrate will look like in the new stream. If a new stream bed is mostly fine sediment soils or sand, as soon as the water is moved to the channel the stream starts cutting down into the substrate by picking up the substrate and carrying it downstream. This process of cutting deeper into a stream is called downcutting.

Straightening a stream exacerbates the problems mentioned above. Without the meanders and bends seen in natural streams, there is very little to slow the stream down. The stream will pick up speed, sustaining an increased velocity and increasing the amount and size of sediment the water can carry, which increases the rate of downcutting and undercutting.

Consequences of Stream Degradation

But why does this matter? Downcutting and undercutting create compounding problems that can take decades or longer to self-correct. Downcutting disconnects the stream from its floodplain. When a stream is incised to the point that the stream is feet below the historic floodplain, the water table for the whole area is lowered, making it difficult for plants to access water. It also prevents the stream from overflowing the banks and flooding the surrounding area. While this might sound like a good thing, it often means is that flooding downstream occurs more frequently and the flood events are more intense. Additionally, riparian and floodplain ecosystems rely on flood events to be healthy. When a stream floods, it carries nutrient rich soil onto the floodplain, which is why floodplains make good farm land. The water is also trapped in the fine soil in the floodplain, saturating the soil and giving plants access to water for longer periods of time. Stream bank undercutting also has consequences for the stream ecosystem. Undercut streams will have steep banks with little to no vegetation on them. Vegetation cannot establish along these banks because the soil is sloughing off into the stream too rapidly, and the reason this is happening is because there is no vegetation to stabilize the bank. Once a stream is in this situation it can take decades to self-correct.

The increase of sediment in the water due to the erosion of the stream banks and substrate also has long-term consequences for the plant and animal life that rely on aquatic, riparian, and floodplain ecosystems. Due to erosion, the stream is filled with fine sediment and has a high turbidity. Gill-breathing macroinvertebrates cannot survive in high turbidity water, as the sediment clogs their gills and prevents them from breathing. As some of the suspended sediment settles to the bottom, it also suffocates macroinvertebrates that live on the stream bottom. High turbidity also has multiple consequences for fish populations. If the turbidity is high enough, it can cause damage to fish gills and decrease visibility, making it difficult for fish to find food. Without a healthy macroinvertebrate population, fish have very little to eat and have a difficult time reproducing. Fish eggs require a continuous flow of fresh water to survive, without which they suffocate. In streams with high turbidity, the sediment will settle onto fish eggs and suffocate them before they can hatch.

Straightened streams also have consequences for fish populations. Fish need pools to lay and fertilize their eggs. Because fish fertilize their eggs outside of the female's body, they need relatively calm water in order for sperm to reach the egg. In straightened streams the water moves too rapidly for eggs and milt (fish semen) to settle.

Human Impacts and Consequences

High quantities of sediment hurt people too. Large amounts of sediment in water sources create problems with water processing facilities. The facilities that give us our clean safe drinking water have to filter out the sediment before cleaning the water. This is done either through settling tanks or by using filters. However, when there is a lot of sediment in the water the filters and/or settling tanks need to be cleaned out much more frequently, increasing costs and labor. While this is not a problem in Helena because our water is taken out before Sevemile Creek joins Tenmile, it is still an important issue that needs to be addressed.

Both undercutting and downcutting do occur naturally in nature. The Grand Canyon is an amazing example of a naturally incised stream. The difference is that the process happened gradually over hundreds, thousands, or even millions of years. The landscape had the opportunity to adapt and change. When caused by people, the landscape and associated ecosystems have no time to adapt, the landscape is abruptly changed and becomes uninhabitable to the plants and animals that rely on those ecosystems.

