Learning about our streams

Today we'll learn about our streams to help look at flood resliency strategies. The more we know about our streams the more likely we are to succeed in finding ways to reduce impacts from flooding.

Today's presentation presented by:

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with VT's
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Hi,

I'm Staci Pomeroy. I'm a River Scientist with VT's Department of Environment Conservation's Rivers Program

I work with various groups, towns, state and federal agencies, and other organizations to provide technical assistance, help collect stream geomorphic data, develop and implement projects, and look at flood resiliency strategies along our river systems.

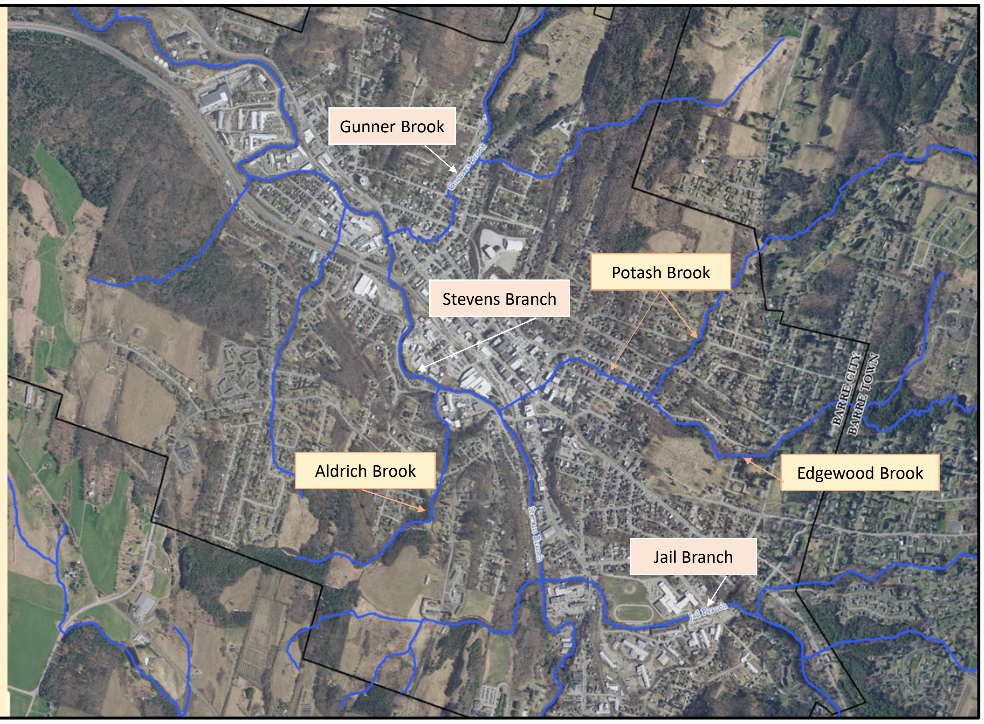
Barre City Streams

Three named streams

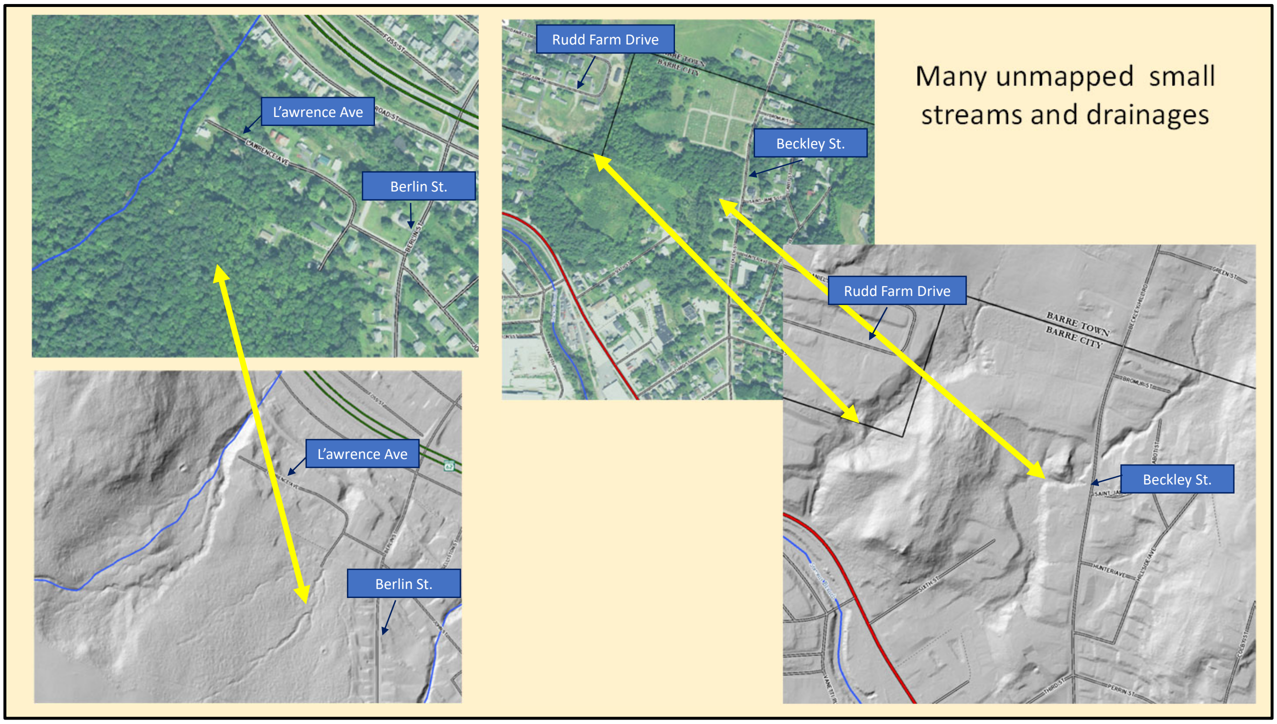
- Gunner Brook
- Stevens Branch
- Jail Branch

Multiple un-named, and
a few locally named streams

- Aldrich Brook
- Potash Brook
- Edgewood Brook



We will take a moment to learn a get familiar with the streams in Barre. There are 3 named streams in Barre, Gunner Brook, Stevens Branch and Jail Branch. There are also multiple un-named tributaries and a few locally named streams: Aldrich Brook, Potash Brook and Edgewood Brook.

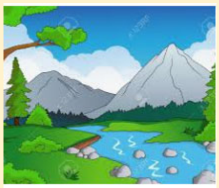
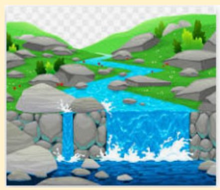


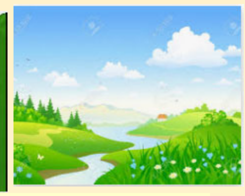
Beyond the mapped streams there are many un-mapped streams and drainages that contribute to the stream system in Barre. These streams can be seen on the LIDAR. LIDAR stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. This allows us to have a 3-D look at the earths' surface.

We will look at a couple examples where we can see un-mapped streams in Barre.

When we look at the imagery of the area near L'awrence Ave and Berlin Street, the area near the Barre Town & City line up by Rudd Farm Dr., and near Beckley St. there is no evidence of streams or drainages on the landscape.
By using the LIDAR we can see many small streams and drainages that are part of the larger stream network in the city.

Stream Characteristics

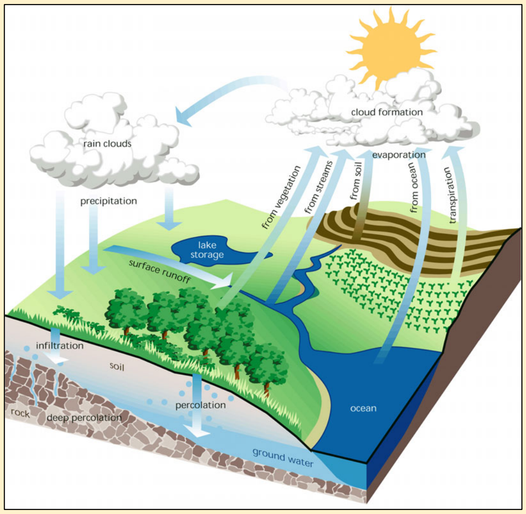


What type of stream are on our landscape?

Some simple stream characteristics are the first things that we need to understand as we begin to work in our streams.

Each stream type is unique in how it functions and responds, so knowing what type of stream you are working in will help your project have a better chance of success.

Watershed Scale Inputs of:
Water
Sediment & Debris



What influences those Inputs:

- Land-use / Land-cover
- Location in the landscape
- Ground water connection
- Climate
- Soils
- Stormwater
- Others……

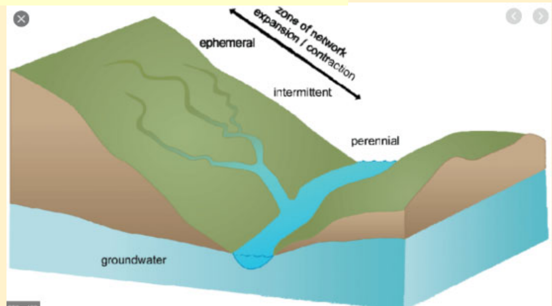
One of our basics for river process is, that rivers transport water, sediment and debris.

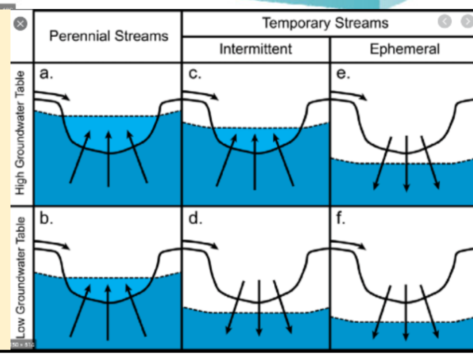
We look at the watershed (aka – all of the land area upstream that drains to a point in the river) for the inputs of water, sediment, and debris that the river will transport. Many things in the watershed will influence how much water/sediment/debris will reach the river at any point. These inputs can change over time as factors in the watershed change over time.

