# Missouri Streams Fact Sheet

## WATERSHEDS

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> *Watersheds are extremely complex systems and their features are constantly changing.*

A *watershed* is the total land and underground area that supplies water, sediment and dissolved materials to a stream. The area of land that water runs off of before it drains into a stream is called a *surface watershed, catchment area, drainage basin* or basin (Figure 1). A surface watershed catches snow, rain and other types of precipitation that fall on the land. Then the surface watershed delivers some of the precipitation to the stream. Uplands, floodplains, riparian corridors and stream channels are all part of the surface watershed. Just as important as the surface watershed is the underground area, called the *recharge area* or *groundwater source area*, that delivers groundwater to a stream.

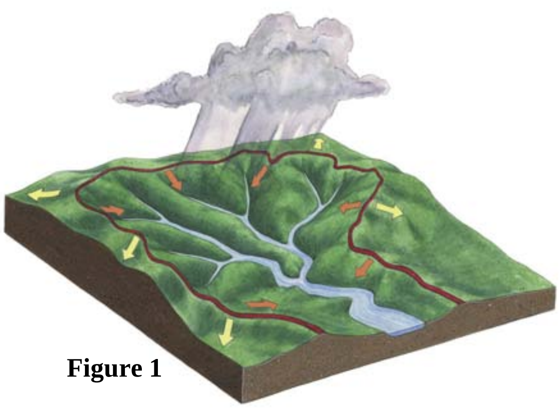

**Figure 1**

### What factors control how a watershed works?

Climate, geology, topography, hydrology, soils, land use and other factors influence watersheds and the streams that flow through them. We have to understand how these factors affect watersheds and streams before we can protect those systems. We also need to understand how and why different parts of the watershed form and change.

### Climate

*Climate* is the major force shaping the land and controlling streamflow. The climate of an area is determined by the area’s latitude, elevation, vegetation, topography and nearness to the oceans or other large water bodies. Together these factors determine temperatures, humidity, wind, precipitation and evaporation in a watershed. Weathering factors, such as rain, snow, wind, glaciers and temperature changes, erode soil and rock formations and change the topography of the watershed. Climate also affects streamflow, which creates and changes stream channels.

*Weathering is the chemical and physical actions of air, wind, temperature changes, precipitation, flowing water, plants, bacteria and other animal life that cause rocks to decay, erode and eventually crumble into soil.*

## Geology

The geology of a watershed is important because it influences topography, direction of water flow, shape of the drainage basin, stream bed materials, water quality and biological productivity. Geologic forces cause the earth's surface to rise or fall and, along with weathering, determine the topography of the watershed.

***Geomorphology** is the branch of geology that studies the shape of the earth's surface and the changes that take place over time.*

***Fluvial geomorphology** is the study of how water shapes the land and how the landscape affects water flow and channels.*

Geology affects where and how water moves in a watershed. For example, *karst* areas like the Ozark region have geology of limestone or dolomite that have openings where water has dissolved the rock along cracks and between layers. These openings act as direct routes to funnel water very quickly to the water table. These routes not only affect quantity of water in streams and groundwater, but can allow pollutants from the land surface to quickly contaminate the groundwater system.

The geology determines the types of bedrock formations, or *parent materials,* and the associated soils of the watershed. The parent materials and the soils produced from them help determine the water quality, biological productivity and aquatic life of a stream. By supplying the materials that make up the bottoms and banks of channels, parent material and soils also affect how vulnerable a stream is to erosion.

Parent materials also provide controls on how stream channels can develop. Bedrock limits how far down into the earth a stream can easily dig its channel. Bedrock can also control the lateral, or sideways, movement of the stream. The best examples of bedrock controlling lateral movement of streams in Missouri are bluffs along streams like the Missouri, Niangua and Big Piney rivers (Figure 2).

**Figure 2**

## Topography

*Topography* is the shape and physical features of land. The topography of a stream channel and its watershed reflects the geology of the watershed. In turn, watershed topography helps produce the pattern and distribution of stream channels. Topography of a watershed also determines the steepness of the land surface and stream channels. We also know this steepness as slope, grade or gradient. The height and steepness of the hills, floodplains and channels contribute to the erosive power of the water in a watershed and its stream channels. Steep slopes allow the force of gravity to quickly accelerate the speed of flowing water. The faster water flows the more energy or power it has to erode and move soil, sand, gravel, boulders and debris.

Topography also affects sinuosity of streams. Channels with low gradients usually meander back and forth, while steep channels do not wind back and forth as much but often have more riffles.