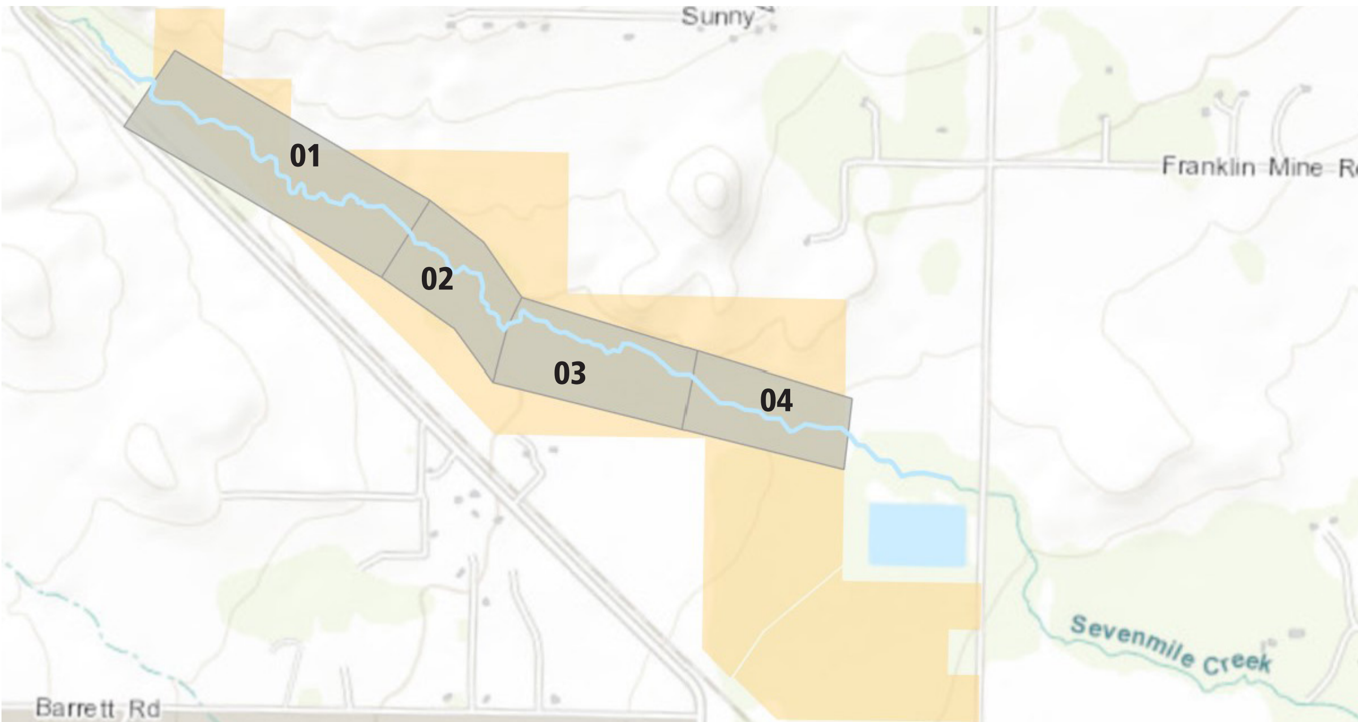
Sevenmile Creek Restoration

Stream restorations are not simple projects. There are many factors that must be thoroughly researched, experts that need to be consulted, and federal, state, and county regulations that need to be followed. A successful stream restoration will include, at a minimum, biologists, ecologists, hydrologists, engineers, and construction crews. Without input from these experts, a stream restoration will not take into account all the necessary information and may not be successful.

Before PPLT, the Sevenmile Creek property was mined for topsoil and consistently overgrazed. Since the '50s most of the woody vegetation in the riparian corridor was mechanically and/or chemically removed, presumably to allow more field space for grazing and cropland. Prior to that point, woody vegetation covered about 25 feet on either side of the creek. Today, on portions of the creek, there is either no woody vegetation at all, or just a thin vegetation corridor right along the creek. Additionally, overgrazing has prevented other vegetation from establishing along the stream banks. The result is that, for large portions of the stream, there is little to no vegetation and therefore rapid bank erosion.

Sevenmile Creek Restoration

Because of the amount of the stream and floodplain, and water rights PPLT acquired, the stream was the perfect candidate for restoration. It has been divided into 4 reaches or sections for management and reference purposes. Two reaches of the stream were severely degraded, while two reaches required only minimal restoration. Reach 1 and 2 were relatively stable and only needed a few modifications to begin recovering naturally. Previous owners dumped rocks onto the eroding banks in an attempt to stop the erosion. When installed properly with the correct material, rock barbs can reduce erosion. Unfortunately, when installed incorrectly rock barbs can create current and eddy changes that increase erosion upstream and downstream. Rock barbs also inhibit the natural lateral migration of the stream and prevent the stream from shifting and changing over time. Rock barbs were removed at 15 locations along the stream, most of which occurred in reach 1.