The river will change over time to accommodate changes in the inputs of water, sediment, and debris from the watershed.

Three main types of streams:

- **Perennial =** Streams that flow year-round (most years), ground water fed.
- **Intermittent** = Streams that flow at different times of the year, or seasonally; ground water fed and lose to.
- **Ephemeral =** Streams that generally exist for short periods of time, usually during a rainy period; no ground water influence



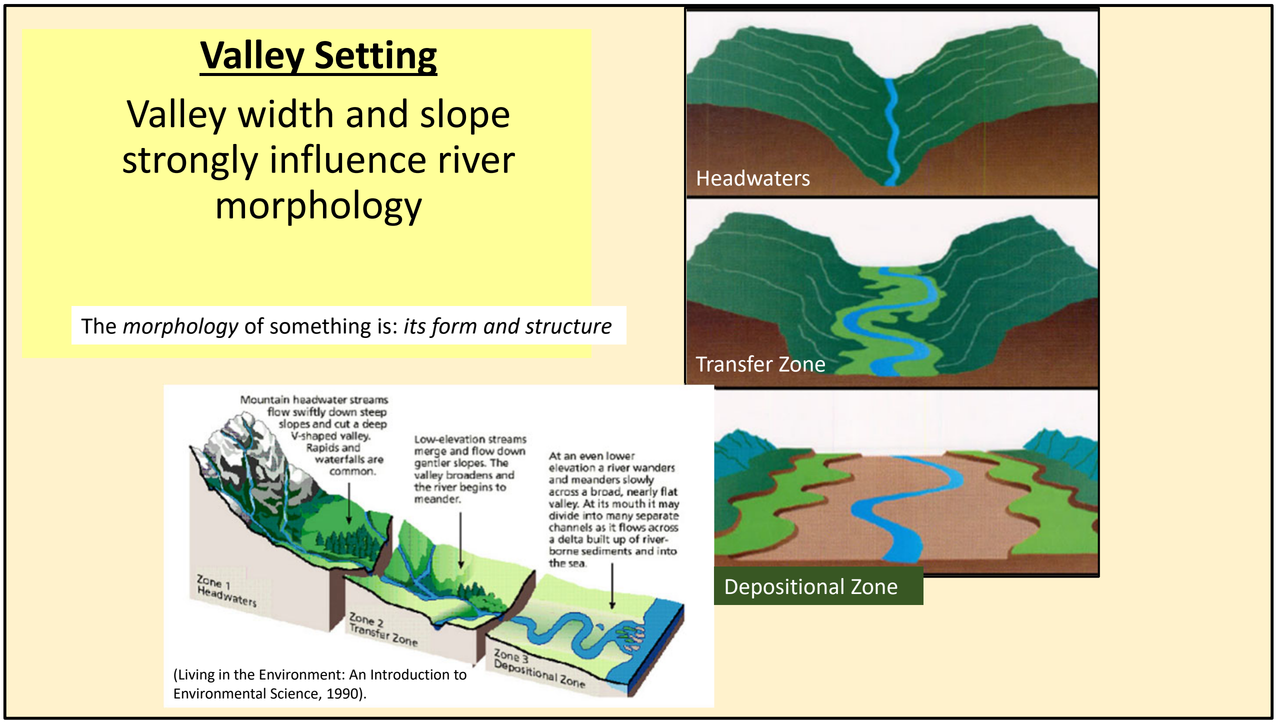


Streams are generally categorized into 3 types: perennial (flow year-round and have ground water contributing all year, most years), intermittent (seasonal streams, have ground water contributing part of the year, most years) and ephemeral (typically only exist during rain or snow melt events, do not have ground water contribution during any part of the year).

While the amount of time that water flow exist in the channel is different between these stream types, there are several things they all have in common,

They all are influenced by the landscape they flow through, create channels as they flow, exhibit river dynamics, and transport water, sediment and debris.

As we do our work along these streams it is essential for us to recognize the importance of accommodating these processes in order to have a successful project.

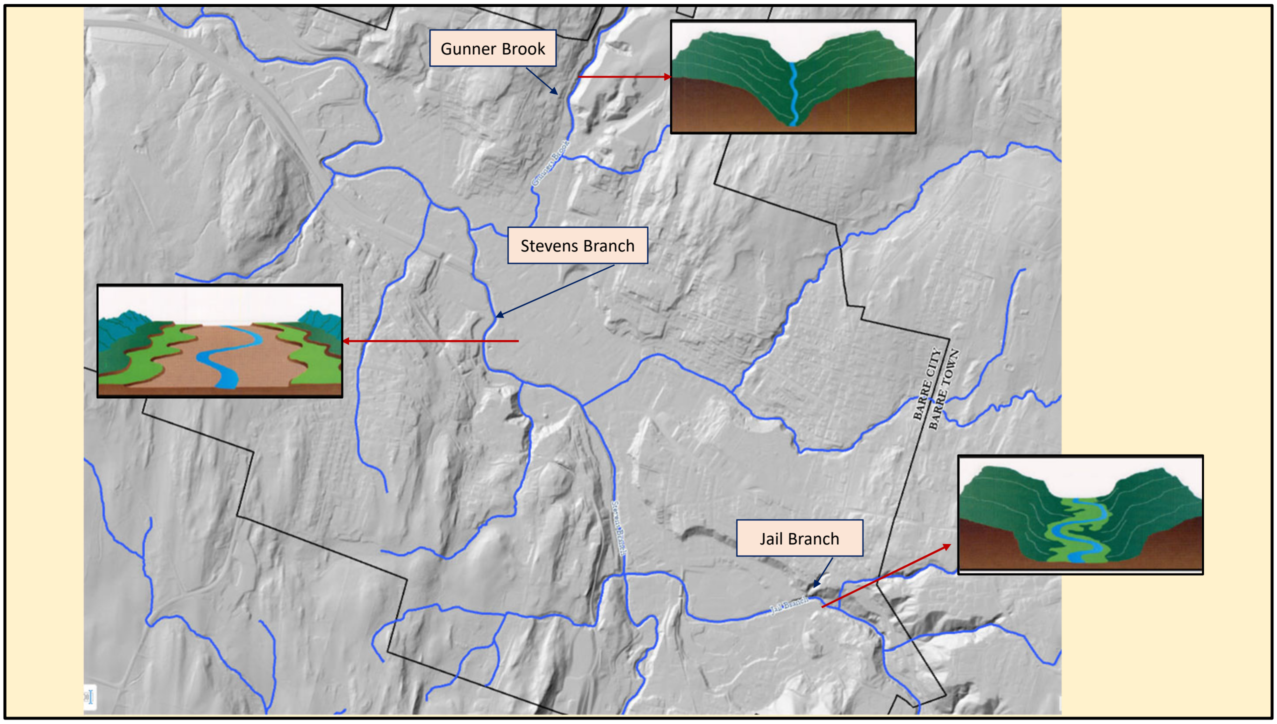


Let's look at a few of the landscape features that influence our stream types.

Valley setting is one of the primary landscape features that effects the type of stream we may find.

The width of the valley the streams goes through determines how much room the river has to move in and how much floodplain is available to spread out during a flood.

Picture our mountainous streams in their confined valleys – these are areas w/ little room for the river to move and have no or limited floodplain; versus our wide lowland valley streams that wind their way across the landscape and have access to broader floodplains.



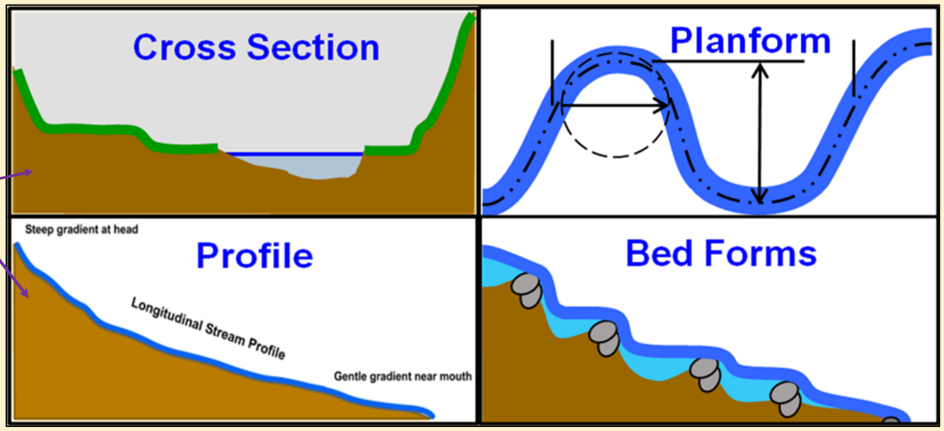
There are examples of each of these valley types in Barre City.

On Gunner Brook there are narrow confined areas; on the Jail Branch there are stretches with a moderately wide valley, and along the Stevens Branch there is a wide valley.

Development, roads and other infrastructure may change the natural valley condition to be more confined, changing how the stream is able to move in the landscape and how it will transport or deposit its water, sediment and debris.

