What is Surface Water?

Water is continually moving around, through, and above the Earth. It moves as water vapor, liquid water, and ice. It is constantly changing its form. Water on Earth is known by different terms, depending on where it is and where it came from.

* **Meteoric water** - is water in circulation
* **Connate water** - "fossil" water, often saline.
* **Juvenile water** - water that comes from the interior of the earth.
* **Surface water** - water in rivers, lakes, oceans and so on.
* **Subsurface water** - Groundwater, connate water, soil, capillary water
* **Groundwater** - exists in the zone of saturation, and may be fresh or saline.

The movement of water is referred to as the global water cycle (hydrologic cycle). Precipitation, evaporation/transpiration, and runoff (surface runoff and subsurface infiltration) are the primary phases in the hydrologic cycle. The global water budget is based on the recycling (movement, storage, and transfer) of the Earth's water supply.

The direct process by which water changes from a liquid state to a vapor state is called evaporation. In transpiration, water passes from liquid to vapor through plant metabolism. Plants are classified as hydrophytes, phreatophytes, mesophytes, or xerophytes. Hydrophytes take their nutrients directly from the water. Mesophytes are plants that grow under well-balanced moisture supplies. Xerophytes are plants that are adapted to dry conditions. Phreatophytes are long rooted plants that absorb water from the water table or directly above it. Golden tamarisk and mesquite are phreatophytes.

How Much Water is There In and On the Earth?

The volume of the Earth's water supply is about 326 million cubic miles. Each cubic mile is greater than 1 trillion gallons. Although water is abundant on a global scale, more than 99% is unavailable for our use. A mere 0.3% is usable by humans, with an even smaller amount accessible! The oceans, ice caps, and glaciers contain most of the Earth's water supplies. Ocean water is too saline to be economically useful, while glaciers and icecaps are "inconveniently located." Click here to see a chart with these data.

Surface water supplies, primarily river runoff, are about 300 cubic miles. That means we have about 1/10,000th of 1% to use! Conservation is important!

Surface runoff plays an important role in the recycling process. Not only does it replenish lakes, streams, and groundwater; it also creates the landscape by eroding topography and transporting the material elsewhere.

A stream typically transports three types of sediment- dissolved load, suspended load, and bed load. Chemical weathering of rocks produces ions in solution (examples- Ca^{2+}, Mg^{+}, and HCO_3^{+}). Hence, a dissolved load. High concentrations of Ca^{2+} and Mg^{+} are also known by another name - hard water. Some of you may be very familiar with hard water! Take a look at some water chemistry**.**

Suspended sediment makes water look cloudy or opaque. The greater the suspended load, the muddier the water. Bed load (silt- to boulder-sized, but mostly sand and gravel) settles on the bottom of the channel. Bed load sediment moves by bouncing or rolling along the bottom. The distance that bedload travels depends on the velocity of the water.

Factors Affecting Surface Runoff

Several factors can affect surface runoff. The extent of runoff is a function (*f*) of geology**,** slope**,** climate**,** precipitation**,** saturation**,** soil type**,** vegetation, and time. Geology includes rock and soil types and characteristics, as well as degree of weathering. Porous material (sand, gravel, and soluble rock) absorbs water far more readily than does fine-grained, dense clay or unfractured rock. Well-drained material (porous) has a lower runoff potential therefore has a lower drainage density. Poorly-drained material (non-porous) has a higher runoff potential, resulting in greater drainage density. Drainage density is a measure of the length of channel per unit area. Many channels per unit area means that more water is moving off of the surface, rather than soaking into the soil.

Drainage basins or watersheds have different shapes and sizes. Large drainage basins are usually divided into smaller ones. Size and shape have a direct effect on surface runoff. Refer to Module 3 to see information about drainage basins.

Which Type of Drainage Basin Has the Greatest Effect on Surface Runoff?

Long, narrow drainage basins generally display the most dramatic effects of surface runoff. They have straight stream channels and short tributaries. Storm waters reach the main channels far more rapidly in long narrow basins than in other types of basins. Flash floods are common in long, narrow drainage basins, resulting in greater erosion potential.

Topography (relief) and slope (gradient) are additional factors affecting water velocity, infiltration rate, and overland flow rate. Water velocity, infiltration rate and overland flow rate affect surface and subsurface runoff rates.