*Missouri's physiographic regions* **-** *Climate, geology and topography all affect conditions in watersheds and streams. As these factors vary across Missouri, so do the physical, chemical and biological characteristics of streams. Missouri streams range from the slow moving, turbid, sand and silt bottom waterways of the Bootheel to the clear, turbulent and chert bottom streams of the Ozarks and to the turbid, sand streams of the northern and western prairies. As you travel around the state it is easy to see that streams reflect the geography and topography of the region, or regions, they flow through.*
*Geographic areas with certain combinations of topography and geology are called* *physiographic regions. In Missouri, the major physiographic regions are the Central Plains of Northern and Western Missouri, the Ozark Plateaus and the Mississippi Alluvial Basin of the Bootheel (Figure 3).*

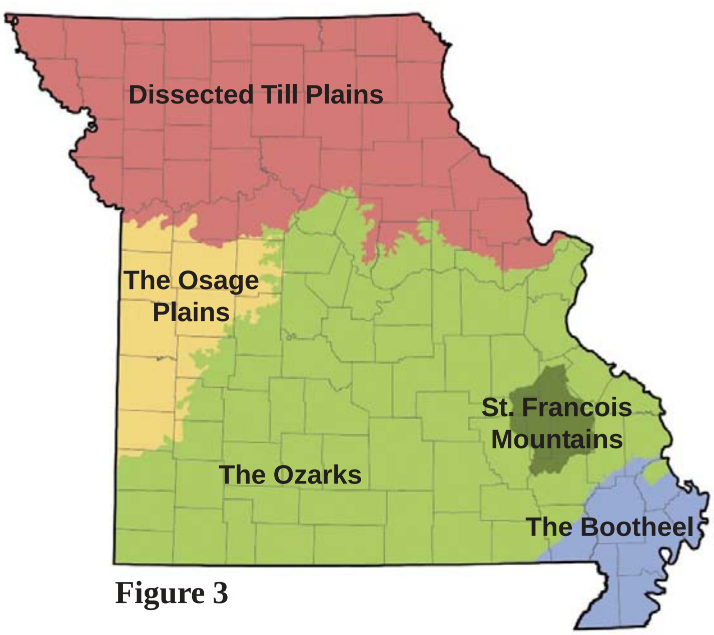


**Figure 3**

## Hydrology

*Hydrology* is the science that deals with the properties, distribution and circulation of water in the atmosphere, on the land and underground. Short-term and long-term climatic conditions affect how much precipitation is available to shape and develop the features of a watershed. The amount, type and timing of precipitation directly affect erosion and deposition in a watershed. Hydrology of a watershed is greatly affected by how much precipitation and temperature vary over time.

## The Hydrologic Cycle

The circulation of water from the oceans to atmosphere, to land, to lakes and streams and back to the ocean and atmosphere is known as the *hydrologic cycle*, or the water cycle (Figure 4). Water movement through and between these various places is irregular and cyclic. The quantities of water falling as precipitation, evaporating from exposed surfaces, transpired by plants, stored as groundwater or contained in stream channels, ponds and lakes varies from day to day, season to season, and year to year. This variation helps produce dynamic aquatic and terrestrial ecosystems.