Understanding the **Shape** of the River

We will focus on cross-section and profile



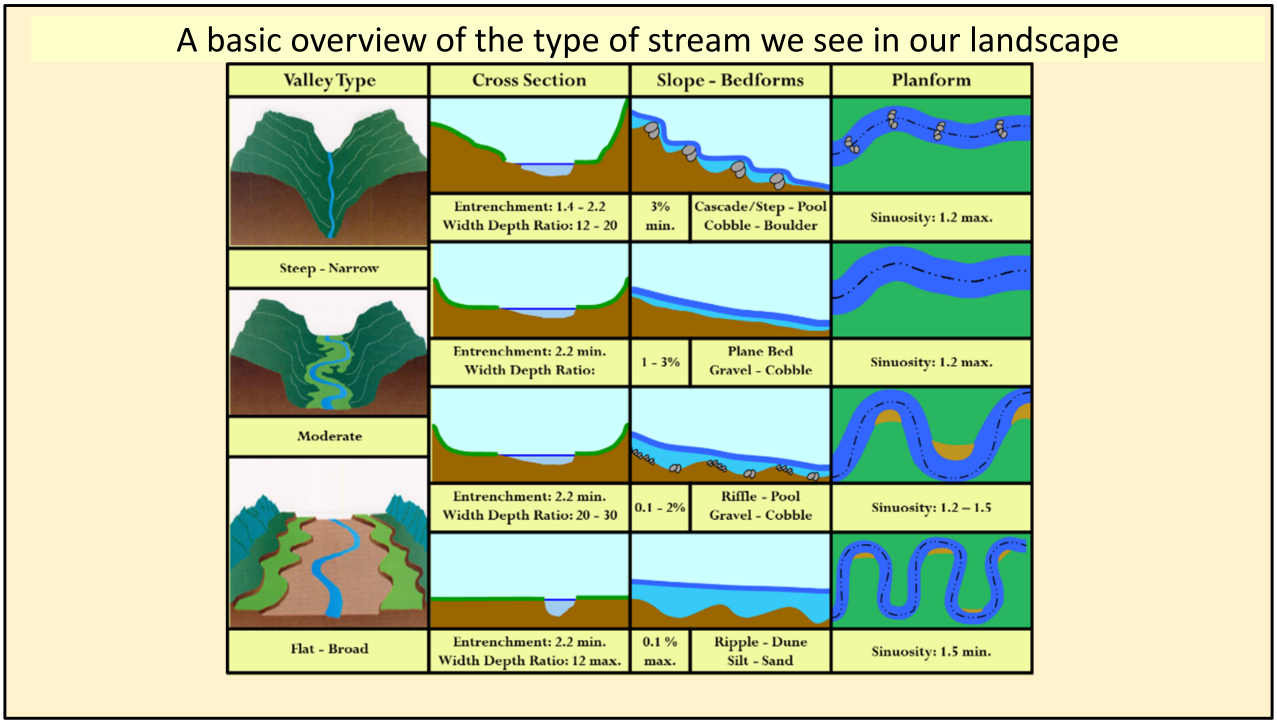
The valley setting also influences the shape of the river.

Features that we focus on are the:
- cross-section (what the stream and valley look like if you were to cut a perpendicular slice across it);
- planform (the meander pattern of the stream across the landscape – how you might see it from a birds eye view);
- profile (the slope of the stream); and
- bedform (the features that make up the channel bed of the stream).

These are important to understand as they are key features in the stream that we can affect with our projects. Changes to these features can have impacts to both the stream and the project.

Knowing more about these features helps us determine what type of stream condition we have in the current condition and what may be achievable to improve conditions and/or reduce impacts to both the stream and project area.

We will focus on the Cross-section and stream profile for this presentation. These features have been changed in many of Barre's streams, and will be important to understand as we look at strategies for addressing various types of flooding and stream process that were seen during the July flooding.

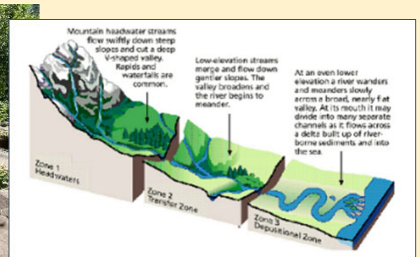


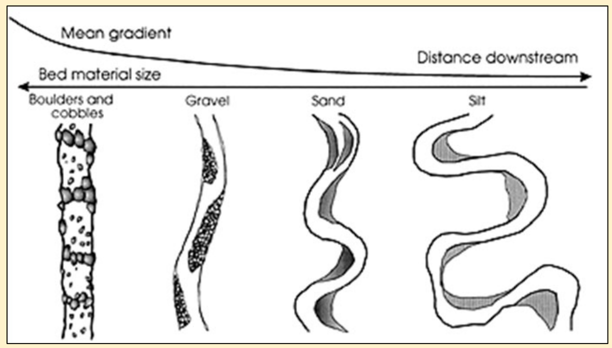
This table provides an overview of the basic characteristics we may see in a stream based on the valley type it is in.

As we begin to know more about the valley and landscape the stream is moving through, we can begin to make some general assumptions about the stream characteristics that we may expect.

I encourage you to start to look at the streams you live by and/or drive by and think about what are the stream characteristics you can pick out and how those fit into the landscape you are in.

Sediment Size & Storage





Streams transport and store sediment throughout their system. Different locations in the watershed are more likley to transport or store sediment based on their valley setting.

Steeper and confined streams generally have larger boulders and cobbles for their stream bed materials. Steeper and confined streams typically do not have floodplains associated and most excess and smaller materials will be transported from these areas. These streams can store excess sediment in their channel where there is materials such as wood or large boulders that help trap the sediment from moving down the channel.

As the valley becomes slightly wider and the slope is less steep, the size of the sediment in the stream becomes smaller cobbles and gravels. These streams will be both a transport and storage areas for sediment, as valleys will have some floodplain available, and channels begin to have sinuosity where gravel bars and storage of sediment may occur.

The wide and lower valley streams typically have low slopes and wider floodplains that allow for sediment deposition and sediment storage. Stream materials are smaller, tending toward small gravels, sands and silts.

Large Woody Material

Large wood materials are an important feature in our streams.   While it may look messy, it provides critical roughness and structure to the stream that helps with sediment storage in the stream and reducing velocities in the channel during high flows.

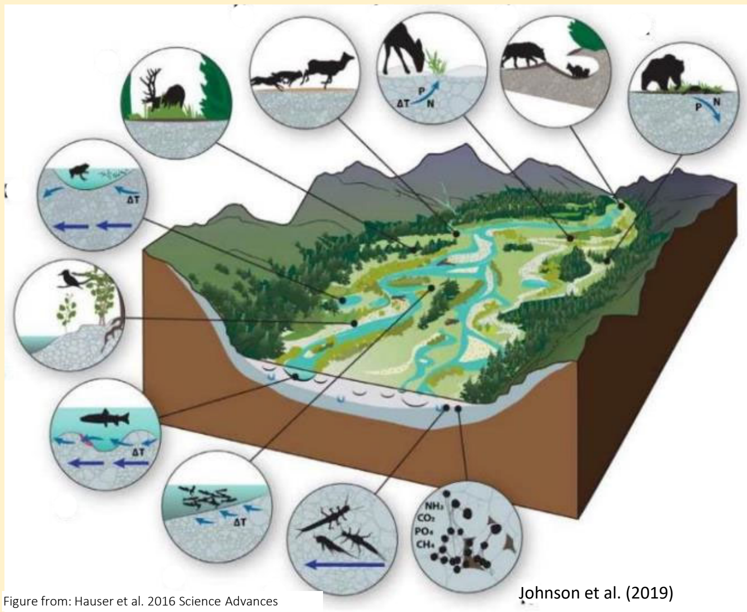
Wood is also a vital part of stream habitat for fish and other wildlife.

Riparian Vegetation

Riparian vegetation is an important part of stream stability as it provides structure and binding properties for the stream banks and floodplains. Tree and vegetation roots help hold the soils in place and provide resistance to erosion during high water events.

Vegetation along the stream banks and floodplain are important habitat features, such as providing shade to maintain cooler temperatures, suppling food to the system, and creating travel corridors for terrestrial animals.

Aquatic & Terrestrial Habitat



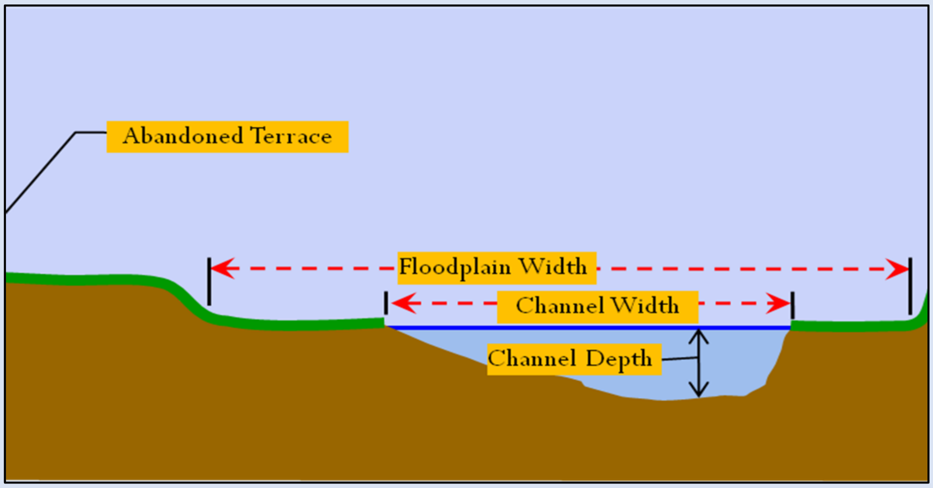
Our river and floodplains are home to a mix of aquatic and terrestrial animals that rely on these systems. Work that we do in and along our streams and floodplains can affect the habitat of different species.

As strategies are considered for restoration and flood resiliency it is important to consider habitat as part of those efforts.