Climate is also important. Precipitation (type, duration, and intensity) is the key climatic factor. Infrequent torrential downpours easily erode sediment-laden topography, while soft drizzly rain infiltrates the soil.

Vegetation aids in slope stability. Removal of vegetation by fire, clear-cutting (logging), or animal grazing often results in soil erosion. The eroded material is washed into streams, adding to the sediment load.

Runoff Paths

There are three runoff paths that water follows to reach a stream channel- throughflow**,** overland flow, and groundwater flow.

Throughflow is a shallow subsurface flow that occurs above the groundwater table. A major requirement for throughflow is a good infiltration capacity. Throughflow commonly occurs in humid climates containing thick soil layers and good vegetation cover. In such locations, saturated soil conditions result in surface runoff (overland flow).

Overland flow occurs when precipitation exceeds infiltration rates. Overland flow is common in semi-arid regions, sparsely vegetated and/or disturbed areas, and locations containing dense, clay-rich layers.

Surface Water /Groundwater Interaction

Surface streams have an effect on the groundwater table. Influent streams recharge groundwater supplies. Influent streams, located above the groundwater table, flow in direct response to precipitation. Water percolates down through the vadose zone to the water table, forming a recharge mound.

Effluent streams are discharge zones for groundwater. Effluent streams are generally perennial (flow year round). Groundwater seeps into stream channels, maintaining water flow during dry seasons.

The Big Lost River in Idaho is a good example of an intermittent, ephemeral influent stream. Natural flow of the Big Lost River terminates in the Big Lost River Sinks, located on the INEEL. But, local irrigation now diverts the Big Lost River from its natural terminus

Groundwater supplies 30% of the water present in our streams. Recall that effluent streams act as discharge zones for groundwater during dry seasons. This phenomenon is known as base flow. Groundwater overdraft reduces the base flow, which results in the reduction of water supplied to our streams.

Equally important is water quality. Salinity, a by-product of water flowing over salt beds, salt springs, and irrigation and evaporation, increases with distance downstream.

Groundwater and Surface Water

In order to understand drinking water contamination, it is necessary to first understand from where our drinking water comes. For most urban residents, relying upon municipal water systems, drinking water comes from two major sources: groundwater and surface water. These two sources of drinking water will be referenced throughout this guide to water contamination.

Groundwater refers to any subsurface water that occurs beneath the water table in soil and other geologic forms (Rail, 2000). Scientists estimate that groundwater makes up 95% of all freshwater available for drinking. Groundwater is a significant source of water for many municipal water systems in the United States. Rural residents, withdrawing their water from wells, also rely upon groundwater.

Surface water refers to water occurring in lakes, rivers, streams, or other fresh water sources used for drinking water supplies. While most drinking water in the United States is withdrawn from groundwater sources, surface water remains a significant water resource.

Each source of water has a unique set of contaminants; groundwater stores pesticide chemicals and nitrate while surface water contains most bacteria and other microorganisms. Because of the interconnectedness of groundwater and surface water, these contaminants may be shared between the two sources. Neither water source can ever be entirely free from water contaminants. Due to the cycle of water (hydrology), the two sources of drinking water feed each other, sharing contaminants.

Groundwater is generally stored in aqueducts, underground layers of porous rocks that are saturated with water. These aqueducts receive water as soil becomes saturated with precipitation or through stream and river runoff. As the aqueducts exceed their capacity for water storage, they will bleed water back into streams or rivers. The aqueducts maintain a natural balance of water, alternately receiving or giving water as their saturation levels oscillate. Throughout this process, water constantly moves between surface and groundwater sources, sharing contaminants.

Earth's water: Rivers and streams

Source: http://www.archives.gov

Rivers? Streams? Creeks? They are all names for water flowing on the Earth's surface. As far as the Water Science site is concerned, they are pretty much interchangeable. I tend to think of creeks as the smallest of the three, with streams being in the middle, and rivers being the largest.

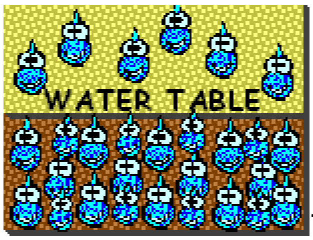
Most of the water you see flowing in rivers comes from precipitation runoff from the land surface alongside the river. Of course, not all runoff ends up in rivers. Some of it evaporates on the journey downslope, can be diverted and used by people for their uses, and can even be lapped up by thirsty animals. Rivers flow through valleys in the landscape with ridges of higher land separating the valleys. The area of land between ridges that collects precipitation is a watershed or drainage basin. Most, but not all, precipitation that falls in a watershed runs off directly into rivers - part of it soaks into the ground to recharge groundwater aquifers, some of which can then seep back into riverbeds.