Stream Reaches

PPLT Land

Sevenmile Creek

In one location, PPLT stabilized a low floodplain bench by transplanting sod mats and willows from other locations on the property and installing coir fabric to stabilize the bank while the vegetation became established (coir fabric is a biodegradable material that comes in both sheets and "logs"). A floodplain bench forms when an eroded stream bank sloughs enough sediment into the stream bed to create a new lower stream bank (see floodplain bench image). Reach 3 and 4 were too degraded to restore the existing creek bed. Both reaches were severely incised, at places sitting 7-8 feet below the historic floodplain with little to no vegetation. The exposed fine grained sediment from the stream banks were sloughing high quantities of sediment into the stream. Over time the creek would most likely stabilize itself by continuing to erode laterally until the creek was wide enough to support a low floodplain bench. Unfortunately, that could take decades and in the meantime the unstable banks would continue to slough large quantities of sediment into the stream and continue to decrease stream quality. Instead of fixing these reaches, PPLT and partners decided to move the stream back to the floodplain. The new channel has been created and vegetation has been planted, but is not yet established. The old reach 3 channel was plugged in different areas to create a series of ponds. Over time, these will turn into wetland habitat that will support more and diverse habitats. Reach 4 is the most degraded section of the creek and the restoration has not yet started. Sometime between 1947 and 1955, reach 4 was mechanically straightened, presumably to drain adjacent wetland and riparian areas, and to improve the area for agricultural use and livestock production. This section of the restoration is currently in design (see proposed restoration plan for reach 4).

In addition to rerouting the stream to the floodplain, reach 3 had an additional challenge - a diversion structure blocked part of the creek. This prevented fish passage and essentially split the creek into two separate habitats. A sample study showed that there were two species of trout in the creek, but one species could only be found above the structure and one could only be found below the structure. The structure has been moved and reach 3 is in the process of being restored.

Stream restorations are not as simple as digging a new creek bed and rerouting the stream. In order to sustainably restore a stream, all elements, the biology and ecology, the hydrology, cost, and permitting, all need to be taken into account. A restoration team first evaluates the problems with the stream and then decides the goal of the restoration. A team of biologists, ecologists, hydrologists, and other experts create a few restoration plans that meet the needs of the ecosystem and include options to accommodate different budgets and regulations. In addition to the planning, federal and local regulations need to be taken into account, and any required permits need to be applied for. The restoration plan goes through several review processes and modifications until it is approved. Once implemented, a successful restoration should meet a few criteria. It should meet its goal, the ecological conditions should be measurably improved, it should result in a self-sustaining creek that requires minimal maintenance, and the implementation of the restoration should not cause lasting harm.

Sevenmile Creek Restoration

Reach 1 and 2 did not require too much restoration and were relatively low cost projects, somewhere between 50-70 thousand dollars, and were not too time intensive. Reach 3 was more severely degraded and was relocated to a newly constructed channel. To create a stable creek, the banks and the bed of the channel were lined with a 12" thick layer of gravel. This layer allows the creek to move laterally without severely eroding the stream banks, as well as preventing the creek from becoming incised. Restoration teams also take into consideration biological needs when creating a new creek bed. Natural streams have riffles, runs and pools, and each of these are necessary to support biologically diverse stream populations (see vocabulary list for definitions). At each bend in the new creek bed for reach 3, the bed was dug deeper to provide pool habitat for different species. Over time, these pools will fill with rocks and debris that are being carried downstream by the creek, producing more habitat. Vegetation has been planted but is not established yet, so the stream banks are still fairly fragile and susceptible to flooding. You will see a lot of newly planted willow cuttings along reach 3. Willows are an excellent plant to use for bank stabilization because they naturally have high concentrations of the growth hormone IBA and the chemical salicylic acid. Combined, these allow willows to rapidly grow roots from branch clippings planted in the ground. Willows grow extensive root systems and, as a result, are very good at stabilizing stream banks. Reach 3 is a work in progress, but is a beautiful example of the beginning stages of a stream restoration.