Now, with a little more knowledge about stream characteristics; let’s take it to the next step by looking at how our project interact with the river system.

Looking at **Vertical & Lateral** Connection

How connected the Channel and Floodplain are to each other

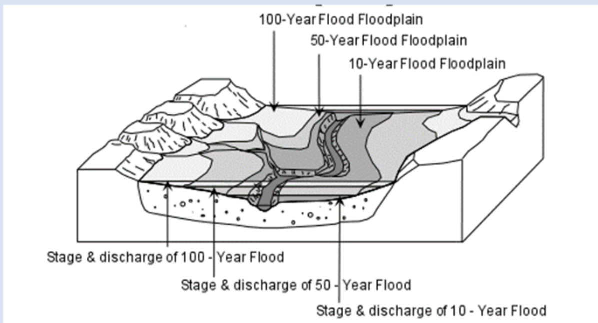


Understanding how the stream is connected to the floodplain provides the basis of how we can approach efforts flood resiliency and water quality efforts.

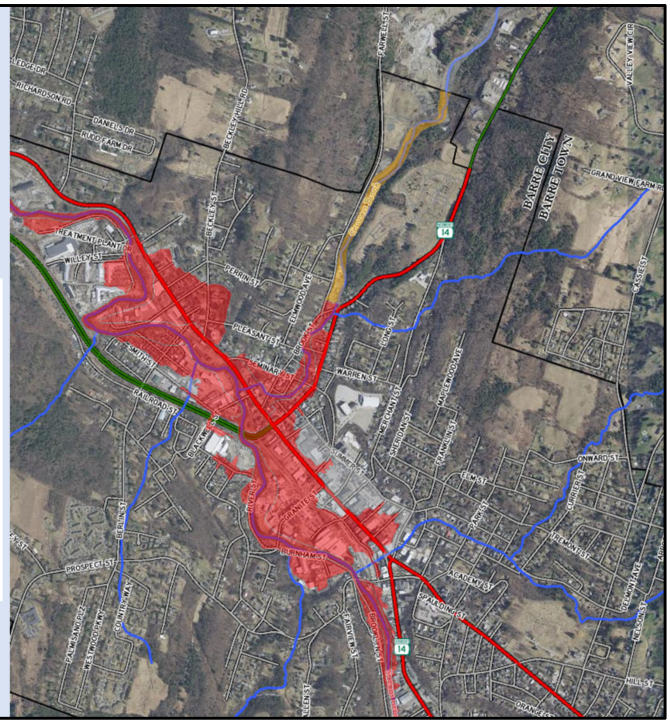
We look at the cross-section of the channel to determine how well the channel is vertically and laterally connected to the floodplain.

Inundation Flooding

Vertical connection of the channel to the Floodplain



Prof. Stephen A. Nelson, Tulane University, 2015



The channel's vertical connection to the floodplain is determined by how deep the water must get in the channel before it is able to access its floodplain. In VT, it would be expected that streams in moderate to lower valley settings would have some level of floodplain and would see floodwaters access those floodplains, on average, every 1.5 to 2 years.

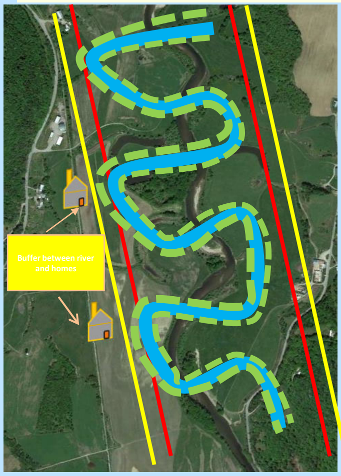
The National Flood Insurance Program Maps (NFIP) provided by FEMA show the area of floodplain that may be accessed during different type of flood events. Terminology, such as "100 year" event are used to describe a flood event of a certain size that has a statistical likelihood to occur in any given year; for example, the "100-year event" has a 1% chance of occurring in any given year and can occur multiple times in a year.

In Barre we can see that not all streams are mapped by the NFIP maps. That does not mean that these streams are not vulnerable to flooding.

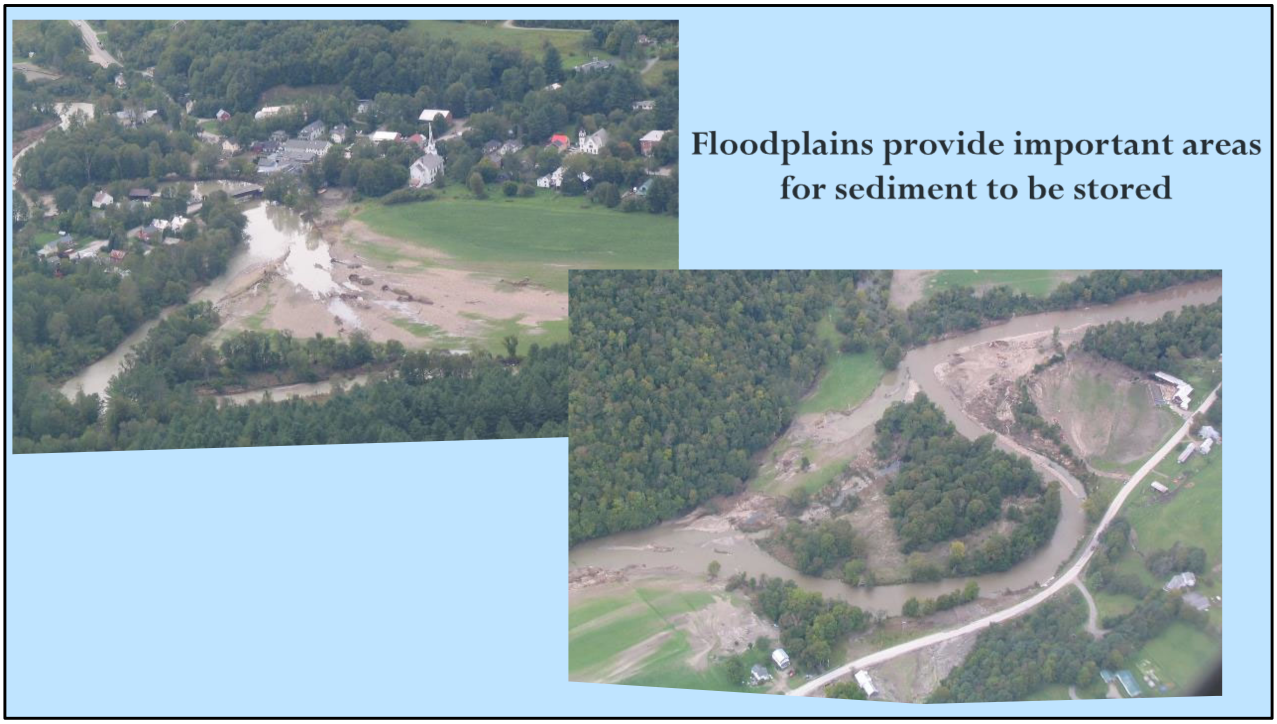
By accessing the floodplain during high water events, the power in the channel is lowered, reducing erosion and channel adjustment caused by excess power contained in a channel. When a channel is disconnected from its floodplain, it is considered vertically unstable. Loss of floodplain connection means more water is held in the channel during flooding; increasing the power in the channel, causing increase erosion and channel adjustment.

Erosion Flooding

Lateral connection of the channel to the Floodplain



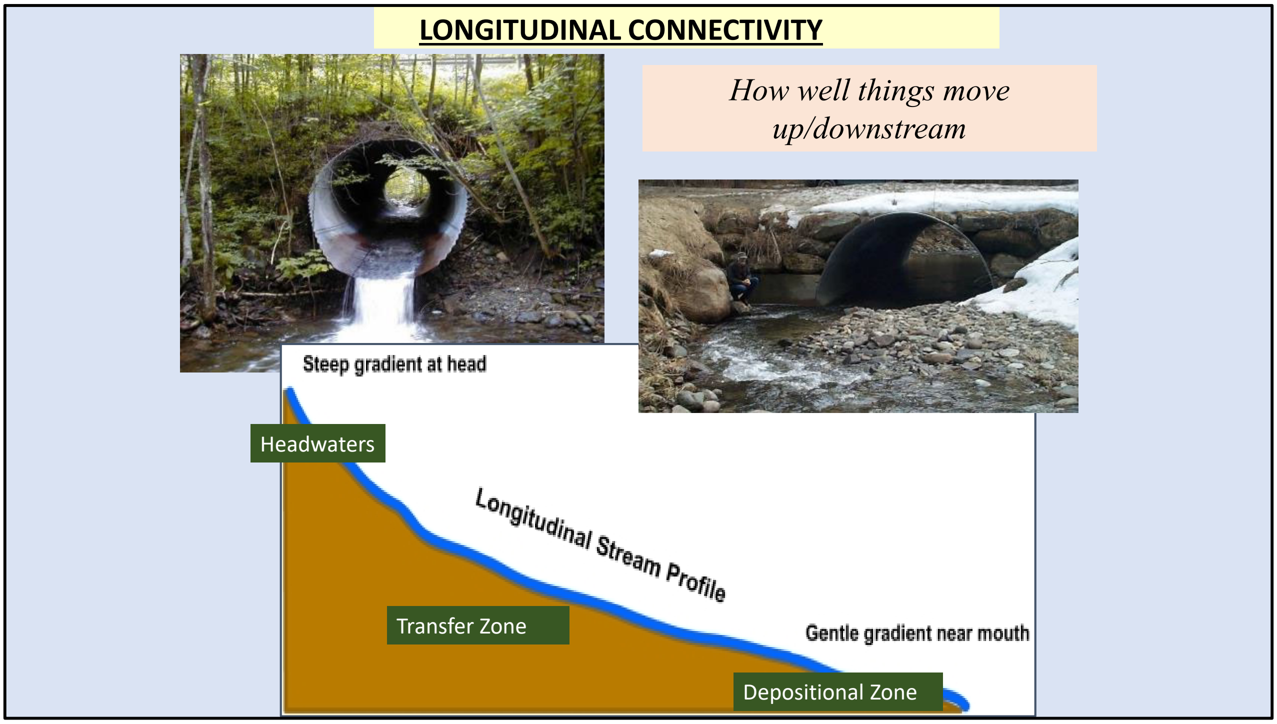
Lateral connection of the channel to the floodplain is seen as channel movement over time across the floodplain. A stable channel is not a static channel, it will move over time. The floodplain area is not only used for floodwaters to spread out on during a flood, but also as the area the channel will use to adjust to the increased sediment, water and debris moving through the channel during flooding.



