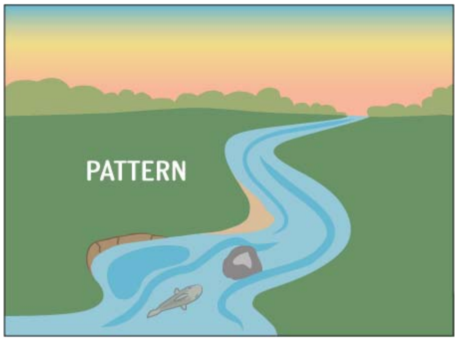
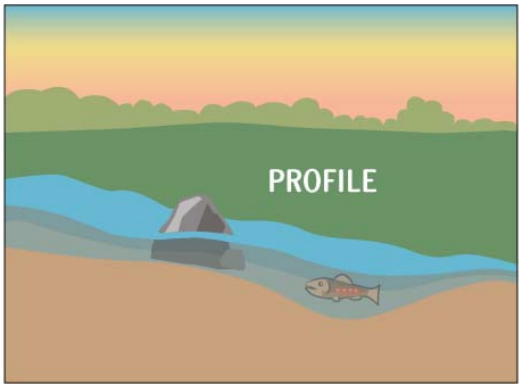
The Shape of Healthy Streams:
Characteristics of Natural Watercourses

Channel stability is an important factor determining a stream's overall health. A stable stream is defined as one that can transport water and sediment while maintaining the channel's width, depth, pattern, and longitudinal profile. Stable streams have predictable shapes based on their watersheds. These shapes are dynamic but their proportions stay relatively unchanged. A stable stream is much less likely to have erosion or sedimentation problems than a disturbed stream.



Rivers and streams of all sizes naturally tend to meander, and the way a channel meanders from side to side is referred to as the stream's *pattern*. Meandering is a fundamental characteristic of flowing water and is critical to the physical stability of the channel and the health of the stream. By increasing the distance that water travels, meandering lowers the slope of the channel. This reduces the water's velocities and tendency to erode the river's banks and bed.



Streams are also sinuous in an up-and-down dimension (a stream's *profile*). It is this vertical sinuosity that gives a stream its pools and riffles.

There is a direct connection between the lateral sinuosity and the vertical sinuosity: it is the motion of the water moving into a bend that creates a downwelling that scours a pool. The opposite can be seen in riffle creation: as water flows through the straight section between two bends, it crosses from one side of the channel to the other, and in doing so it deposits larger sediment particles. The diverse habitats created by meandering streams yield diverse aquatic communities, such as insects, mussels, fish, and plants. Mussels and many aquatic insects filter the water while plants growing on the riverbanks prevent erosion and improve water quality by taking up nitrogen and other nutrients.

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Benefits of healthy, stable, natural watercourses

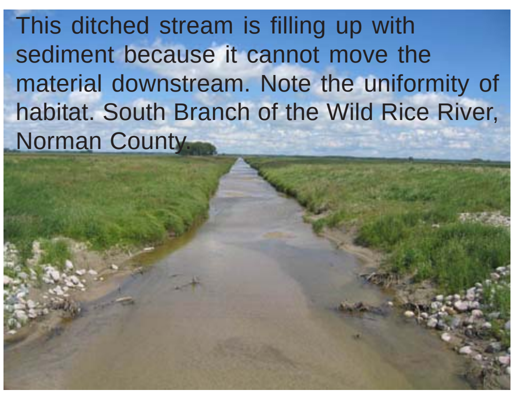
- Maintain themselves by moving their sediments downstream without becoming clogged
- Save time and money that would be spent on channel maintenance
- Provide habitat in the channel and on the banks for fish and wildlife
- Provide opportunities for water-based recreation such as swimming, bird watching, and canoeing
- Reduce downstream flooding
- Process nutrients effectively
- Are aesthetically pleasing

Effects of Ditch Cleanouts

- Create head cuts that move upstream
- Increase erosion
- Increase sedimentation
- Cause direct loss of habitat

Implications

- Generate ongoing maintenance costs
- Produce instability upstream and downstream
- Decrease water quality
- Decrease habitat diversity and quality, leading to a diminished aquatic community
- Cause flooding downstream



This ditched stream is filling up with sediment because it cannot move the material downstream. Note the uniformity of habitat. South Branch of the Wild Rice River, Norman County.

