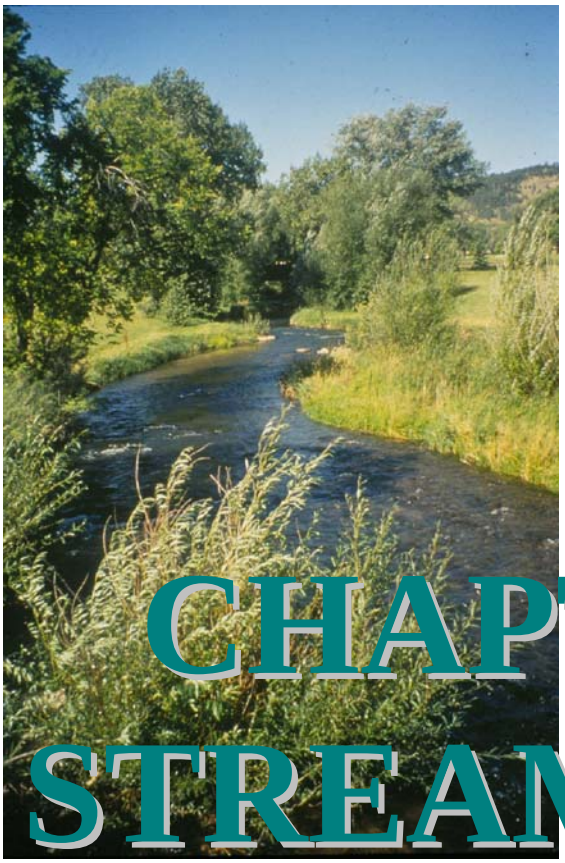
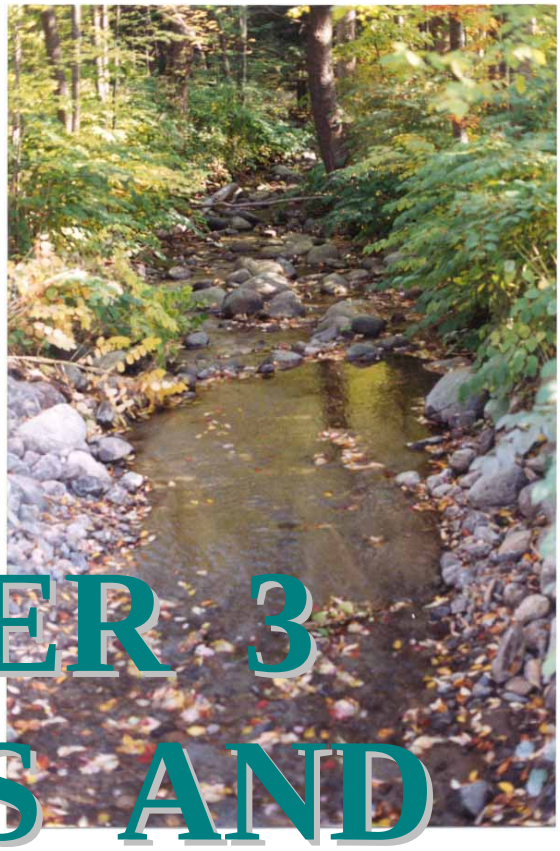




CHAPTER 3
STREAMS AND FLOWS

3.01 Streams & Flows

A stream is a body of water with a current, confined within a bed and stream-banks. Streams are important as conduits in the water cycle, instruments in groundwater recharge, and they serve as corridors for fish and wildlife migration. Stream is an umbrella term used in the scientific community for all flowing natural waters, regardless of size. The study of streams and waterways in general is known as surface hydrology and is a core element of environmental geography.

