



Missouri Streams Fact Sheet



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A stream channel is the path for water and sediment flowing within the stream banks (Figure 1). A stream channel constantly adjusts to changes in streamflow, sediment load, stream slope and vegetation. Channel shape and sediment transport through erosion and the deposition of rocks and sediment make these adjustments. In turn, these changes affect stream habitats, and aquatic and terrestrial life. Natural rates of erosion and deposition make streams healthy, dynamic ecosystems as these processes create and alter aquatic and terrestrial habitats.

A Stream's Struggle to Balance

Over geologic time, streams constantly evolve in response to climatic and geologic processes. Through decades or centuries, a natural stream channel adjusts to streamflow, the amount and sizes of sediment it carries, the slope of its valley and the resistance to erosion provided by geology, soils and vegetation along its banks.



Figure 1

A stream is constantly working toward a natural balance with its primary components: water, sediment, energy and vegetation. This balance is often called a *dynamic equilibrium* because the primary components are always changing as climate and landscape change. In other words, the stream is trying to hit a moving target as water, sediment, energy and vegetation naturally fluctuate over time.

A stream reach, or section of stream between two defined points, is said to be in a dynamic equilibrium when the sediment load leaving the reach is equal to the load entering the reach. The shape of a *stream reach* in dynamic equilibrium can change, but erosion in the reach is balanced by deposition. When *scouring* of the streambed occurs progressively throughout a reach, the channel is degrading.

Channel degradation is caused by decreased sediment load, increased streamflow, decreased channel width, floodplain constriction or increased slope due to natural process or activities such as gravel dredging or channelization. A reach is aggrading when deposition of sediments steadily fills the channel. *Channel aggradation* reflects an increase in sediment load, a decrease in discharge, an increase in channel or floodplain width or a decrease in slope produced by channel obstructions like log jams, dams and low-water crossings.

Many activities can disrupt the dynamic equilibrium of a stream:

- Dams change flood flows and trap sediments.
- Excessive clearing, urbanization and other changes in a watershed can increase discharge and sediment load.
- Channel straightening, or *channelization* (Figure 2), channel widening, gravel dredging and other activities altering channel slope and shape change how much energy is available to transport sediment.
- Removal of riparian vegetation increases streambank erosion.



These changes immediately cause a strong imbalance between the stream and its primary components. The stream will begin working to regain a dynamic equilibrium through complex sequences of *accelerated degradation*, *aggradation* and streambank erosion, which cause destruction of important stream, riparian and wetland habitats.

Reasons for a stream reach being out of balance cannot usually be figured out just by looking at the problem

Figure 2

area. Changes in water, sediment, *energy* or vegetation that occurred many years ago or far away are often the causes of the instability.

Channel Volume, Velocity and Sediment

A stream channel is formed by flowing water. How much water flows in a stream is determined mainly by precipitation, geology, soils and vegetation in the watershed. The velocity of the flowing water is controlled mostly by the force of gravity and the topography of the watershed: the steeper the topography, the steeper the slopes and channels, and therefore the swifter the velocity. Shape and

roughness of the channel affect velocity, as well as obstructions in the channel and the depth of flow. Resistance created by the roughness of the banks and bed slows the water velocity by causing friction. Channel erosion occurs if the force exerted by flowing water on the stream's bed or banks is stronger than the resistance of the bed and bank materials (Figure 3). These counteracting forces of roughness and water velocity, paired with sediment carried in the water, create the size and shape of the stream channel.



Figure 3

Sediment Load

When it comes to sediment, the amounts and sizes of rocks and soil particles are what affect the stream channel's size and shape. These materials make up what is called the stream's *sediment load* (Figure 4).



Figure 4

To become part of the sediment load, a particle must be eroded and then transported by the flow. Factors affecting the rate of particle erosion include:

- the geology and topography of the watershed
- the intensity, duration and distribution of precipitation
- amount and duration of streamflow
- amount and sizes of sediment
- and in-channel erosion factors.

Deposition and *scour* are the effects of flow and sediment load affecting one another in the stream channel. Sediments are deposited in the channel when the sediment load is too large and heavy for the energy of flowing water to carry. Scouring can occur when the power of flowing water is greater than needed to transport the existing sediment load. For example, when a dam traps sediment, the water flowing over or through the dam is carrying little or no sediment. So, the water has a lot of excess energy to scour the streambed and erode banks downstream of the dam.

Localized scour and deposition also occur around channel obstructions like rootwads and boulders and can be an important factor in habitat diversity in a stream.

Scour and deposition can be seen easily in most streams. In a meandering stream, outside bends are scoured and much of the eroded material is deposited on bars on the insides of bends downstream.