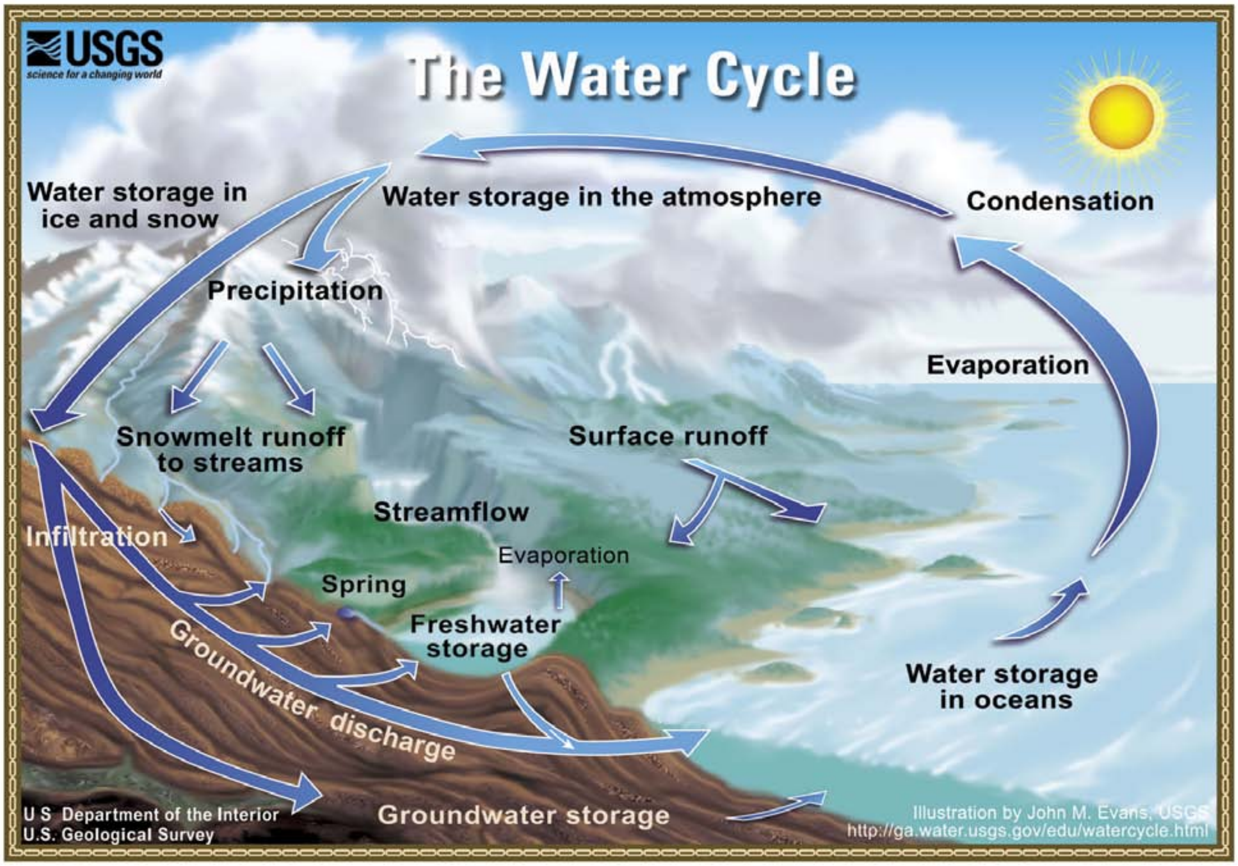


**Figure 4**

The four basic parts of the hydrologic cycle are *precipitation, evapotranspiration, storage* and *runoff*. Precipitation includes rain, hail, snow and other forms of moisture falling from the atmosphere to the earth. Evapotranspiration returns water vapor to the atmosphere through evaporation from surface water and through transpiration by plants. Most of the precipitation falling on Missouri is intercepted by depressions or vegetation and is then evaporated or transpired back to the atmosphere. Water that remains in wetlands and lakes or soaks through the ground and infiltrates to groundwater is called storage. Runoff, or overland flow, is water that hits the earth and flows over land and into channels.

*Base flow* or groundwater flow is the precipitation that percolates deep into the soil and is slowly released over weeks or months to a stream channel or spring. Base flows sustain many streams and springs during long, dry periods.

***Evapotranspiration*** *is the process of transferring moisture from the earth to the atmosphere by evaporation of water and transpiration by plants. Solar energy, temperature and wind cause water on the earth's surface to change to vapor through evaporation. Transpiration is the process by which water is evaporated from the pores of plant leaves.*

## Water Shapes the Watershed

Precipitation and runoff sculpt the land surface. Each watershed has its own runoff patterns and erosion rates that depend on geology, vegetation, land use and topography. Changes in runoff can increase erosion and sedimentation of the land surface. Excessive runoff can cause downstream flooding and accelerated erosion of the land. Too much runoff can also cause destructive amounts of streambed and streambank erosion as channels adjust over time to carry more water. High runoff can also increase the amounts of soil, sand, gravel, nutrients and pollutants flushed into streams.

*Water at the top of a stream has a certain amount of stored energy called potential energy. The elevation above sea level determines how much potential energy the water has. The farther above sea level the water is, the more potential energy it has.*

*As water moves downstream, its potential energy is converted to kinetic energy - the energy of motion. Most of this kinetic energy is changed to heat through friction between the water and the stream channel.*

*The kinetic energy that isn't changed to heat does the work of eroding and transporting sediment. The energy expended to do this work is known as stream power. Stream power is the energy that forms and shapes stream channels.*

## Soils

Soil is unconsolidated (loose) mineral matter on the surface of the earth. Soil can support plants because physical, chemical and biological processes have changed it. In turn, plants and their roots influence the soil.

The most important features of soils are their ability to soak-up, hold and transport water, support plants and cycle nutrients. Soils directly affect the kinds of vegetation that can grow along a stream, on floodplains and in the watershed. Soils can reduce water and air pollution by buffering agricultural fertilizers and pesticides, organic wastes and industrial chemicals. Many physical, chemical and biological properties determine the quality of a soil. Soil depth, texture, water-holding capacity, porosity, nutrient and mineral levels, organic matter content and actions of organisms like moles, earthworms and bacteria all affect soil quality.