What is a river?

A river is nothing more than surface water finding its way over land from a higher altitude to a lower altitude, all due to gravity. When rain falls on the land, it either seeps into the ground or becomes runoff, which flows downhill into rivers and lakes, on its journey towards the seas. In most landscapes the land is not perfectly flat -- it slopes downhill in some direction. Flowing water finds its way downhill initially as small creeks. As small creeks flow downhill they merge to form larger streams and rivers. Rivers eventually end up flowing into the oceans. If water flows to a place that is surrounded by higher land on all sides, a lake will form. If people have built a dam to hinder a river's flow, the lake that forms is a reservoir.

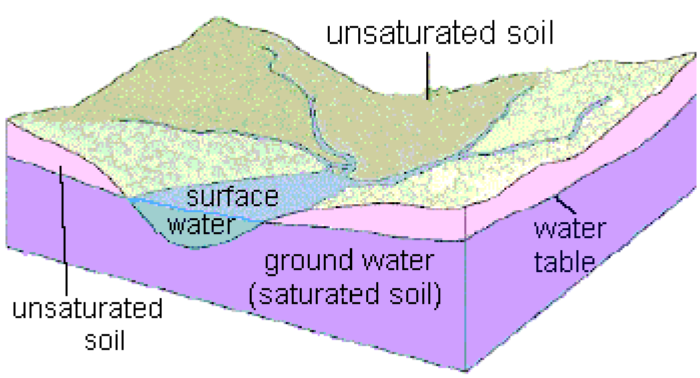
Major rivers of the world.

Where does the water come from?



The water in a river doesn't all come from surface runoff. Rain falling on the land also seeps into the Earth to form ground water. At a certain depth below the land surface, called the water table, the ground becomes saturated with water. If a river bank happens to cut into this saturated layer, as most rivers do, then water will seep out of the ground into the river. Groundwater seepage can sometimes be seen when a road is built through water-bearing layers, and even on a driveway!

Look at the diagram below. The ground below the water table, the aquifer (the purple area), is saturated, whereas the ground above (the pink area) is not. The top layer (unsaturated soil/rock material) is usually wet, but not totally saturated. Saturated, water-bearing materials often exist in horizontal layers beneath the land surface. Since rivers, in time, may cut vertically into the ground as they flow (as the river cuts into the purple section in the diagram), the water-bearing layers of rock can become exposed on the river banks. Thus, some of the water in rivers is attributed to flow coming out of the banks. This is why even during droughts there is usually some water in streams.



Rivers serve many uses

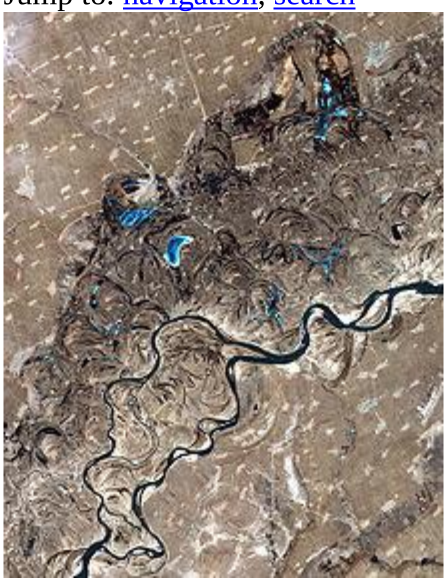
The phrase "river of life" is not just a random set of words. Rivers have been essential not only to humans, but to all life on earth, ever since life began. Plants and animals grow and congregate around rivers simply because water is so essential to all life. It might seem that rivers happen to run through many cities in the world, but it is not that the rivers go through the city, rather, the city was built and grew up around the river. For humans, rivers are diverted for flood control, irrigation, power generation, municipal uses, and even waste disposal. And, if you ask any of these people recreating on the Chattahoochee River in Atlanta, Georgia what the best use of a river is, they might just say "to have fun."