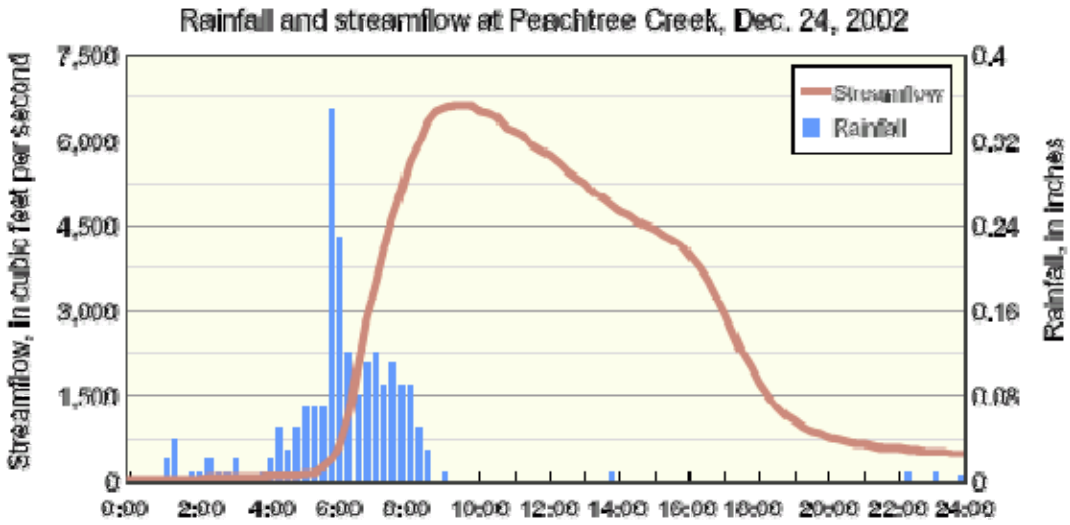
Streams typically derive most of their water from precipitation in the form of rain and snow. Some of the water proceeds to sink into the earth by infiltration and becomes groundwater, much of which eventually enters streams. The rest of the water flows off the land as runoff, the proportion of which varies according to many factors, such as wind, humidity, vegetation, rock types, and relief. When this water is concentrated in a channel, a stream has its birth.

The U.S. Geological Survey (USGS) uses the term "streamflow" to refer to the amount of water flowing in a river. Streamflow is always changing, from day to day and even minute to minute. Of course, the main influence on streamflow is precipitation runoff in the watershed. Rainfall causes rivers to rise, and a river can even rise if it only rains very far up in the watershed - remember that water that falls in a watershed will eventually drain by the outflow point. The size of a river is highly dependent on the size of its watershed. Large rivers have watersheds with lots of surface area; small rivers have smaller watersheds. Likewise, different size rivers react differently to storms and rainfall.

Large rivers rise and fall slower and at a slower rate than small rivers. In a small watershed, a storm can cause 100 times as much water to flow by each minute as during base-periods, but the river will rise and fall possibly in a matter of minutes and hours. Large rivers may take days to rise and fall, and flooding can last for a number of days. After all, it can take days for all the water that fell hundreds of miles upstream to drain past an outflow point.

Hydrologists use a hydrograph to study streamflow in rivers. A hydrograph is a chart showing, most often, river stage (height of the water above an arbitrary altitude) and streamflow. Streamflow is defined as the amount of water, usually in cubic feet per second passing by a given point. To help visualize streamflow you can picture a computer monitor which is slightly larger than a cubic foot. The Mississippi River has an

average streamflow of 572,000 cubic feet per second. This is like having over half a million computer monitors coming at you at one time. After picturing this it is easy to see how streams can shape the landscape. Other properties, such as rainfall and water-quality parameters can also be plotted. The hydrograph on the following page shows rainfall and streamflow for a single day for Peachtree Creek at Atlanta, Georgia.



On Dec. 24, 2002, about two inches of rainfall fell in the Peachtree Creek watershed. This provides a good example to describe streamflow characteristics during a storm since the rain fell for only a few hours on that day and Peachtree Creek was at base-flow conditions before the rain started. The chart above shows rainfall, in inches, during each 15-minute increment on Dec. 24th and the continuous measure of streamflow, in cubic feet per second (ft3/s).

The brown line in the chart shows that streamflow is much higher during the flood period than just before it. The line shows that the baseflow was about 50 ft3/s before the river started to rise, but that just a few hours later, at 9:00 AM streamflow was over 6, 000 ft3/s - that is about 150 times the amount of water flowing by as during baseflow conditions. This is characteristic of small streams, especially urban streams where runoff enters the river very quickly.