During flooding, channels are carrying excess sediment that has been input from the watershed. Floodplains provide an important area for sediment storage to occur in the watershed.

Disconnected floodplains means more sediment is being transported further down the river system until the river can access a floodplain somewhere downstream.

To maintain a healthy system and reduce impacts to downstream areas, floodplain connections throughout the watershed are necessary to help store water, sediment and debris during flooding events.

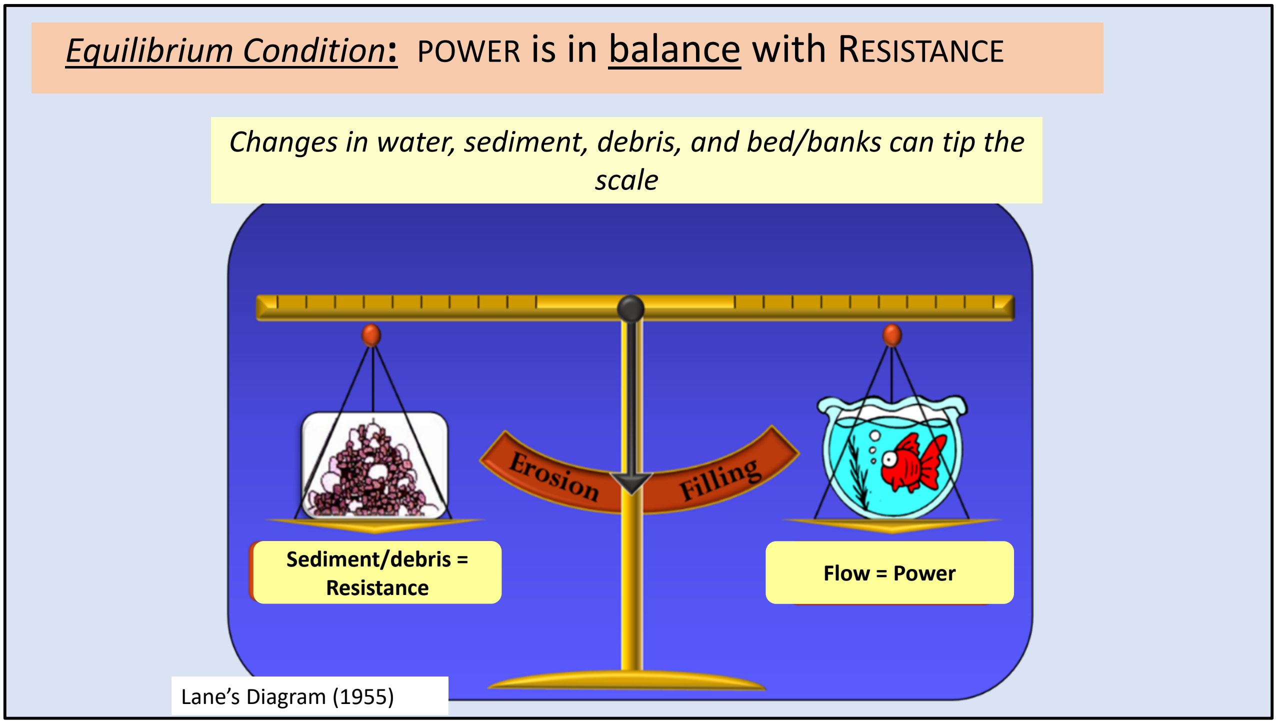


The longitudinal connectivity is how well the water, sediment and debris in the river is able to move from upstream to downstream.

When that connection is interrupted, the channel will adjust to its new condition, changing how materials are stored or transported from an area.

A culvert is a good example of a structure that interrupts the upstream to downstream movement of materials in the river.

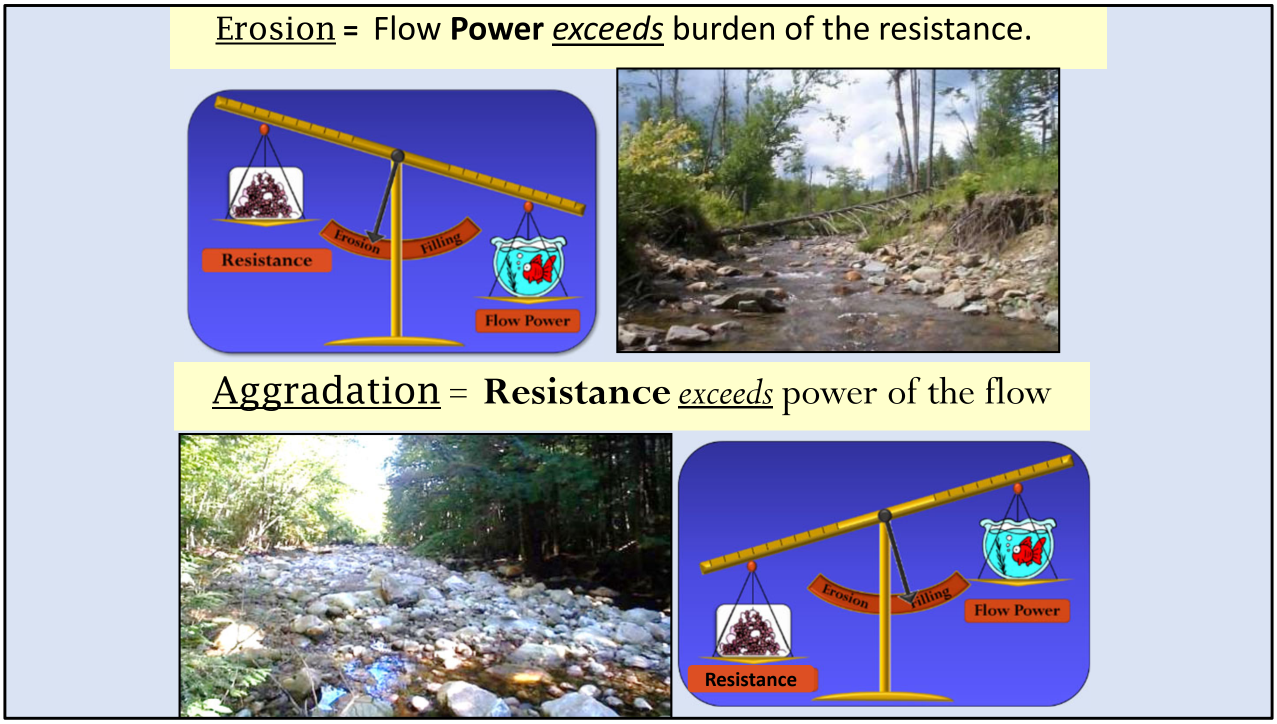
Culverts have historically been put in at a lower slope than the channel and smaller than the width of the stream. This was due to how structures were historically sized only on how much water flow they could pass for a given storm event (think back to that FEMA “100-yr” description), and cost considerations that often made installing a smaller structure a financially appealing option. By only sizing the structure to pass the water, structures often could not pass the sediment and debris moving downstream, causing the structure to become vulnerable to plugging and scouring on the downstream side. These structures become vulnerable to failure during flooding and can increase flooding risk in other areas due to impounding waters upstream and/or release of high water and sediment to downstream of the structure when it fails.
New sizing requirements look at the channel width, slope, storm event to pass, and the type of sediment and debris that needs to be passed through the structure. These structures are more flood resilient and reduce potential upstream/ downstream impacts during flooding.



Lane's balance diagram demonstrates how the channel may respond to a change in the various parameters, such as: sediment load, channel geometry, channel slope, erosion resistance and discharge (hydrologic load)

In a natural condition, the river system is a dynamic balance, it is always fluctuating along its course from filling and erosion, but not tipping too much to either side. Some areas of the watershed and river system are more prone to erosion or filling, depending on where the site is in the system. Think back to those stream characteristics we talked about earlier.

As we look at the work we do on a river for different management objectives and strategies, our goal is not to tip the balance too much in either direction, causing the river to respond in its attempt to come back into balance.



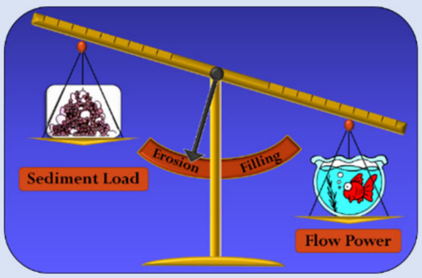
Two processes that are triggered when the balance is tipped too much in either direction.