Facts

To get a better perspective of the relative importance of large and small rivers in maintaining continental water balance, consider some statistics on the amounts of water that flow or discharge out of rivers. The Mississippi, North America's largest river, has a drainage area of 1,243,000 square miles (about 40 percent of the total area of the 48 conterminous states) and discharges at an average rate of 620,000 cubic feet per second. This amounts to some 133 cubic miles per year and about 34 percent of the total discharge from all rivers of the United States. The Columbia, nearest competitor of the Mississippi, discharges less than 75 cubic miles per year. Relatively speaking, the great Colorado River is a watery dwarf, discharging only about 5 cubic miles annually. On the other hand, the Amazon, the largest river in the world, is nearly 10 times the size of the Mississippi, discharging about 4 cubic miles each day or some 1,300 cubic miles per year -- about 3 times the flow of all U.S. rivers. Africa's great Congo River, with a discharge of about 340 cubic miles per year, is the world's second largest. The estimated annual discharge of all African rivers is about 510 cubic miles. It has been estimated that the total amount of water physically present in stream channels throughout the world at a given moment is about 500 cubic miles, The estimated total discharge from all rivers, large and small, measured and unmeasured, is about 8,430 cubic miles yearly (about 23 cubic miles daily). The estimated total discharge from all rivers about 23 cubic miles daily, with about 4 cubic miles coming from the Amazon River and about 1 cubic mile from the Congo River in Africa. (EPA). (http://www.epa.gov/safewater/kids/wsb/pdfs/The%20Water%20Sourcebooks%20-%20Grade%20Level%209-12.pdf)

Oxbow lake

From Wikipedia, the free encyclopedia
Jump to: navigation, search



Songhua River, northeast China. Swirls and curves, showing paths the river once took, as well as oxbow lakes, are easily seen in this satellite photo.

An **oxbow lake** is a U-shaped body of water formed when a wide meander from the main stem of a river is cut off to create a lake. This landform is called an oxbow lake for the distinctive curved shape, named after part of a yoke for oxen. In Australia, an oxbow lake is called a billabong, derived from an indigenous language. The word "oxbow" can also refer to a U-shaped bend in a river or stream, whether or not it is cut off from the main stream.[1][2]

Contents

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[edit] Formation

An oxbow lake is formed when a river creates a meander, due to the river's eroding the banks through hydraulic action and abrasion/corrosion. After a long period of time, the meander becomes very curved, and eventually the neck of the meander will touch the opposite side and the river will cut through the neck, cutting off the meander to form the oxbow lake.

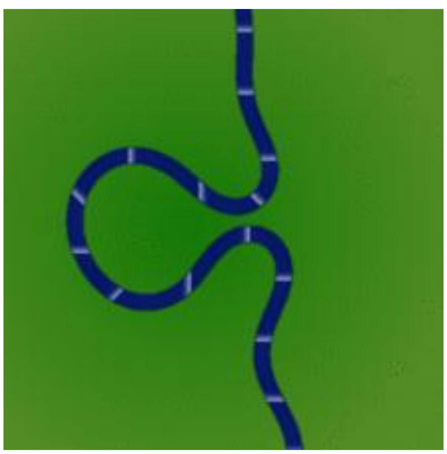
An oxbow in the making: meanders and sandbank deposition on the Nowitna River, Alaska

When a river reaches a low-lying plain, often in its final course to the sea or a lake, it meanders widely. In the vicinity of a river bend, deposition occurs on the convex bank (the bank with the smaller radius). In contrast, both lateral erosion and undercutting occur on the cut bank or concave bank (the bank with the greater radius.) Continuous deposition on the convex bank and erosion of the concave bank of a meandering river cause the formation of a very pronounced meander with two concave banks getting closer. The narrow neck of land between the two neighboring concave banks is finally cut through, either by lateral erosion of the two concave banks or by the strong currents of a flood. When this happens, a new straighter river channel is created and an abandoned meander loop, called a cut-off, is formed. When deposition finally seals off the cut-off from the river channel, an oxbow lake is formed. This process can occur over a time scale from a few years to several decades and may sometimes become essentially static.