Sediment load includes *washload*, *suspended sediment* and *bedload* (Figure 4). Washload consists of tiny (floating) soil particles carried by the properties of water rather than by the velocity of the water. Suspended sediment can be soil, sand and gravel carried in suspension by the velocity of the stream that settles quickly when velocity slows. Bedload includes sand, gravel and larger materials that roll and slide along the streambed during floods. Some suspended sediment load and most washload result from *sheet erosion*, *rills* and gullies. Gully and stream erosion are the main causes of suspended sediment and most of the bedload.

Spiraling Flow and Secondary Currents

Water flows down a stream channel in a spiral motion. This spiraling leads to the erosion of outside bends and deposition on the *point bar*. The direction of the spiral is thought to generally flow from the bottom to the top of the water column at outside banks. However, the spiral motion can change direction as flow level changes. In response to channel shape and obstructions, the spiraling flow can produce *secondary currents* (Figure 5). These currents also spiral down the channel, though they generally have less energy than the main current. Habitats created by secondary currents add to the habitat diversity of streams.

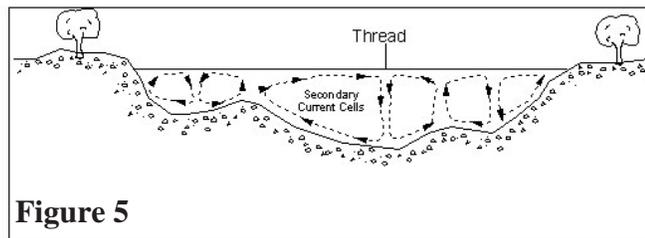
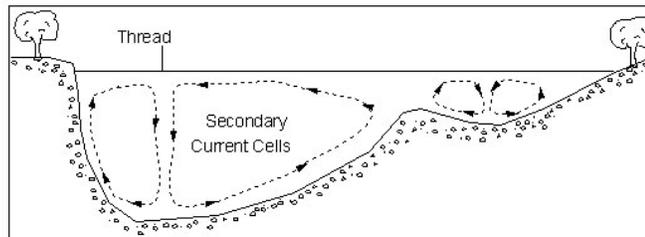


Figure 5

What determines channel size?

Usually, the more water there is to carry, the bigger a stream will be. Therefore, watershed size and runoff are important factors in determining stream size. Unless bedrock or boulders limit channel size, undisturbed streams typically will size themselves to carry the *bankfull discharge*. The bankfull discharge is generally thought to be the natural flow that fills the channel but does not leave the channel. This occurs every one to three years, on average. Although a bankfull discharge is usually not large enough to cause flooding, it is powerful enough to carry a large sediment load.

Individually, large floods carry more sediment but don't occur as often as the bankfull flow. Stream and riparian habitats are changed by large floods, but over time, the bankfull discharge carries more sediment and is generally a stronger influence on channel size than large floods.

Why do different channel shapes exist?

The cross-sectional shape of a natural stream channel is determined by streamflow, the amount and type of sediment carried by the stream and the rocks, soils and vegetation that make up the bed and banks of the channel. Most natural channels tend to be asymmetrical at bends and trapezoidal in



Figure 6



Figure 7

straight stretches. Larger streams are often more rectangular. A stable stream can maintain a fairly constant shape and size because the erosion of one bank is balanced by deposition on the other side of the channel.

Channel slope and erosion resistance of the bed and banks are the main factors affecting channel shape. Changes in discharge will change channel size, but roughness and slope of the channel have more influence on channel shape. For a given discharge and slope, a channel will be narrow if the banks are more resistant to erosion than the bed (Figure 6). If the banks are less resistant than the bed then the channel will be wide (Figure 7).

Banks and streambeds made of hard-packed clay or rock are more resistant to erosion caused by the velocity of the water. Flowing water can more easily erode banks of loosely-packed soils and large amounts of sand or gravel. Because gravel

banks are less resistant to erosion than clay banks, gravel streams are often wide and shallow compared to channels with more clay in their banks. However, a clay bank is more likely to absorb water and then collapse from its weight as floods recede.

Vegetation in the channel helps reduce the flow energy acting on the channel's bed and banks. Roots of plants, trees and further vegetation growing in the bank add resistance to erosion caused by flowing water. Roots below the surface of the bank act much like reinforcing rods in concrete to add

strength to the bank. Tree roots, however, become less effective at reducing erosion as bank height increases.

Channel shape and size often change little as a healthy stream naturally erodes. Streambank erosion and streambed scour are natural and important processes in stable streams. Saying a stream channel is stable does not mean it is rigid. A healthy stream is in balance.