*Runoff, precipitation that reaches the ground and quickly flows to a stream, equals Precipitation minus Evapotranspiration minus Groundwater Storage.*

Under natural conditions, soil at a given location can reach a balance between inputs and exports of substances. This balance depends on local climate, geology, vegetation and topography. Inputs of minerals by weathering and of organic matter by decomposition of leaf, root and other plant materials are balanced by export of materials. Some organic materials are decomposed and returned to the atmosphere. Nutrients dissolved in water are cycled through vegetation or percolate through the soil to streams. Solid mineral particles and some organic materials are removed by erosion of the soil.

*Soil erosion is classified as <u>splash erosion</u>, erosion by sheet flow and erosion by channelized flow. Splash erosion is caused by raindrops, which fall at a speed of about 30 feet a second, or 20 miles an hour (Figure 5).*

*When a raindrop strikes bare soil it creates mud that is splashed as much as two feet high and five feet away. Because of gravity, splash erosion results in soil particles traveling farther downhill than uphill. This causes overall downhill movement of soil on slopes. A cover of vegetation intercepts and reduces the impact of raindrops on soil.*

*<u>Sheet flow</u> is runoff that flows downhill on the land surface in irregular sheets rather than in channels. Sheet flow causes erosion of soil particles by rolling them, causing them to hop as they move downward or by carrying them in the water.*

*As water moves over the soil, some concentrates in the paths of least resistance and cuts small channels, called <u>rills</u> and <u>gullies</u>. Rills are small, eroded channels that are only a few inches deep and can be smoothed by a plow. Larger channels that cannot be smoothed by a plow are called gullies. Gullies are often a direct link between the land and streams (Figure 6).*

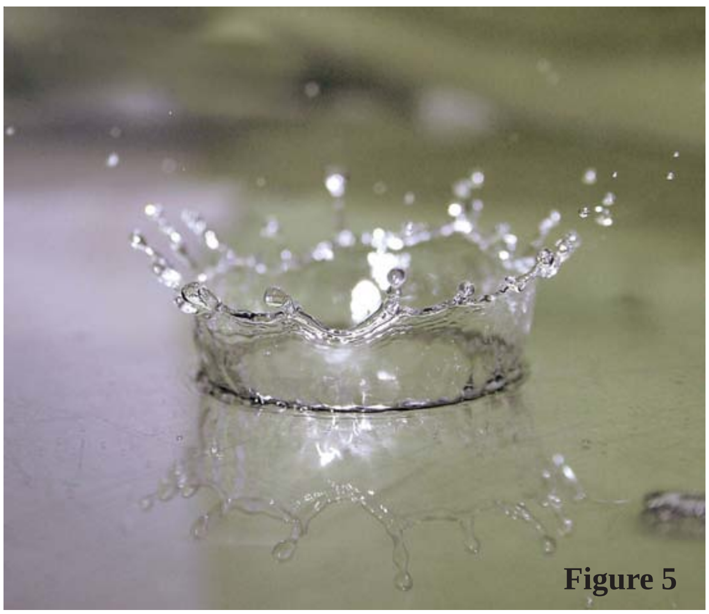

**Figure 5**

**Figure 6**

The erosion that soil undergoes in this state of balance is called the *geologically normal rate of erosion*. Human influences on land usually increase the rate of erosion by significant and sometimes catastrophic amounts. The term accelerated erosion is often used to describe this increase. Accelerated erosion not only can drastically reduce soil quality but can cause downstream deposition that causes flooding, erosion and destruction of habitats.

The rate at which soil can soak up rainfall is called its *infiltration capacity*. Runoff occurs when more rainfall reaches the ground than the ground can soak up.  Infiltration rates depend on the texture and structure of surface soils, vegetative cover and land use. Soil type, soil depth and infiltration capacity determine the amount of subsurface flow. Highly *permeable* soil at the surface, such as tilled soils or forest litter, can allow water to flow downhill and underground to a channel. When the infiltration capacity is reached, water begins to collect in surface depressions. When the depressions are filled, water starts to move downhill as overland flow - runoff. As it travels down slopes, water gains velocity and has more energy to cause soil erosion. When the water reaches a gentler slope its velocity slows and some of the soil it carries will be deposited.

Along with topography and geology, soils determine the route water will take after it falls on the earth. Areas of level topography and deep soils, like northern Missouri, allow the rain and the nutrients and chemicals it carries to slowly infiltrate and *percolate* down into the water table. Soil can filter out many pollutants. In areas of hilly terrain and shallow soils, more of the infiltrated water flows to channels as subsurface flow.

Gravelly streambank soils fill with water and drain quickly. However, the low cohesiveness of gravelly streambanks makes them very susceptible to erosion by flowing water, which can pull gravel and particles of soil from the bank.