Gathering of erosion products near the concave bank and transporting them to the convex bank is the work of the secondary flow across the floor of the river in the vicinity of a river bend. The process of deposition of silt, sand and gravel on the convex bank is clearly illustrated in point bars.[3]

River flood plains containing rivers with a highly sinuous platform will be populated by longer oxbow lakes than those with low sinuosity. This is because rivers with high sinuosity will have larger meanders and greater opportunity for longer lakes to form. Rivers with lower sinuosity are characterized by fewer cutoffs and shorter oxbow lakes due to the shorter distance of their meanders.[4]

The effect of the secondary flow can be demonstrated using a circular bowl. Partly fill the bowl with water and sprinkle dense particles such as sand or rice into the bowl. Set the water into circular motion with one hand or a spoon. The dense particles will quickly be swept into a neat pile in the center of the bowl. This is the mechanism that leads to the formation of point bars and contributes to the formation of oxbow lakes. The primary flow of water in the bowl is circular and the streamlines are concentric with the side of the bowl. However, the secondary flow of the boundary layer across the floor of the bowl is inward toward the center. The primary flow might be expected to fling the dense particles to the perimeter of the bowl, but instead the secondary flow sweeps the particles toward the center.



Animation of the formation of an oxbow lake

The curved path of a river around a bend causes the surface of the water to be slightly higher on the outside of the river bend than on the inside. As a result, at any elevation within the river the water pressure is slightly greater near the outside of the river bend than on the inside. There is a pressure gradient toward the convex bank which provides the centripetal force necessary for each parcel of water to follow its curved path. The boundary layer flowing along the floor of the river is not moving fast enough to balance the pressure gradient laterally across the river. It responds to this pressure gradient and its velocity is partly downstream and partly across the river toward the convex bank.[3][5] As it flows along the floor of the river, it sweeps loose material toward the convex bank.

This flow of the boundary layer is significantly different from the speed and direction of the primary flow of the river, and is part of the river's secondary flow.

When a fluid follows a curved path, such as around a circular bowl, around a bend in a river or in a tropical cyclone, the flow is described as vortex flow: the fastest speed occurs where the radius is smallest, and the slowest speed occurs where the radius is greatest. The higher fluid pressure and slower speed where the radius is greater, and the lower pressure and faster speed where the radius is smaller, are all consistent with Bernoulli's principle.

[edit] Examples

Early stages of formation of coastal plain ox-bow lake. Gower Peninsula, southwest Wales

The Reelfoot Lake in west Tennessee is an oxbow lake formed when the Mississippi River changed course following the New Madrid Earthquake of 1811–1812. There are many oxbow lakes alongside the Mississippi River and its tributaries. The largest oxbow lake in North America, Lake Chicot (located near Lake Village, Arkansas), was originally part of the Mississippi River.

The Oxbow (Connecticut River), a 2.5-mile (4.0 km) bend in the Connecticut River, is disconnected at one end.

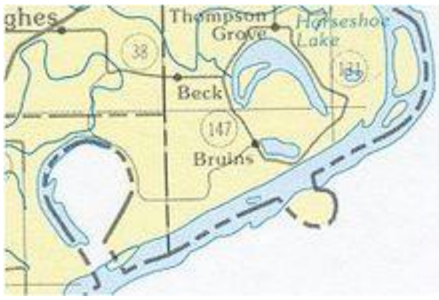
The town of Horseshoe Lake, Arkansas is named after the horseshoe-shaped oxbow lake on which it is located.

Cuckmere Haven in Sussex, England contains a widely meandering river with many oxbow lakes, often referred to in physical geography textbooks.

Kanwar Lake Bird Sanctuary, India contains rare and endangered migratory birds and is one of Asia's largest oxbow lakes.

Carter Lake, Iowa was created after severe flooding in 1877 led to the river shifting approximately 1.25 mi to the southeast.

[edit] Artificial oxbow lakes



A Horseshoe or oxbow lake near Hughes, Arkansas, USA.
The bulges in the border reflect changes in the course of the river; when the river shifted its course and cut off the former channel, the border did not change.

Oxbow lakes may be formed when a river channel is straightened artificially to improve navigation or for flood alleviation. This occurred notably on the upper Rhine in Germany in the nineteenth century.[6]

An example of an entirely artificial waterway with oxbows is the Oxford Canal in England. When originally constructed, it had a very meandering course, following the contours of the land, but the northern part of the canal was straightened out between 1829 and 1834. The work reduced its length from 91 to 77 and a half miles (approximately) and left a number of oxbow-shaped sections isolated from the new course.[7]

[edit] See also

- Secondary flow around river bends
- Fallacy regarding formation of point bars

[edit] References

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7. ^ Boughey, Joseph (1994). *Hadfield's British Canals*. Sutton Publishing. ISBN 0750918403.