This ditched stream has been allowed to re-establish a meandering channel between ditch banks. Lawndale Creek, Wilkin County.

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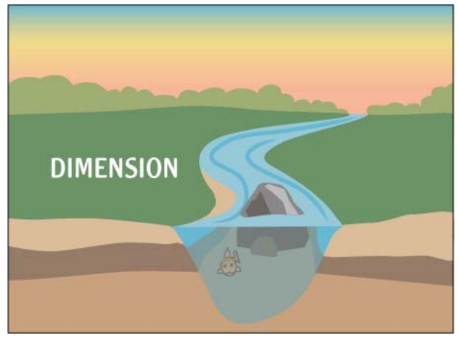


To be stable, streams must also have the proper channel width and depth (*dimension*). Streams that become too wide or shallow lose their ability to transport the sediment supplied by their watershed, leading to stream channel instability.

Another important facet of stable, natural streams is that they consist of two parts, the channel and the floodplain. Stream channels carry floods that occur two out of every three years, on average. These frequently carry the most sediment over time. Larger floods, which are carried in the floodplain, carry large amounts of sediment but occur less frequently. Vegetation growing in the floodplain protects it from erosion during these large floods. This two-stage system efficiently transports both water and sediment from floods of all sizes.

. . . a stream channel reacts to disturbance by attempting to revert to its stable dimension, pattern, and profile and to regain its channel-to-floodplain connection.

Potential for Recovery

Stream channels that have been channelized or dredged in the past have a chance to recover if they are allowed to revert to their stable dimension, pattern, and profile. Frequently, however, when streams begin to erode their new shapes, landowners feel that the best action is to clean out the channel to maintain it in a straight line. In addition to the harm this causes to the ecosystem, it can also be a losing battle for the landowner because the problem will not be solved for long; the river will immediately begin to revert to its stable, sinuous shape.

Permit Requirements

An individual public waters permit is required for most projects constructed below the ordinary high water level (OHWL) of public waters as determined by the DNR. Permit questions should be directed to your local DNR Area Hydrologist. The DNR's Division of Waters website lists Area Hydrologists at www.dnr.state.mn.us/waters. Other government units (federal, state, city, county, township, and watershed authority) may require a permit for that portion of the project within their jurisdiction. It is advisable to contact them.

Causes and Effects of Stream Destabilization

When a channel is dredged or straightened, several changes occur that destabilize and degrade the stream. First, habitat to support native aquatic organisms is lost. Instead of having riffles and pools, dredged streams have uniform beds and lack habitat diversity. When a meandering stream is straightened, its slope is greatly increased. This initiates head cutting upstream of the channelization project and sedimentation downstream of the project. As a result of the head cut, the stream is no longer able to reach its floodplain when flood flows surpass bankfull stage. This leads to bank erosion as the channel meanders again in an attempt to create a new floodplain that corresponds to a new, lower streambed elevation. Large amounts of sediment can be produced by bed and bank erosion, and this can overwhelm downstream channels and ditches, leading to a decline in water and habitat quality. In addition, channels that are mechanically widened to increase their capacity lose their ability to transport sediment and ultimately fill with sand and silt.

Head cutting is a process of active erosion in a channel caused by an abrupt change in slope. Turbulence in the water undercuts substrate material resulting in collapse of the upper level. This undercut-collapse process advances up the stream channel.

Habitat diversity is important even in streams that do not support game fish. Nongame communities of plants and aquatic animals can be very diverse and help to maintain a stream's health. Mussels, for example, may siphon pollutants from water. Many of these streams are tributaries to larger streams, and the nongame species are an important component of supporting the needs downstream. Additionally, plants and mussels play key roles in resisting erosion on the streambed, streambanks, and floodplain.

1. Spring Prairie Creek upstream of the head cut. Notice the stable, well-vegetated banks.

In effect, a stream channel reacts to disturbance by attempting to revert to stable dimension, pattern, and profile and to regain its channel-to-floodplain connection. If left alone after a major disturbance to its channel or floodplain, a stream can eventually regain its stability. If disturbances continue to recur, however, the channel instability will continue.