Restoration of reach 4 is planned to be complete by Spring 2020. In addition to being the most degraded section of the creek, which makes the restoration more expensive, reach 4 is also part of a Federal Emergency Management Agency (FEMA) mapped floodplain. Streams and rivers regularly overflow their banks, flooding the surrounding area. Most often these are minor floods that do not cause any damage to property. However, there is a chance on any given year for more damaging flooding to occur. The floodplain is typically mapped to reflect a 100-year flood event. This means that in any given year the mapped area has a 1% chance to be inundated by flood water. The name refers to the 1% annual chance of flooding, if you were to compound the 1% annual chance over 100 years there would be a 100% chance of a flood event occuring within the 100 year time frame. FEMA maps these 100-year flood events and the area that will be affected. The FEMA mapped area around Helena includes reach 4 of Sevenmile Creek and impacts the restoration of reach 4. FEMA allows changes to be made to creeks that will only raise the elevation of the floodplain by up to 0.5 feet without any special permitting. Unfortunately, because reach 4 is so severely incised, the floodplain will need to be raised 7-8 feet in order to restore the creek to its historic floodplain. This means that before reach 4 can be restored, it needs to go through a permitting process that is reviewed by FEMA and then needs to be approved by the county. The county needs to approve it because anyone that would like to develop there in the future will need flood insurance. This process can take 9-10 months and costs 25-30 thousand dollars.

Because there is little to no infrastructure on the floodplain that will be affected, PPLT is optimistic that the permit will be approved. Similar to reach 3, the plan for reach 4 is to move the stream to a new location that will raise the creek back to its historic floodplain. Currently, at the bottom end of reach 3, there is a step pool feature that connects reach 3 down to the existing reach 4. Reach 4 will connect to the new reach 3 channel above that step feature, which will be either plugged or filled. The end of reach 4 will also need to incorporate a step feature to connect the new creek bed to the existing Sevenmile Creek that is not on the PPLT property. Reach 4 is being designed by a different restoration company than did reach 3, and they will be attempting to mimic the form of a naturally occurring stream. The plan is to have an 18-inch thick layer of gravel lining the stream banks and bottom that will extend 4-6 feet on either side of the creek. This will allow the creek to move laterally like a natural stream would without jumping outside of the gravel and starting to erode the banks again. In addition, this restoration will include more riffles and pools to mimic a natural stream habitat. This restoration will be more expensive, over $1 million, and PPLT is in the process of acquiring the funds. The hope is that the reach 4 restoration will be completed by the end of 2020.