Rivers are always moving, which is good for everything, as stagnant water doesn't stay fresh and inviting very long. There are many factors, both natural and human-induced, that cause rivers to continuously change:

Natural mechanisms

- Runoff from rainfall and snowmelt
- Evaporation from soil and surface-water bodies
- Transpiration by vegetation
- Ground-water discharge from aquifers
- Ground-water recharge from surface-water bodies
- Sedimentation of lakes and wetlands

Human-induced mechanisms

- River-flow regulation for hydropower and navigation
- Construction, removal, and sedimentation of reservoirs and stormwater detention ponds
- Stream channelization and levee construction
- Drainage or restoration of wetlands
- Land-use changes such as urbanization that alter rates of erosion, infiltration, overland flow, or evapotranspiration
- Wastewater outfalls
- Irrigation wastewater return flow

3.02 Currents and Erosion

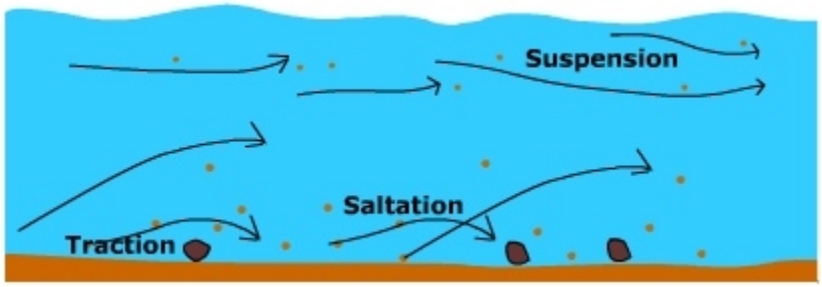
A current, in a river or stream, is the flow of water influenced by gravity as the water moves downhill to reduce its potential energy. The current varies spatially as well as temporally within the stream, dependent upon the flow volume of water, stream gradient, and channel geometrics. It is this current that transports sediment and contributes to erosion and landscape shaping.

Water flowing through a stream performs three kinds of geologic work. Moving water erodes material from the bed and sides of the channel, it transports the eroded material to a new location, and then deposits it. Material deposited by streams is called alluvium. The ability of a stream to do work is a function of stream velocity and discharge.

Stream erosion is the degradation of material from the bed or sides of the channel. Approximately 95% of a stream's energy is used to overcome frictional effects imposed by the channel and internal particles. This leaves only 5% of the stream's energy for vertical and lateral cutting. Flowing water erodes in three ways. First, flowing water dissolves materials from the channel contributing to stream's dissolved or, solution load. Secondly, the impact of water, or hydraulic action on the sides and bed of the channel dislodges materials and makes them available for transport as part of the stream load. Materials too heavy to suspend, scoot and roll across the bed, eroding the channel by abrasion.

Once material is detached from the channel it can be transported. Transportation is the movement of earth material, in this case, by water. As particle size increases, so too does the velocity needed to transport it. The material transported through the stream is it's stream load. Stream load is composed of dissolved or solution load, suspended load, and bed load. The dissolved load comes primarily from groundwater seepage into the stream. Ions in solution also come from the solution of materials that line the channel.

Suspended load is comprised of sediment suspended and transported through the stream. Turbulent flow suspends clay and silt in the stream. Suspended load comes from material eroded from the surface bordering the channel and deposited in the stream, as well as, erosion of the channel itself.



The stream capacity is the maximum load of sediment a stream can carry for a given discharge. As one might expect, stream capacity increases with increasing flow velocity. Increased water velocity imparts a greater frictional drag on bed to erode it. Turbulent flow occurs under higher velocity thus increasing the water's ability to dislodge material from the bed or sides of the stream. Stream competence is the largest size material the stream can move under a given discharge.

Bed load is that which is moved across the bed of the channel. Bed load is transported in two ways, traction, which is a scooting and rolling of particles along the bed. The second is saltation, a bouncing-like movement. Saltation occurs when particles are suspended in the stream for a short distance after which they fall to the bed, dislodging particles from the bed. The dislodged particles move downstream a short distance where they fall to the bed, again dislodging particles upon impact.