On the other hand, clay streambanks are very cohesive and more resistant to erosive energy of flowing water. Unfortunately, clay banks are prone to slide or slump failures. For example, during a flood the clay banks slowly soak up water, but when the flood recedes the water drains slowly from the bank. The weight of the water in the clay bank and low shear strength can cause the bank to slump or fall.

Streambanks are rarely made up of only one kind of soil, though. Different layers of soils are often present in a streambank. This is called soil stratification. Along with bank height and rooting depth of bank and riparian vegetation, the number, sequence and types of soil layers strongly influence how a bank will erode. It is often difficult to predict how a stratified bank will erode because the rate of rise, peak, duration and rate of fall of each flood will dictate which layers are most likely to erode.

## Vegetation and Land Use

The more vegetation there is in a watershed to intercept and transpire water, the less runoff there will be. The amount and type of vegetation in a watershed influence the rates of runoff and erosion in that watershed. Plants reduce the impact of raindrops on soil and slow the speed of water flowing across the surface of the land, allowing more water to infiltrate into the soil. A forested or native grass watershed typically delivers its runoff slowly so soil and channel erosion are usually not severe.

Runoff rates and amounts are usually excessive in watersheds with too much timber clearing, row cropping, grazing, paving, urbanization and other types of development. Runoff increases in these situations because less water is allowed to infiltrate to groundwater or return to the atmosphere through transpiration. Unnaturally high runoff rates produce more frequent, larger and faster-rising floods. Likewise, more runoff can increase erosion of the land surface. More flooding can increase streambed and streambank erosion as channels adjust to the new channel-forming flows.

Many conditions and activities in a watershed can influence a stream. Uncontrolled erosion and runoff from construction sites; row cropping of highly erodible land; construction of houses, buildings and parking lots that prevent infiltration and speed runoff of precipitation; removal of riparian vegetation; improper disposal or excessive application of industrial, agricultural or household chemicals; point and nonpoint sources of nutrients and runoff from strip mines are some ways receiving streams can be degraded. These and other factors contribute to poor water quality, unstable stream channels and unhealthy biological communities. Setting up erosion control practices on construction areas and farmland, limiting the amount of impervious area associated with urban developments and maintaining or establishing areas of timber and grasses are important efforts toward reducing the negative effects on streams caused by our uses of the land.

*The muddy color of floodwaters is caused by suspended sediment - soil suspended by the speed and properties of water.*

## Watershed Size

Watersheds can be big or small. The bigger the stream, the bigger the watershed - at least within areas of similar climate, geology and topography. A small intermittent Ozark stream may have a surface watershed of only a few acres, while the drainage basin area of the Mississippi River is about 1,151,000 square miles (Figure 7).

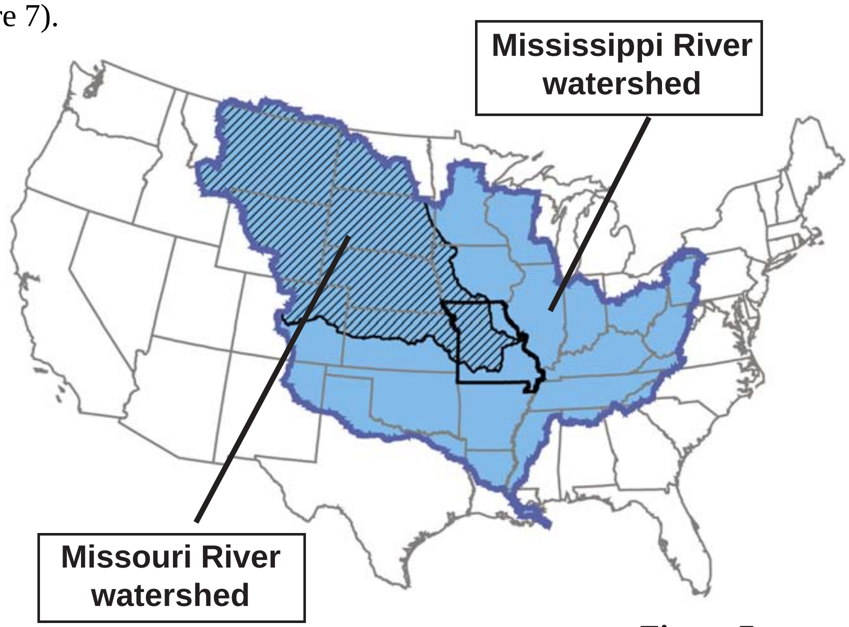


**Figure 7**

In small watersheds, flood levels in the mainstem stream mostly depend on how long it takes for water to run off of the land. Small watersheds have quick peaks and rapid declines in flood flow.  Flood levels in mainstem streams of large watersheds depend on how long it takes for water to work its way down the network of channels. Large watersheds produce floods that last longer but do not peak as quickly. In much the same way it affects delivery of runoff, watershed size influences deliver of sediment eroded from the land and channels.