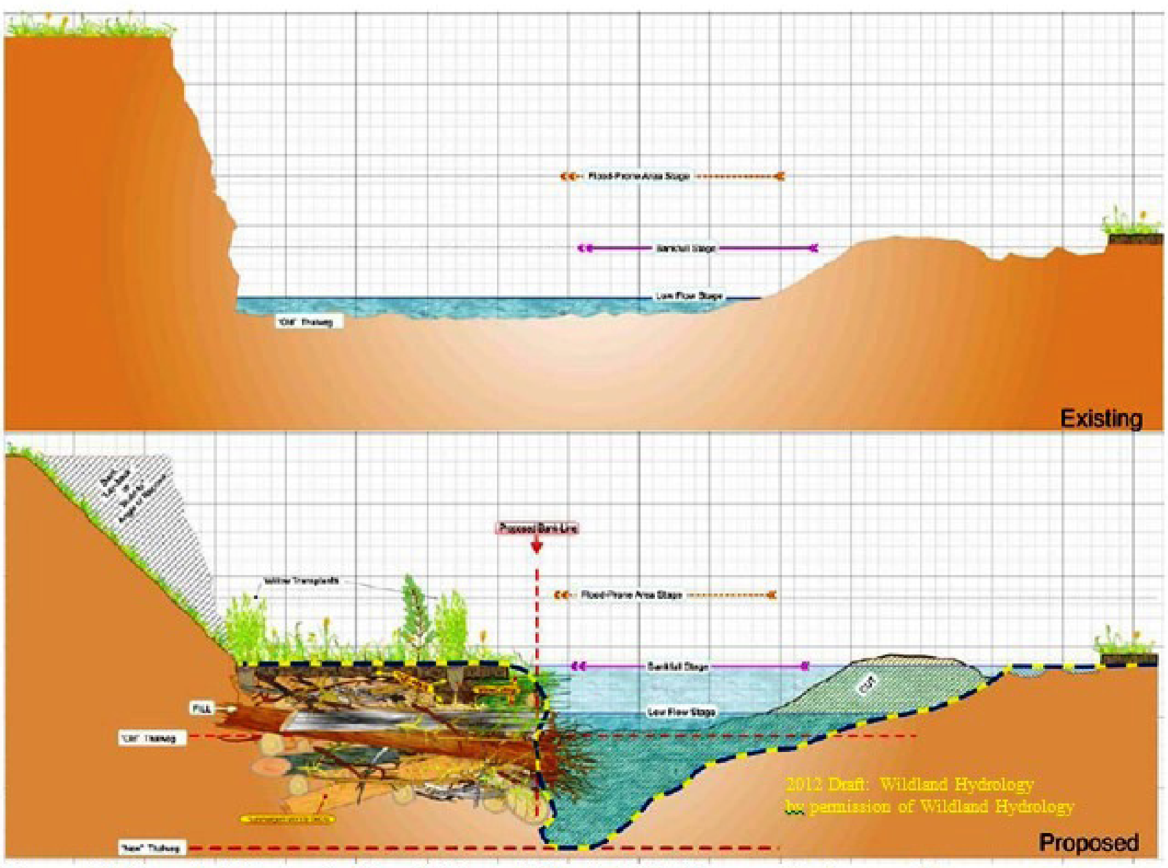


Figure 12: Re-establishment of bankfull bench (floodplain)- Geomorphic Approach

Salmon Game

Materials

Prepare students for the outdoors with warm layers and safety boundaries.

Rope (at least 15 feet long)
Hula Hoop
Buckets (2-3)
Noodle (5' insulation tube)
Predator puppets (optional)
Caution tape or orange jacket
Cones (optional)

Game Play

Students split into two groups and play a game mimicking the salmon's story. One half of the students start out as baby salmon on a hillside (representing their natal mountain stream) who must run along the stream (trail or 10' wide path marked out by cones) to the ocean (large area with a toy boat) where they run around the boat four times to represent their four years out at sea. They then have to return to their home on the mountain, walking backward to represent the tough current. If they are tagged by the other half of students (playing the roles listed below), they have to trade roles with the person who tagged them. Along the way, they face many challenges (played by other students):

Predators (bear, eagle, lynx, fox, salmon, orca, sea lion)
Fisherman (noodle and student with foot in bucket holding hula hoop)
Dam (two responsible students or adults swinging long jump rope)
Sediment/turbidity (Caution tape or orange jacket with foot in bucket)

These students have to plant one foot on the outside of the stream, and may tag the young salmon as they go by. The recreational fisherman may tag with the noodle. The commercial fisherman in the ocean may "catch" salmon inside his hula hoop (net). The dam is created across the "stream" with a spinning jump rope, and explained to students as the spinning blades of the turbines that create hydroelectric power. Students soon figure out that there is an area between the edge of the "stream" and where the person is holding the rope that they may use to crawl through. This represents a fish ladder. If students can hop the rope or run through unscathed, then they're free to continue out to sea. Pollution starts below the hill and can only move downstream slowly, for their foot is in a bucket. They can tag salmon in the stream.

The game is played for 20 minutes, and then students reflect on their experience being salmon. The facilitator needs to check to make sure every student has had the chance to be a salmon before the game ends. Ask students, is it hard being a salmon? How many salmon made it to their spawning stream up on the mountain? Why do you think so few salmon get to be adults? How many salmon in real life get to be moms and dads for baby salmon? (1 in 1,000) Did people make their lives harder? How did we do that? What can we do now to help them out? (Fish ladders, limiting catch numbers, protecting habitat, reducing and eliminating sources of pollution) What is one thing you could do this year to help salmon survive?

Note:
Play one 20-30 minute round of the game without human interactions (remove the dam, pollution, and fishermen), and then play another round after that for 20-30 minutes adding in the trials of human impact. Students may understand the added challenges humans have made to salmon habitat.

Non-Classroom Activities

Erosion Jeopardy

http://www.regentsearthscience.com/jeopardy/erosion/jeopardy.htm

Stream Restoration Video Tour

https://www.youtube.com/watch?v=irKwfyuSNV8

Great Online Interactive Game to Teach Students About Salmon Migrations

https://lltk.org/project/survive-the-sound/

HAPPY.

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TRAILS.

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