[edit] External links

- NASA Remote Sensing Tutorial: Fluvial/Deltaic/Coastal Landforms

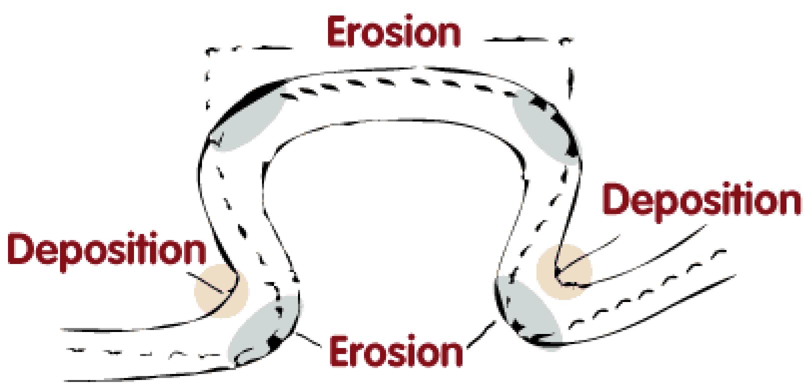
Wikimedia Commons has media related to: ***Oxbow lakes***

[hide]v · d · eRiver morphology	
Large-scale features	Drainage basin • Drainage network • Strahler number (stream order) • River valley • River delta
Alluvial rivers	Meander • Meander cutoff • Point bar • Cut bank • Riffle • Stream pool • Braided river • Bar (river morphology) • Anabranch • River bifurcation • River channel migration • **Oxbow lake** • Floodplain • Riparian corridor • Avulsion (river) • Mouth bar • Thalweg • Channel pattern
Bedrock river	Canyon • Knickpoint • Plunge pool • Bedrock erosion
Bedforms	Lower plane bed • Current ripple • Dune • Upper plane bed • Antidune
Regional processes	Aggradation • Degradation (geology) • Base level • Erosion and tectonics
Mechanics	Playfair's Law • Hack's law • Sediment transport • Water erosion • Deposition (geology) • Exner equation

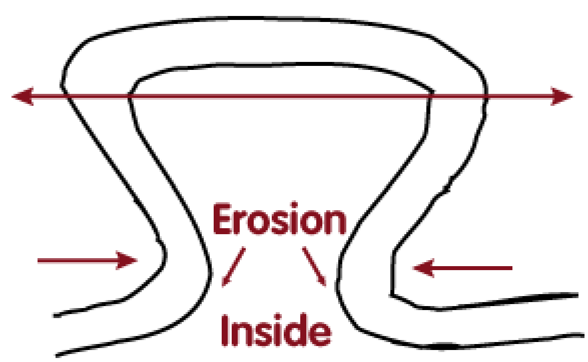
What Is An Oxbow Lake?

An oxbow is a crescent-shaped lake lying alongside a winding river. The oxbow lake is created over time as erosion and deposits of soil change the river's course. You can see how an oxbow lake takes shape below:

(1) On the inside of the loop, the river travels more slowly leading to deposition of silt.

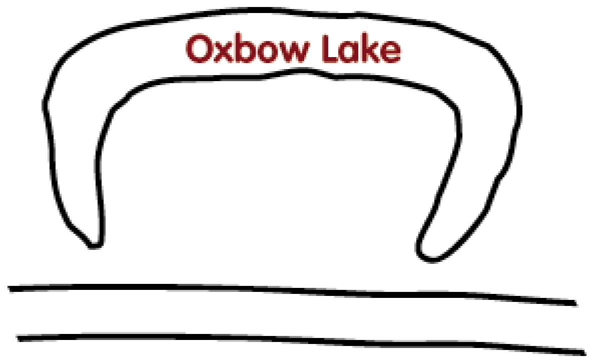


(2) Meanwhile water on the outside edges tends to flow faster, which erodes the banks making the meander even wider.