The shape, or *topography*, of the land surface determines the size of a surface watershed. Surface watersheds can be outlined on maps that show land contours. Fairly accurate watershed boundaries can be drawn using 7.5 minute topographic maps. By following the ridge lines and other topographic divides on a map, you can draw the boundary of the surface watershed that contributes runoff into a particular stream. A drop of water that falls outside the boundary, called the *watershed divide*, will flow into another watershed unless the drop infiltrates to the recharge area of a stream in the outlined surface watershed.

Since the recharge area of a stream is underground, it is usually not as easy to identify as its surface watershed. Scientists commonly use harmless dye tracings to determine the recharge area of groundwater contributions. For some streams that receive much of their water from springs, the recharge area can be much larger than the surface watershed. The recharge area of a stream can be so large that it is important to focus stream conservation efforts on surface watersheds *and* recharge areas.

When outlined on a map, the boundaries of a stream’s surface watershed and recharge area are usually not the same, but they do have large areas that overlap (Figure 8). Remembering that watersheds shown on most maps only match the surface watershed is important. Recharge areas are usually excluded or outlined separately.

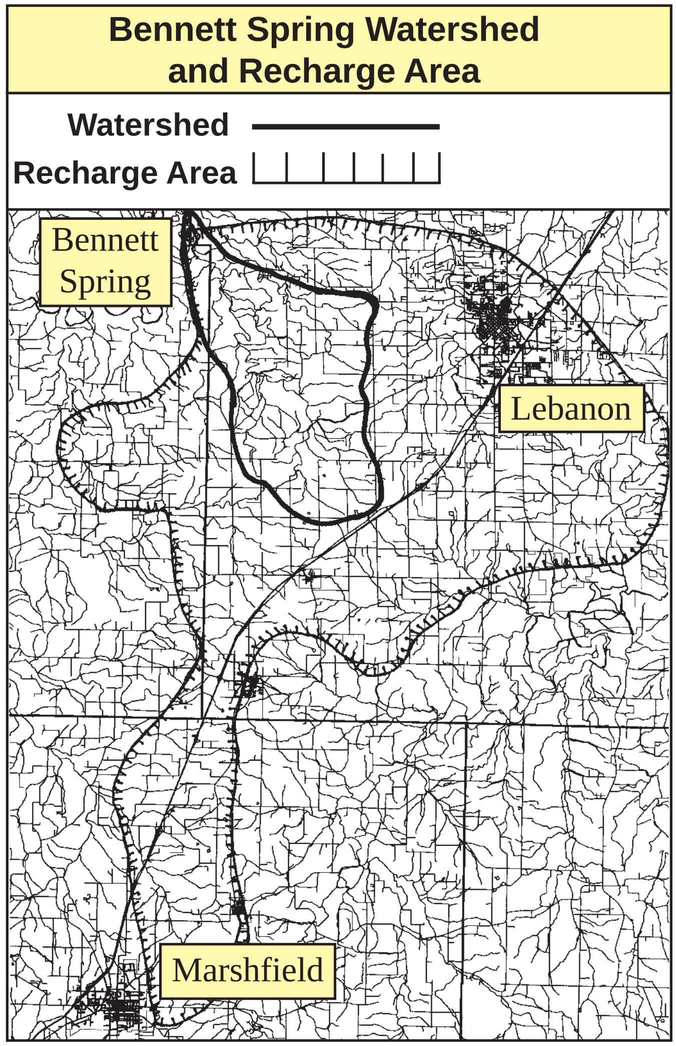


Figure 8

## Stream Order

Calculating watershed size can be time-consuming. You can use a stream classification system called *stream ordering* to quickly compare relative sizes of streams and sub-watersheds within a surface watershed. For most purposes, only streams shown as blue lines on 7.5 minute topographic maps are classified by stream order. The *Strahler method* is the most widely used stream-ordering method. For the Strahler stream ordering method, the intermittent headwater streams shown as dotted blue lines on 7.5 minute topographic maps are called first order streams. Where two first order streams meet, they form a second order stream. Note that where a first order stream joins a second order stream, the larger stream is still second order stream, not a third order. A third order stream is only created where two second order streams flow together. Two third orders form a fourth order, and so on (Figure 9).