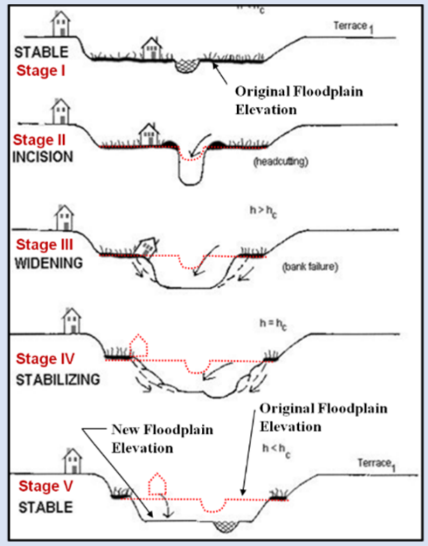
When there is more power than resistance in the channel, the channel bed and banks will erode until the bed and/or bank are more resistant and able to withstand the power in the channel.

When there is more resistance than power, the channel bed materials will build up (aka. aggrade) until the power in the channel can transport the material provided to it from upstream.

Channel Evolution

Severe changes can result in dramatic long-term responses in the channel - known as **Channel Evolution.**





Schumm Channel Evolution Model (1977)

When the balance is tipped, the channel will respond, in what is called the Channel Evolution.

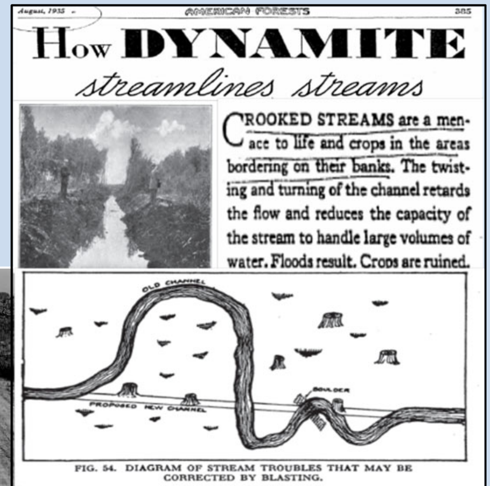
The Channel Evolution model provides a visual way to look at how a channel will adjust over time to changes in the channel, inputs to the channel, and floodplain.

Throughout VT many of our channels are undergoing this type of evolution process as they respond to past and current management practices and to natural flooding and adjustments that have occurred over time.

The Channel Evolution process is used to help understand how a channel may respond to a given change and how our management/project efforts may/may not cause additional adjustment in the river, and to know how that adjustment may/may not affect our project.

Working to not tip the balance is important in not triggering undue channel adjustments that can have long-term affects and response in the channel as it works back toward a more stable dynamic balance.

What are Factors that lead to channel evolution?


August, 1935 — AMERICAN FORESTS 385

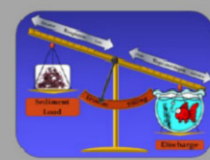
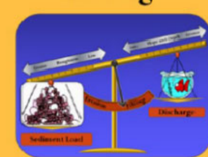
How DYNAMITE streamlines streams

CROOKED STREAMS are a menace to life and crops in the areas bordering on their banks. The twisting and turning of the channel retards the flow and reduces the capacity of the stream to handle large volumes of water. Floods result. Crops are ruined.

FIG. 54. DIAGRAM OF STREAM TROUBLES THAT MAY BE CORRECTED BY BLASTING.

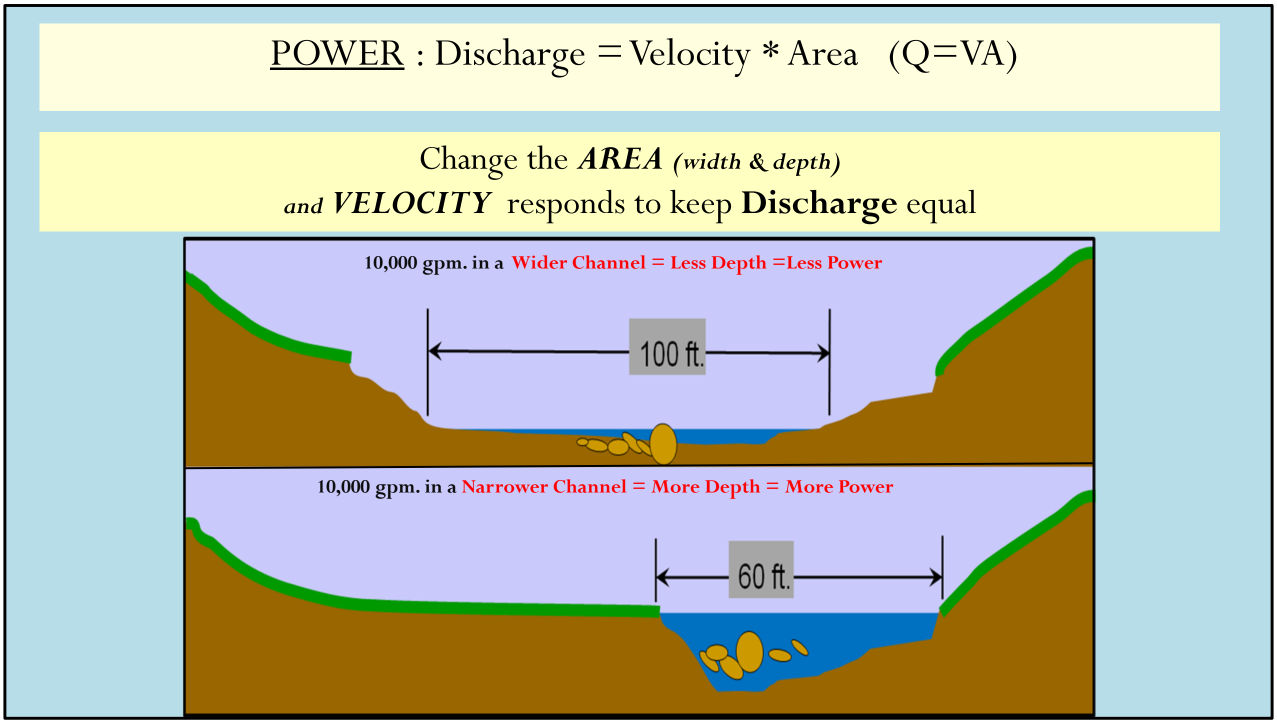
Many factors can lead to that channel evolution.

We are still seeing the channel response from historic practices that changed where and how streams stored and transported the water, sediment and debris they are carrying, and how those streams are connected to the floodplain,

Activity	Resulting Change to Equilibrium Factors	Channel Response
Over Dredging	Increased Depth	Erosion 
Over Dredging	Decreased Resistance & Sediment Volume	
Channel Narrowing	Increased Depth	
Channel Berming	Increased Depth	
Channel Straightening	Increased Slope	
Increased Runoff Rate	Increased Depth & Slope	
Undersized Culvert	Decreased Slope Upstream	Filling 
Channel Widening	Decreased Depth	
Upstream Landslides	Increased Sediment Volume	

This table provides examples of common practices that can tip the balance.

When projects affect the balance the channel will respond, and both the river system and the project will be affected by that response.



A change in the channel's cross-section will affect how the same amount of water moves through the channel.

If we look at 10,000 gallons per minute (gpm) moving through the river we can see a change in the velocity of the water as it moves through a wider or narrower cross-section.

A wide cross-section will have less power due to the area of the cross-section being greater ,and the velocity being slower through the wide cross-section. This could tip the balance to be increase the build up materials in the channel.

A narrow cross-section will have more power, due to the area being less, and the velocity being faster through a narrow cross-section. This could tip the balance to be more likley to increase erosion of the channel bed and banks.

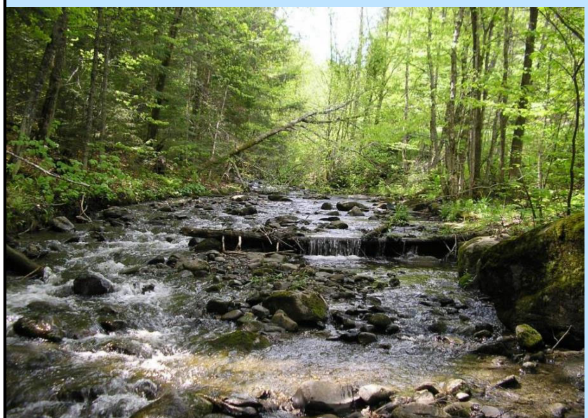
Work we do in the river needs to maintain the right cross-section width and depth in order to make sure we do not change the power in the channel through a change in the velocity.

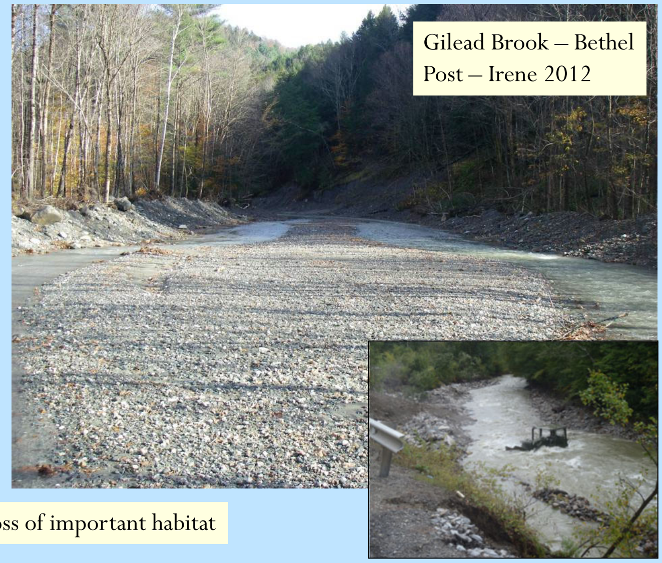
Digging channels deeper to hold more water increases power in the stream

Strategies for flood recovery, such as digging the channel deeper, change the cross-section area of the stream by increase the depth and holding more water in the channel during flooding.   This increases the power in the channel.