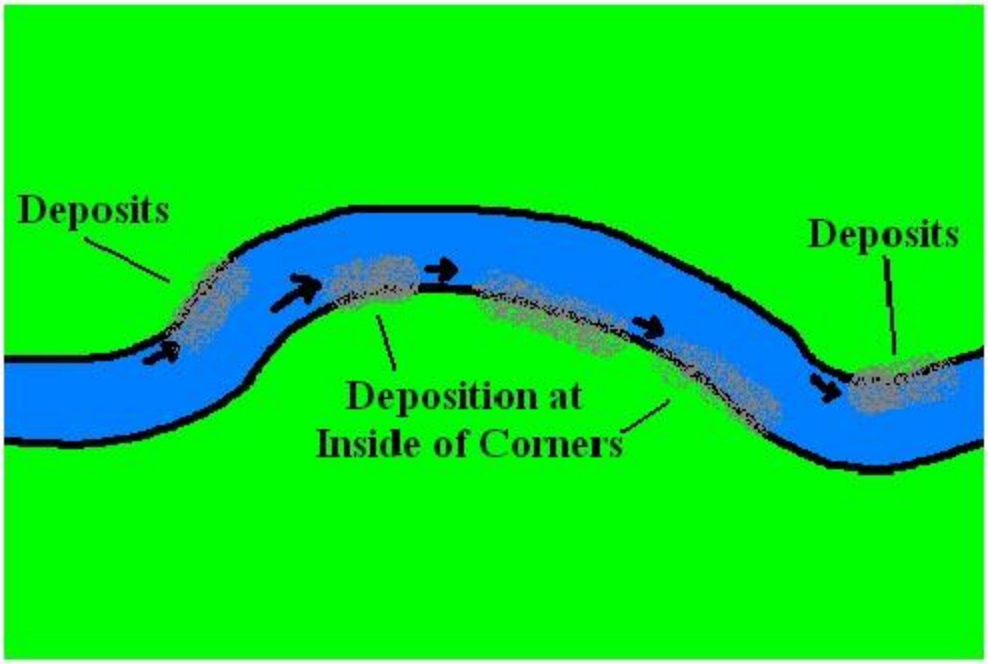


(3) Over time the loop of the meander widens until the neck vanishes altogether.

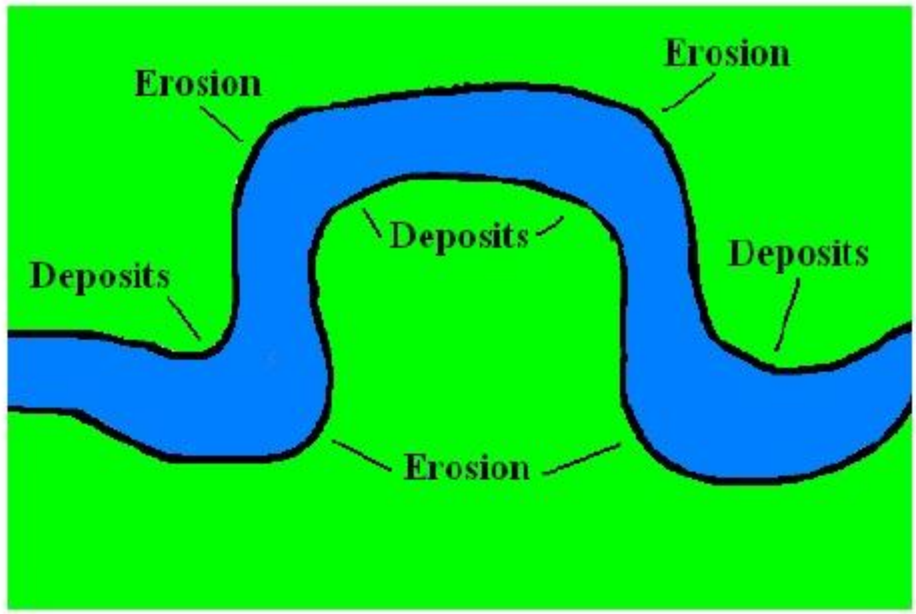
(4) Then the meander is removed from the river's current and the horseshoe shaped oxbow lake is formed.