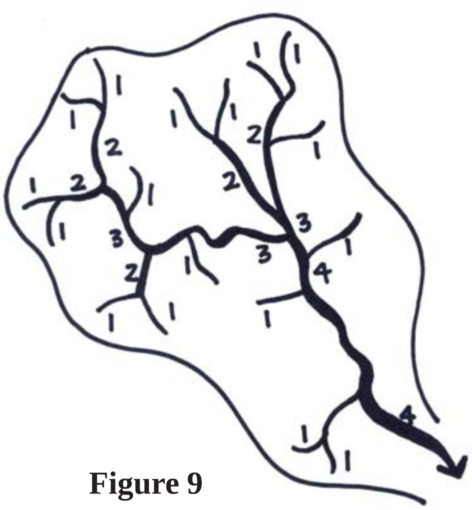

Figure 9

The Strahler method is simple and sensible because larger surface watersheds within a geographic region generally produce larger stream orders. However drainage basin shape can affect stream order, making comparing stream size using stream order less accurate. For example, long narrow watersheds with many first and second order streams can catch a lot of water and produce fairly large streams that are only second or third order streams.

Realizing that inconsistencies between maps and cartographers exist is important, and using different map scales can result in unreliable stream ordering. Knowing the map scales and stream ordering method is important whenever you are comparing stream orders.

## Watershed Shape

Watersheds have many different shapes. Like watershed size, watershed shape affects how quickly precipitation and sediment are delivered to the mouth of the mainstem (Figure 10).

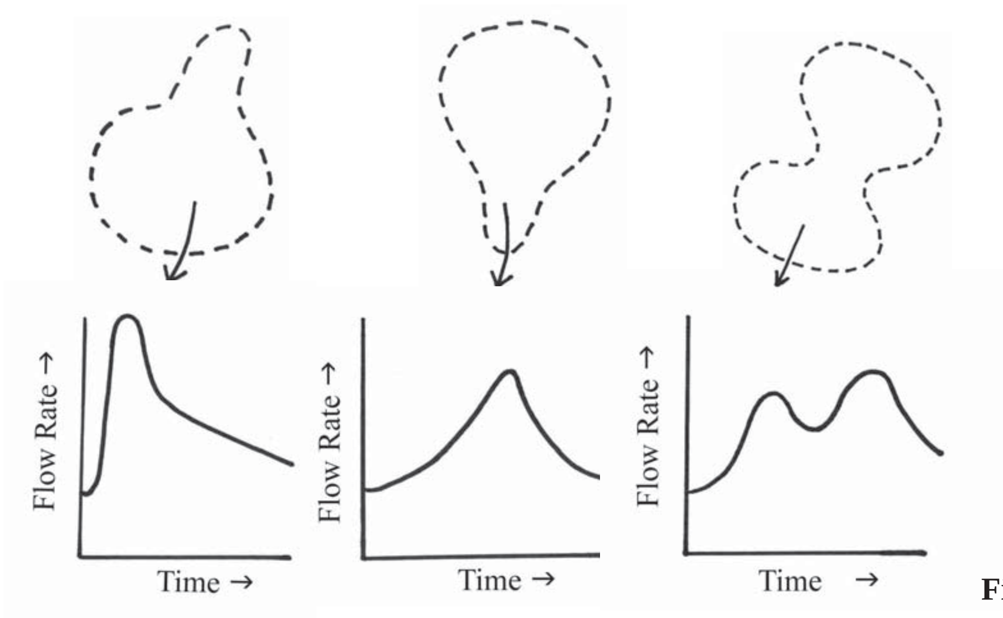


**Figure 10**

A watershed with a round shape produces fast, high flood peaks because water has a shorter distance to travel from headwaters to mouth. Long, narrow watersheds have longer distances for water to travel and will have more moderate flood peaks (Figure 11).