An increase in erosion of the bed and banks of the channel is seen as the channel responds to the increase in power.

Resistance = wood and other course material
Removal increases power in the stream





Gilead Brook – Bethel
Post – Irene 2012

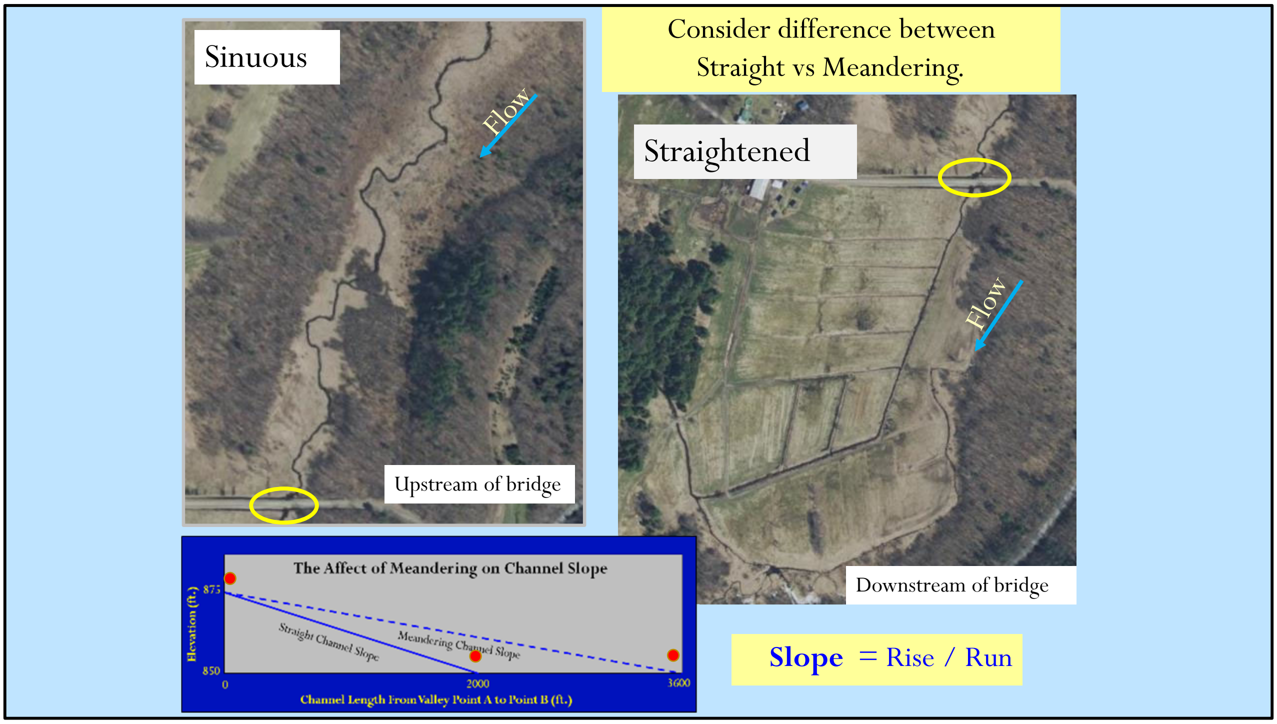
Loss of important habitat

Removal of wood and large sediment deposits is often seen as a strategy for flood recovery.

Wood and sediment play an important role in creating the resistance to the power in the channel. These features help to slow the water, trap sediment and materials in all areas of the watershed. When there is too much wood and sediment removed from the stream, the stream becomes more vulnerable to erosion; because it no longer has the resistance needed to prevent the increase in power the water will have moving through a smooth channel. This can set the channel up for increased damages in the next flood as the river erodes its bed and banks; and can transfer issues of sediment deposition and erosion to areas upstream or downstream of the area where sediment and wood were removed.

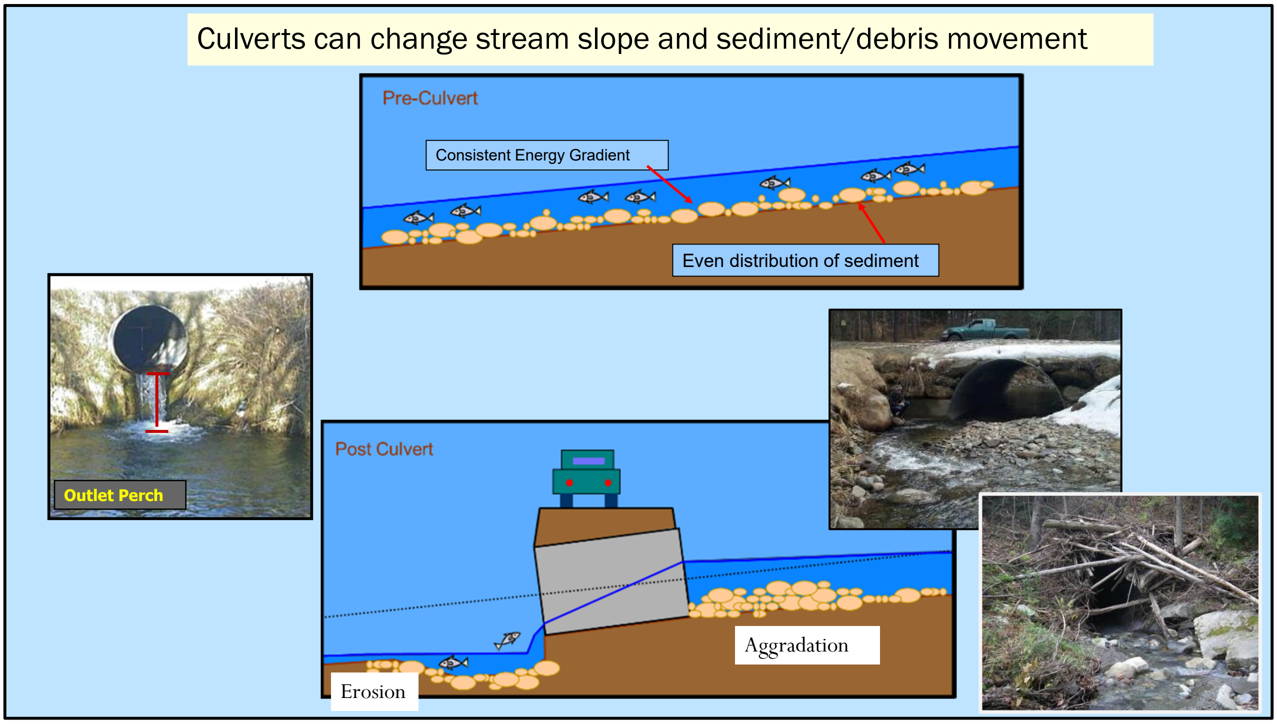
While some removal of excess wood and sediment may be part of the flood recovery work, it is not a strategy to resolve flooding impacts in all areas.

Our work can also impact the habitat in, and along the stream. This not only impacts the fish and wildlife, but it also impacts our communities when we lose these valuable resources, both economically and culturally.



Over the years many of VT's streams have been channelized to a straighter planform.

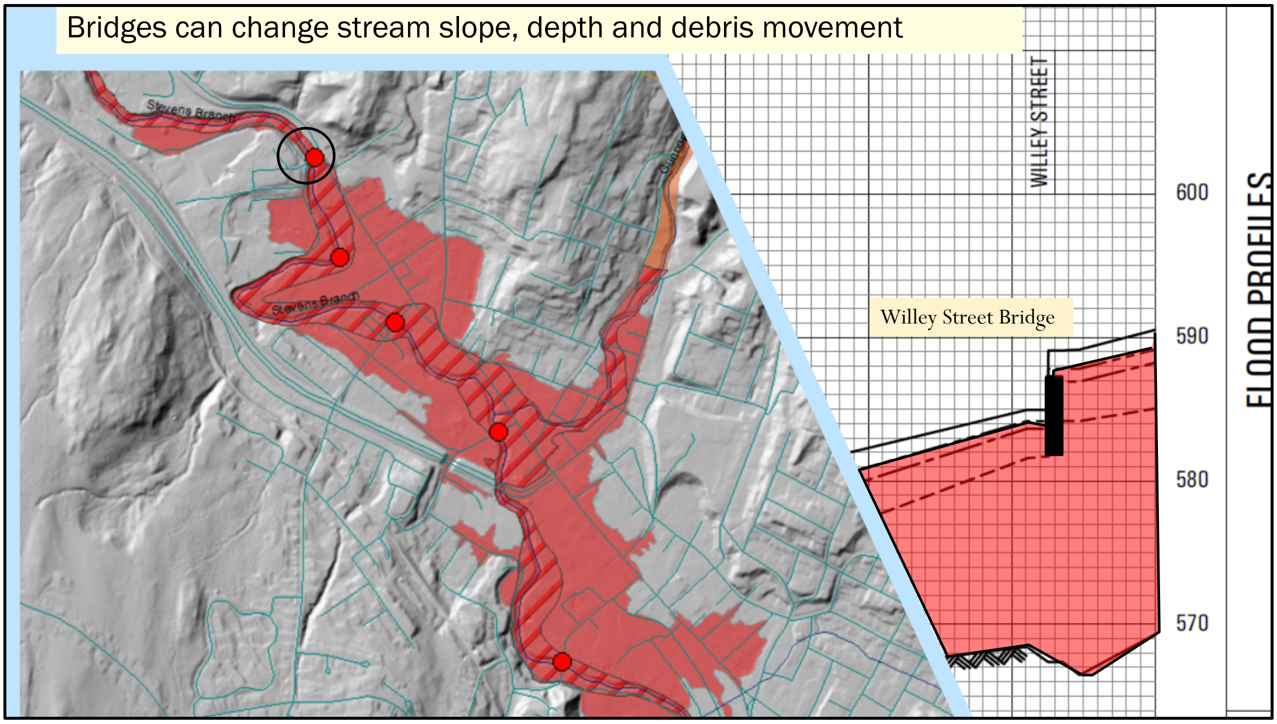
In the example shown in these images, the stream upstream of the bridge (yellow circle on the image) still has meanders, and downstream of the bridge the stream was channelized into a straight condition. Straightening the channel reduced its length and increased the slope. That increase in slope translates to an increase in velocity and power in the channel, tipping the scale toward more erosion.