The last type of work that moving water does is depositing sediment. As velocity and discharge decreases, the ability of the stream to move sediment through it decreases. The heaviest particles deposit on the bed first, with the smaller and lighter particles transported much further before accumulating. Aggradation raises the elevation of the bed by the accumulation of sediment in the channel. Deposits of sand and gravel as bars can separate the channel into numerous smaller channels resulting in a braided channel.

3.03 Realigned Ditches, Meanders, Bank Stabilization, Stream Restoration, Conservation Easements and the TSMP

One of the big misconceptions in urban areas is that a stream, if left alone, will remain the same. In reality, a stream left alone in nature has the power to carve the Grand Canyon or perpetually replenish the Nile floodplain. The natural tendency of a stream is for it to constantly be trying to alter its path to the sea. The physics of the flow of water combine with the action of the soil particles to scour the streambed and alter the meanders of the waterway. This process occurs over the millennia and accounts for things such as oxbow lakes and cut-offs. Thus, one could think of a stream as a highly dynamic and ever-changing facility, but whose changes take many years to become obvious.

In an urban area, development patterns sometime tend to crowd the locations of the streams. The increased storm runoff generated by the greater number of streets and rooftops only adds to the water volume and velocities in the nearby stream, exacerbating the damaging forces acting on the streambed and increasing the rate of change of the stream path. Thus, those lots that adjoin a stream might witness the stream degradation first-hand as the streambanks slough off and take parts of backyards with them.

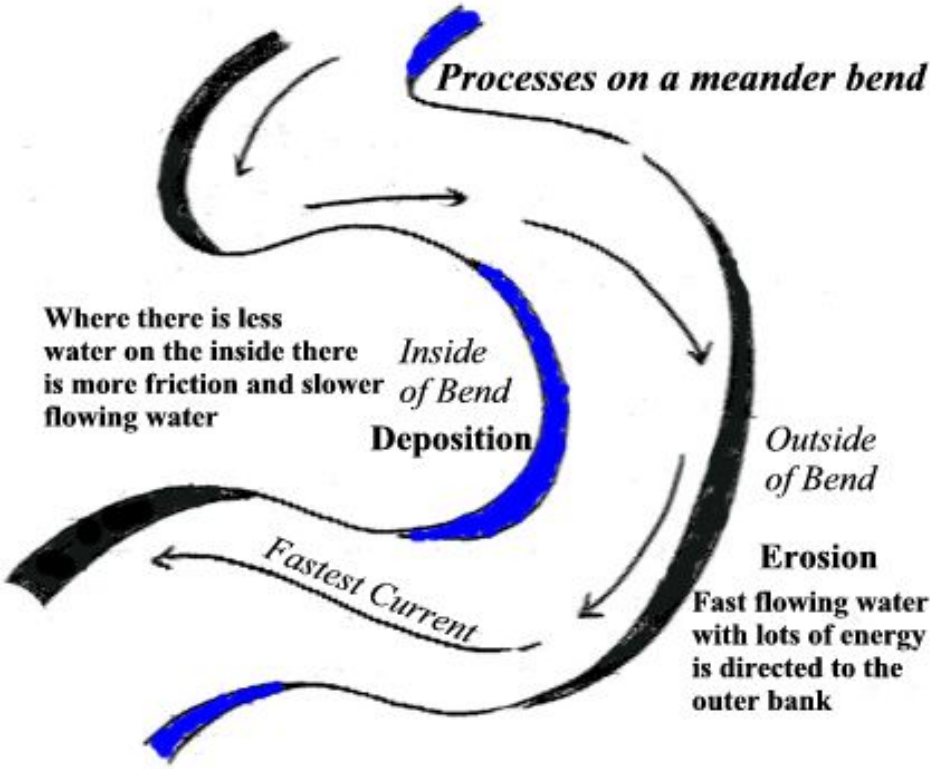
Although natural forces continuously act on a stream and try to change its course, steps can be taken to slow or maybe stop those changes. The more urbanized and developed an area is, the more elaborate the measures might be to combat those forces.