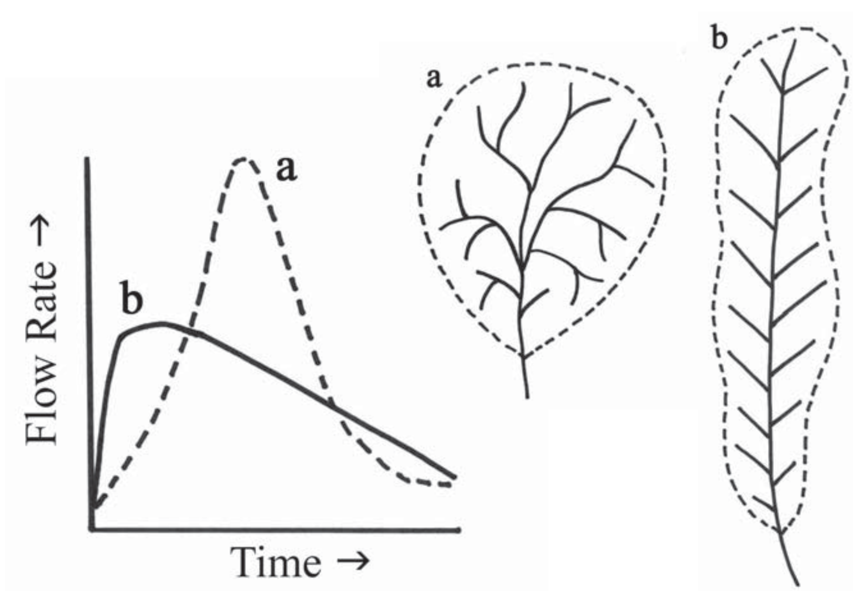


**Figure 11**

## Drainage Network Patterns

A *drainage network* is the entire system of channels on the land surface that transports water, sediment and other natural and manmade materials from a surface watershed. Each watershed has its own, unique network of channels. Drainage networks can consist of streams ranging from small, high gradient headwater channels to broad, meandering streams like the lower Mississippi River.

The look or pattern of a drainage network depends on the geology and topography of the watershed. A stream network evolves as flowing water follows the paths of least resistance. The network gradually grows as the flowing water begins to create channels. Over time the network enlarges as the main channels and tributaries erode their beds and work their way up slopes. This upstream growth also means sediment is continually being added to and transported by the stream system. Eventually the number of tributaries decreases as continuous weathering reduces the relief of the topography and tributaries join (Figure 12 A-C).

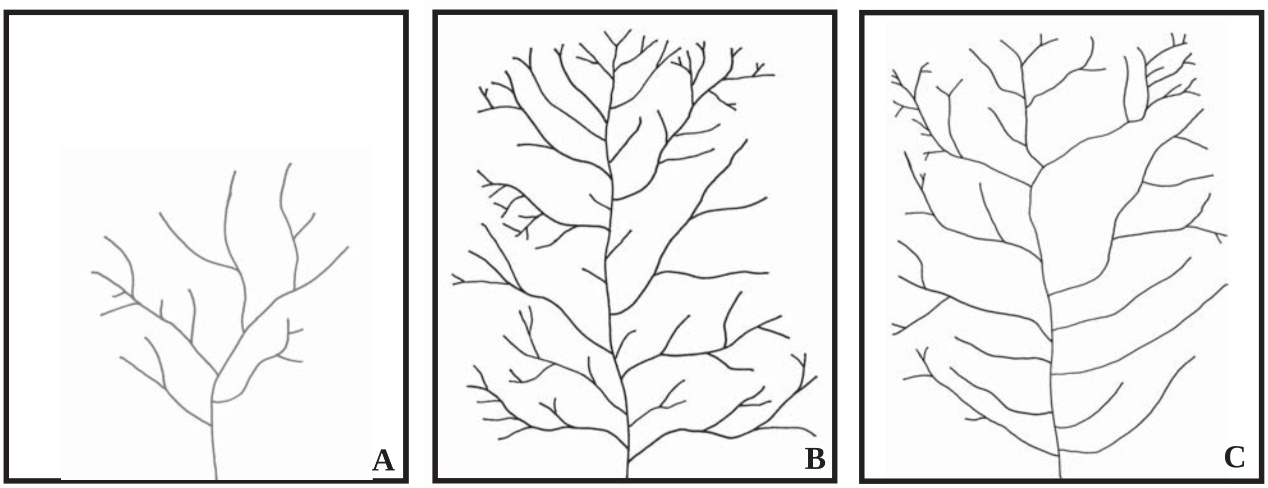


**Figure 12**

One way to describe watersheds is by their *drainage patterns*. Most drainage networks in Missouri show a dendritic pattern, which looks like the branching of a tree.

Drainage patterns, along with the shape of the watershed, will affect the timing and delivery of floodwaters and sediment to each part of the network.

## We’re All Tied Together

Climate, geology, topography, hydrology and soils all play a part in the formation and function of watersheds. These factors provide habitat, nutrients, flow and water quality that aquatic organisms need to survive. Human-induced alterations of watershed-forming factors are common and can change our watersheds, sometimes permanently. Common indications of these changes include flashier streams, steep, eroded streambanks, the filling of stream pools, shallower water depth and many other indicators. Organisms that live in a stream are thereby affected most by watershed changes, but people are affected too. The losses of land by erosion and valuable water resources impact everyone. Therefore, by minimizing land use impacts in the watershed, we can help the resource, aquatic life and ourselves.

## You Can Help

Watersheds consist of uplands, floodplains, riparian corridors, stream channels and ground water. A stream is merely a reflection of these watershed parts. If the watershed is healthy and maintains natural functions, the stream will reflect that. Likewise, if it is not healthy and maintained naturally, the health of the stream will reflect that.

Each of us influences our watersheds by our actions on the land. Therefore, we are all responsible for the health of our stream systems.