The culvert is a good example of a structure that tips the balance in the channel in both directions. Culverts that are narrower than the channel width and/or installed without consideration of the stream slope can lead to impacts to both the structure and the stream.

Upstream of the culvert, the power is reduced due to backwatering and lack of ability to move the sediment efficiently through the structure; causing it to aggrade; increasing chances of the culvert becoming plugged

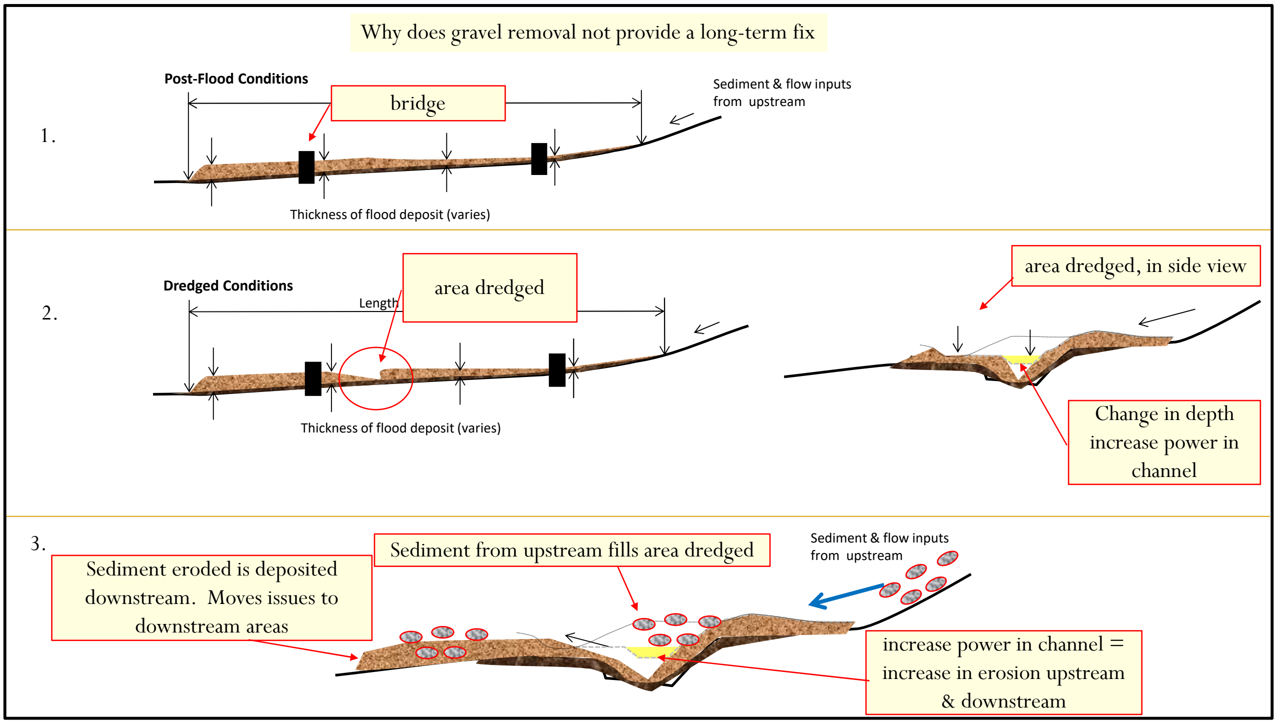
Downstream of the culvert, there is more power in the flow coming from the culvert due to an increase in velocity coming out of the narrower culvert increasing the erosion below the culvert. To help visualize how that velocity is increased, think of putting your thumb over a hose and how the water goes from a drizzle to a spray as you pinch down the area the water has available to come out of the hose. As the water from upstream is squeezed through a culvert that is narrower than the channel width, it has the same affect your thumb over the hose had, causing the velocity and power in the channel to increase through that smaller opening; increasing scour impacts at the culvert outlet



Bridges can also change the stream's slope, depth and debris movement.

The Willey Street Bridge is an example of a structure that has an affect on the floodwaters as they move through the system. The bridge slows the water and impounds water up behind it during flooding. The additional impounding of water upstream of the bridge, can affect how flooding is seen in the areas surrounding the bridge. The slowing and impounding of water behind the bridge also means that the transport of sediment through the bridge is slowed and can cause an increase in sediment deposition upstream of the bridge.

Structures like the Willey Street Bridge are areas where there may be opportunity for reducing flooding impacts through improvement/changes to the structure.



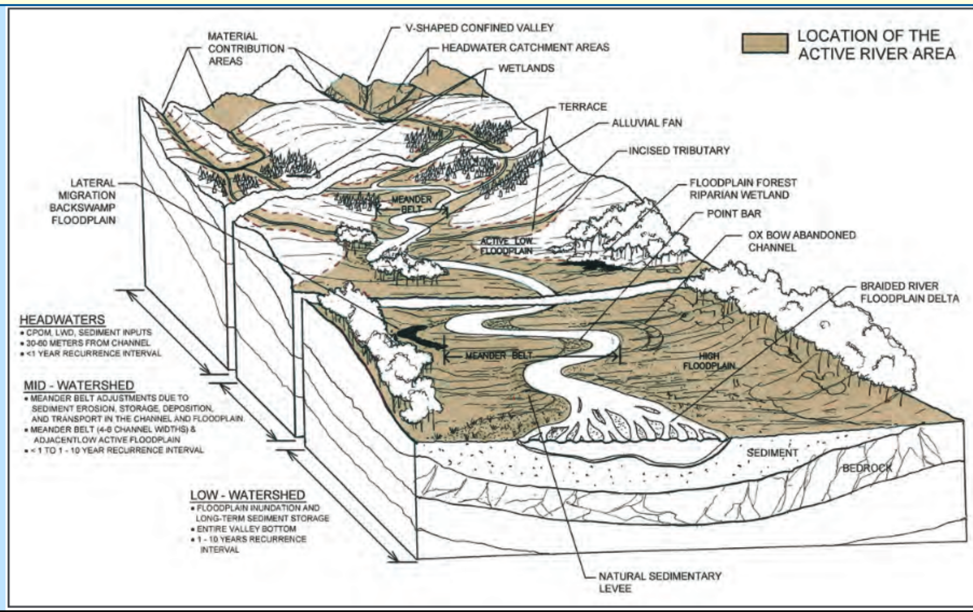
Sediment and wood removal are often viewed as ways to provide extra space in the channel during a flood. The idea being, similar to a bathtub, if you remove material in the bathtub there will be more space to hold more water.

Unfortunately, a river is not like a bathtub and the simple removal of material does not immediately equal extra space for more water over time. That is because the river is moving water, sediment and debris all the time, so the area where sediment was removed will be filled back in again as new sediment and wood are transported from upstream to the area; and if it was an area sediment deposited before, it will again (remember those stream characteristics we talked about earlier). That means that during a flood, there may be a short period of time that there is a little more room in the channel where sediment and wood were removed, but during the flood that space will be filled in again and the capacity for extra flood water would be lost.

Sediment removal in areas that are prone to deposition will not be a long-term fix if the conditions for why the river is depositional are not changed. We can keep digging it out, but it will continue to deposit there.

Watershed and flood resiliency planning can help identify areas where there are conflicts, such as undersized culverts and bridges, where sediment and wood removal will be needed over time to maintain the channel’s capacity in that infrastructure; and determining ways of addressing the undersized structures that could reduce excess sediment and wood deposition caused by the bridge.

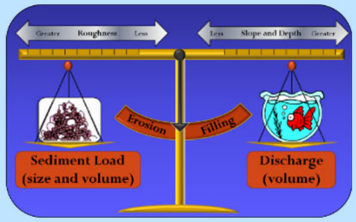
The strategies we use for flood mitigation are affected by where we are & what stream type we're working on



There are many "tools" in our "tool-bag" that are used as strategies for flood mitigation. Having a basic understanding of the river and where the project is in the system is important.

Some strategies are more affective than others, but all must be used with an understanding of where we are in the watershed and what type stream system the work is happening on in-order to be affective at all.

Our actions can tip the scale for a stream's stability and habitat features



If a project is to be successful, we need to understand how our project(s) tip the Balance.

As we work together to figure out what are the ways we can address flooding concerns, part of the goal of our projects will be to make sure we do not tip the balance too much in either direction.

Helping maintain that dynamic balance will improve the results of the project and reduce future impacts to both the project and river from un-intended river responses triggered from our work.

<u>Strategies for our work with the community:</u>

- Identify areas of flooding -
  - What are the reasons for flooding in that area? For example:
    - Inundation
    - Erosion
    - Stormwater
    - Culvert plugged
  - Was it a mapped floodplain?

- Put together ideas for ways to reduce flooding
  - How does it address the reason for flooding?
  - What factors (sediment, wood, water) in the stream are being changed?
  - What are habitat features to consider?
  - Does it take working upstream/downstream of the site?
  - Are there areas where more/less opportunity is available?
  - Is it a short or long-term fix? – Will it require maintenance?

Some ideas for next steps the community may look at for how to learn more about the type of flooding that occurred and questions to keep in mind as strategies are explored to reduce flooding impacts in the future.