Streams in poor condition are not just a local concern. The effects of stream instability can be felt throughout a stream's watershed. Minnesota's streams and rivers eventually flow into the Gulf of Mexico, Lake Superior, and Hudson Bay and can have detrimental effects on natural resources from the source of the impact to these huge bodies of water.

2. A 5-foot head cut caused by a channel-straightening project by a downstream landowner.

Spring Prairie Creek

One channel-straightening project in the Buffalo River watershed is a good example of the negative effects that cleanouts can have. When Spring Prairie Creek was straightened, the channel straightening increased the streambed slope and the velocity of the water, resulting in a 5-foot head cut that severely eroded through the pasture of an upstream landowner. This made a stream crossing unusable and severely degraded the stream. The head cut produced large amounts of sediment that filled a legal ditch downstream of the cleanout project.

3. Spring Prairie Creek after the head cut passed through and the channel downcut.

4. A ditch downstream filled with sediment due to upstream channelization and the ensuing head cut.

Examples of Change

Spring Brook, in northwestern Minnesota's Two Rivers watershed, was a ditched stream that had filled in with sediment. Rather than cleaning out the ditch as had been done in the past, in 2003 the local leaders decided to restore the stream to a self-maintaining condition. Their goal was to decrease the amount of time and money spent on ditch maintenance in the long term. During spring 2004, after detailed planning, the river channel was excavated to its proper dimension, pattern, and profile. The stream will now be able to handle the water and sediment that move through the watershed without changing the overall shape and proportions of the stream channel. In addition to saving time and money, the restored stream now provides diverse habitat that can support a healthy population of fish and other aquatic creatures.

Excavation of a meandering channel to stabilize and provide ecological value to an eroding ditch, Spring Brook, in the Two Rivers watershed (Blake Carson, project engineer, JOR Engineering). A setback levee will provide protection for adjacent farmland.

Dalen Coulee project in spring 2005 after revegetation.

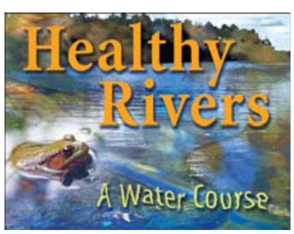
A similar project was also completed in 2002 at **Dalen Coulee** in west-central Minnesota, where more than 2.5 miles of channel was restored. This site is approximately 3 valley miles upstream of the stream's confluence with the Wild Rice River, which later flows into the Red River of the North. The implications of these stream restoration projects extend far beyond the local area: the benefits extend downstream to the ocean and upstream as well.

A ***watercourse*** is any river, stream, creek, coulee, or ditch. A natural watercourse is defined in Minnesota statute as a "natural channel that has defined beds and banks capable of conducting confined runoff from adjacent land." An altered watercourse is a natural watercourse whose shape or dimensions have been changed by human actions.

There are more than 92,000 miles of natural watercourses in Minnesota, enough to wrap around the perimeter of the state 61 times. Those having drainage areas greater than 2 square miles are protected as public waters belonging to all citizens of Minnesota.

Because of this protection, it is important to check with the Department of Natural Resources before you begin work in a river so that you can determine whether the practice is allowed and whether an individual permit is necessary.

For More Information



Interested in learning more about how healthy rivers work? The multimedia CD-ROM *Healthy Rivers: A Water Course* interactively teaches river form and function. Visit the DNR website (http://www.dnr.state.mn.us/healthyrivers/index.html) to learn more about this exciting teaching media.

DNR Contact Information

For information about the DNR Stream Habitat Program, see the Ecological Services website: www.dnr.state.mn.us/ecological_services
DNR Ecological Services in St. Paul: 500 Lafayette Road, Box 25, St. Paul, MN 55155, (651) 259-5100
DNR Waters website: www.dnr.state.mn.us/waters
DNR Waters in St. Paul: 500 Lafayette Road, St. Paul, MN 55155-4032, (651) 259-5700

DNR Information Center

Twin Cities: (651) 296-6157; Minnesota toll free: 1-888-646-6367; Telecommunication device for the deaf (TDD): (651) 296-5484; TDD toll free: 1-800-657-3929