Channel Patterns

Streams also can be described by the pattern of the channel as viewed from above. Most natural channels of streams around the world are straight, *sinuous*, *meandering* or *braided* (Figure 8). These patterns can be found in different streams in a watershed, or even in a single stream. Channel patterns are described by the number of connecting channels and the sinuosity, or curviness of the stream. Differences in geology, slope, streamflow and sediment load create the various channel patterns. Like channel shape, channel size and the *drainage network*, channel pattern can change over time and over the length of a stream. Note the difference between natural braiding (Figure 8) and the unnatural channelization of a stream bordered by farmland (Figure 9).



Figure 8

The stream channels in Missouri are mostly meandering. Generally, the rule is *the bigger the stream the longer the distance between bends*. Some naturally straight channels occur in headwaters streams and (in larger streams) where bedrock controls the meandering patterns. Even in straight reaches the deepest part of the channel, called the *thalweg*, curves back and forth. Valley walls often control the channel pattern in headwater streams. Channel pattern in wide valleys of *alluvial material* such as clay, silt, sand and gravel is not as influenced by the landscape.

Before humans attempted to tame them, the Missouri and Mississippi rivers had braided stretches. This braiding added to the variety of aquatic and terrestrial habitats like wetlands and produced diverse and abundant populations of fish and wildlife. Some reaches of channelized streams in North Missouri have become braided. In these damaged streams, erosion of the streams'



Figure 9

beds and banks causes excessive sedimentation in the channels. As flowing water moves, it redistributes the excess sediment load and braiding develops. This unnatural braiding provides long stretches of unstable, shallow, sand-laden channels, providing poor quality aquatic habitats. Although braiding is a natural process, it also appears in streams that have been severely altered.

Sinuosity is a description of how little or how much a stream meanders across its valley. Why streams meander is not fully understood by geomorphologists. Some believe that meandering reflects a stream's attempts to carry its sediment load at a constant rate with as little energy as possible. Others view meandering as a result of flow being directed by natural variations in the materials of a stream's bed and banks. Still others believe it is a combination of the two processes. One thing is certain: despite many attempts by humans to the contrary, streams do not "want" to go straight! Occasionally a stream will naturally cutoff of a meander loop when it becomes too sinuous for the slope of the valley or channel, or when flow is obstructed by sediment or debris. Still, the overall pattern of a natural stream will always be meandering.

Stream channels are the ultimate adaptors.

Streams constantly adjust to balance the water and sediment loads they carry. Everything we do in a watershed that changes one of the primary components (water, sediment, energy or vegetation) will ultimately be reflected in the stream channel as it changes to adapt to that watershed alteration.

Many Missouri stream channels are still adapting to changes that were made to their watersheds over 100 years ago. These changes include extensive logging in the

Ozarks for railroad ties and extensive channelizations in North and Southeast Missouri for agricultural purposes. The original and channelized pathways of the Missouri River are shown in Figure 10. These practices changed the water, sediment, energy and vegetation components and ultimately continued to affect stream channels, habitat and aquatic organisms as the channels still try to regain equilibrium.

We can learn many lessons from the past. By minimizing our watershed alterations, future generations can enjoy stream channels that are in balance and able to support diverse aquatic life.

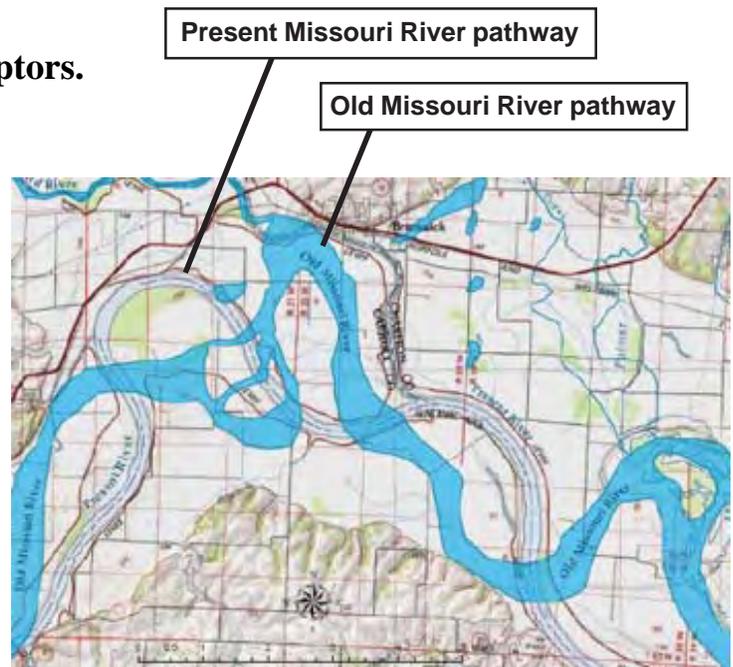


Figure 10