A realigned ditch is used to describe a naturally occurring stream that is redirected in a way that is more suited for an urbanized area. This redirection could come in many forms including concrete channels, box culverts, or just eliminating naturally occurring meanders to conform the ditch to a railroad or street. The Town of Collierville has become one of the leaders in protecting natural stream environments and trying to simulate natural vegetation and meanders in streams.

A meander in general is a bend in a sinuous watercourse also know as an oxbow. A stream of any volume may assume a meandering course, alternatively eroding sediments from the outside of a bend and depositing them on the inside. The result is a snaking pattern as the stream meanders back and forth across its down-valley axis. When a meander gets cut off from the main stream, an oxbow lake is formed. Over time meanders migrate downstream, sometimes in such a short time as to create civil engineering problems for local municipalities attempting to maintain stable roads and bridges.

Most meanders occur in the lower course of the river. Erosion is greater on the outside of the bend where velocity is greatest. Deposition of sediment occurs on the inner edge because the river, moving slowly, cannot carry its sediment load, creating a slip-off slope (Point Bars). The faster moving current on the outside bend has more erosive ability and the meander tends to grow in the direction of the outside bend, forming a river cliff. This can be seen in areas where willows grow on the banks of rivers; on the inside of meanders, willows are often far from the bank, while on the outside of the bend, the roots of the willows are often exposed and undercut, eventually leading the trees to fall into the river. This demonstrates the river's movement. Slumping usually occurs on the concave sides of the banks resulting in mass movements such as slides. This erosion and slumping has led to a need for many bank stabilization projects in town.

Bank stabilization is the process of permanently stabilizing actively eroding stream banks. This can be accomplished by re-sloping vertical banks and using bio-engineering techniques that incorporate living materials, rock, and structures that reduce the erosive near-bank velocities and provide in-stream habitat.



A local example of a bank stabilization project would be in Queen Oaks ditch. When a meander is growing in a developed area, continuing erosion of the bank can consume adjacent properties. In this instance Queen Oaks ditch had consumed a portion of the greenbelt trail and would continue expanding unless a solution was found. The Town decided to install a Redi-Rock wall to simulate the shape of the meander while preventing further erosion. This allows the stream to maintain its natural flow path while protecting those adjacent to the stream. After monitoring the first installation, the Town will see if this is a possible solution to other erosion issues in Town streams.

The Town of Collierville wants to continue to improve on its bank stabilization project at Queen Oaks and provide further stream restoration in the future. Stream restoration is the process of returning a significantly degraded, disturbed, or totally altered stream, including the adjacent riparian zone and flood-prone area, to a natural stable condition based on reference conditions. Restoration will typically include rebuilding the appropriate channel pattern, profile, dimensions, and riparian zone to the extent that watershed conditions will allow. The Town is currently trying to protect these zones before they are damaged by limiting developer's impacts on existing aquatic vegetation and establishing conservation easements in critical areas of the Town's streams.

Conservation easements can ensure that the mitigation projects are protected in perpetuity by prohibiting certain activities or land uses within the designated area, while allowing landowners to retain ownership of the property. Additionally, landowners may deduct the value of the donated easement as a charitable contribution. These easements are seen along the greenbelt, Sanders Creek, and Queen Oaks ditch among others.

Some of these efforts are beginning to fall under the Tennessee Stream Mitigation Program (TSMP). The TSMP funds mitigation projects on degraded streams throughout the state. Through valuable partnerships with government agencies such as the Natural Resources Conservation Service (NRCS), TDEC, the Tennessee Department of Agriculture (TDA), and nonprofit conservation groups, the TSMP identifies streams where the physical habitat has been impaired or degraded. With permission and cooperation from participating riparian landowners, the TSMP designs and implements mitigation projects
that benefit both the stream and the landowner. All TSMP projects are constructed at no cost to the landowner. Mitigation projects are monitored for success over a period of two to five years and must be protected by perpetual conservation easements held by the Tennessee Wildlife Resource Foundation.