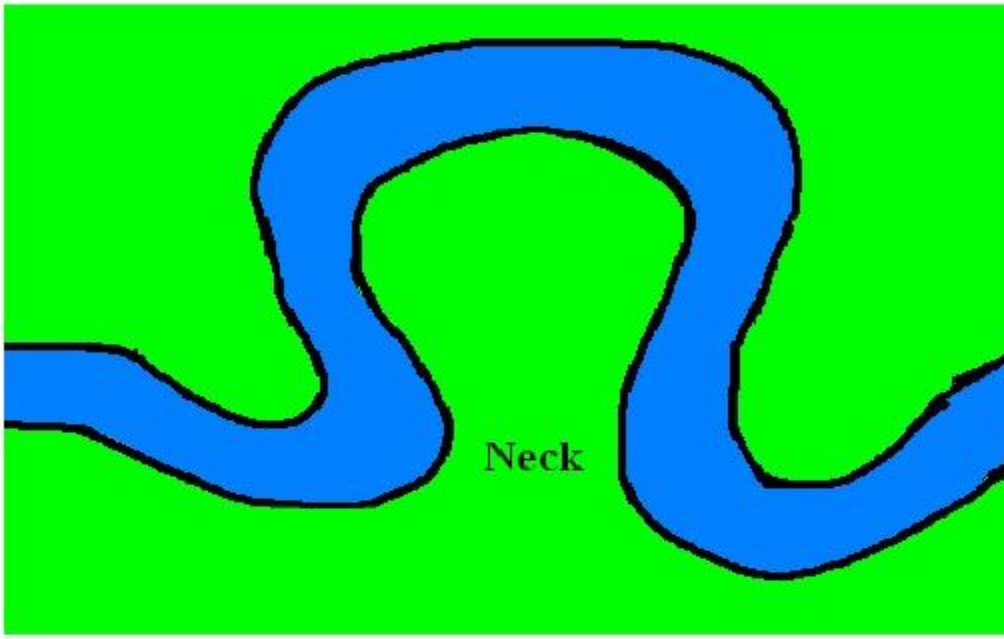
Without a current to move the water along, sediment builds up along the banks and fills in the lake.



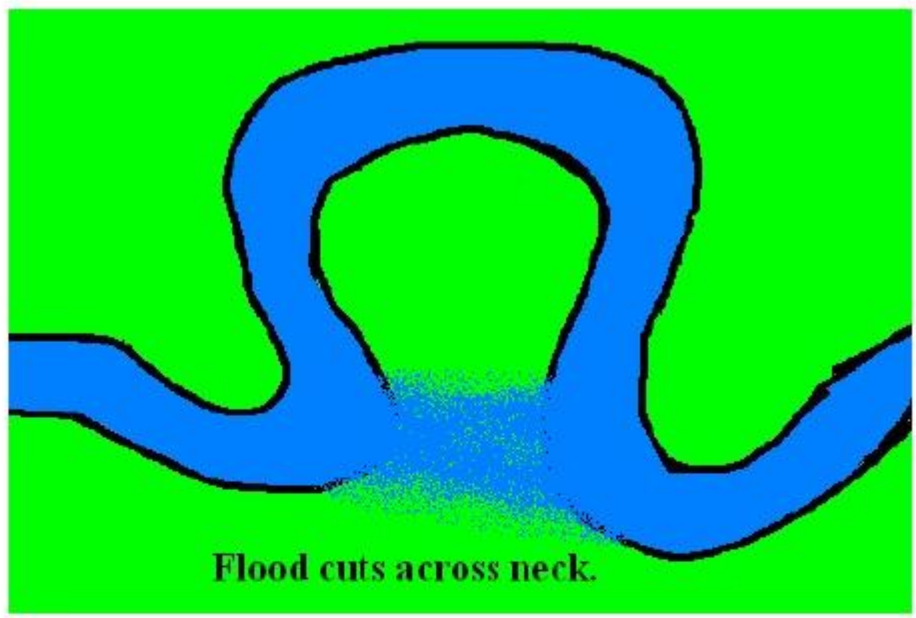
3. Meanwhile, on the inside banks of corners in the river, the water flows more slowly, leading to sediment settling out of the water and building up



4. Gradually, the inside banks are filled in with accumulated deposits, and the outside bends extend further and further, forming a wide loop in



5.The loop continues to bend further and further, until a thin strip of land called a neck is created at the beginning and the end of the meander.



6. Eventually, the narrow neck is cut through by either gradual erosion When this happens, a new straighter channel is created, diverting the flow of the river from the loop into the new channel.