WATERSHED DYNAMICS LESSON: Stream Anatomy & Function



TOPIC: Stream Anatomy & Function

AUTHOR: Beaver Water District

CLASS TIME NEEDED:

One class period of 45-60 minutes for instruction.

One class period 45-60 minutes for site visit of an on-campus or nearby creek or stream.

SUBJECT/GRADE LEVEL: K-12 Physical Science/Biology/Earth Science/ETS/Environmental Science

ARKANSAS SCIENCE STANDARDS:

Grades K-2

- Physical Science – K-PS2-1, K-PS2-2, K-PS3-1, 2-PS1-1, 2-PS1-2, 2-PS1-3, 2-PS1-4, 3-PS2-1
- Biology – 2-LS4-1
- Earth Science – K-ESS2-1, K-ESS2-2, K-ESS3-2, K-ESS3-3, 2-ESS1-1, 2-ESS2-1, 2-ESS2-2, 2-ESS2-3
- Engineering, Technology, & Application of Science –K-ETS1-1, K-ETS1-2, K-ETS1-3, 2-ETS1-1, 2-ETS1-2, 2-ETS1-3

Grades 3-4

- Physical Science – 3-PS2-1, 3-PS2-2, 4-PS3-1, 4-PS3-3, 4-PS4-1
- Biology – 3-LS3-2, 3-LS4-3, 3-LS4-1, 3-LS4-3, 3-LS4-4
- Earth Science – 3-ESS2-1, 3-ESS2-2, 3-ESS3-1, 4-ESS1-1, 4-ESS2-1, 4-ESS2-2, 4-ESS3-1, 4-ESS3-2
- Engineering, Technology, & Application of Science – 3-ETS1-1, 3-ETS1-2, 3-ETS1-3, 4-ETS1-1, 4-ETS1-2, 4-ETS1-3

Grades 5-8

- Physical Science – 5-PS1-1, 5-PS1-2, 5-PS1-3, 5-PS1-4, 5-PS2-1, 6-PS3-5, 7-PS1-2, 7-PS1-5, 8-PS2-1, 8-PS2-2, 8-PS3-1, 8-PS3-2, 8-PS4-1
- Biology – 7-LS2-1, 7-LS2-2, 7-LS2-4, 7-LS2-5
- Earth Science –5-ESS2-1, 5-ESS2-2, 5-ESS3-1, 6-ESS2-4, 6-ESS2-5, 6-ESS2-6, 6-ESS3-3, 6-ESS3-4, 6-ESS3-5, 7-ESS2-1, 7-ESS2-2, 7-ESS3-1, 7-ESS3-2
- Engineering, Technology, & Application of Science – 5-ETS1-1, 5-ETS1-2, 5-ETS1-3, 6-ETS1-1, 6-ETS1-2, 6-ETS1-3, 6-ETS1-4, 7-ETS1-1, 7-ETS1-2, 7-ETS1-3, 7-ETS1-4, 8-ETS1-1, 8-ETS1-2, 8-ETS1-3, 8-ETS1-4

Grades 9-12

- Physical Science - PSI-LS2-7, PSI-LS4-5, PSI-ESS2-1, PSI-ESS3-1, PSI6-ETS1-1, PSI6-ETS1-2, PSI6-ETS1-3, PSI6-ETS1-4
- Biology – BI-LS2-1, BI-LS2-2, BI-LS2-6, BI-LS2-7, BI-LS4-6, BI3-ETS1-3, BI-ESS2-2, BI-ESS2-4, BI-ESS2-5, BI-ESS3-5, BI6-ETS1-2, BI6-ETS1-3, BI-ESS3-1, BI-ESS3-2, BI-ESS3-3, BI-ESS3-4, BI-ESS3-6, BI7-ETS1-1, BI7-ETS1-4
- Earth Science - ES-ESS2-2, ES-ESS2-5, ES2-ETS1-1, ES2-ETS1-3
- Environmental Science - EVS-ESS2-2, EVS-ESS2-3, EVS-ESS2-5, EVS-ESS2-6, EVS-ESS3-5, EVS1-ETS1-1, EVS-LS2-1, EVS-LS2-2, EVS-LS2-6, EVS-LS2-8, EVS3-ETS1-3, EVS-LS2-2

LEARNING PERFORMANCE TARGET(S): (learning expectations for this lesson; combines a science practice, crosscutting concept and core idea embedded in the lesson)

Students will learn the order and functions of riffles, runs, pools, and riparian zones.

SCIENCE AND ENGINEERING PRACTICES:

Lab work, field work, acquire data, graphing, planning and carrying out investigations, analyzing and interpreting data, asking questions and defining problems.

CROSSCUTTING CONCEPTS:

Structure and Function, Stability and Change

CCSS CONNECTIONS: (include mathematical concepts and reading, writing, speaking and listening opportunities in the lesson)

All exist throughout the lesson.
ELA/Literacy
Mathematics

MATERIALS:

- Online Resources Search Terms: "River Features", "Stream Anatomy", "Fluvial Geomorphology"
- Factors That Shape Streams & Watersheds (p. 4); Links to Stream Dynamics Videos (p. 5); Streambank, Channel, and Riparian Zone Restoration Projects (p. 6); Stream Terminology (p. 7); Stream Table Demonstration (p. 8)
- Clipboards, drawing paper, color pencils or markers
- Stream Table or Watershed Model (NW Arkansas Educators: Request these resources online: www.bwdh2o.org/education-outreach/tours-speakers/

TEACHER PREPARATION:

1. Give students instruction on riffle, run, and pool locations in a stream. Show riparian zone location (200 ft. on each bank of the stream).

2. Identify the functions of each. See **"Factors That Shape Streams & Watersheds"** (p. 4); "**Stream Terminology"** (p. 6).

Use a stream table to demonstrate or diagram on the board to illustrate:

3. Stream flow pushing water through the gravel, where it is filtered and oxygenated as it bounces over the rocks. The water transitions in the run. Then the water spreads out and slows down in the pool in order for it to settle the remaining pollutants. This process happens over and over again producing cleaner and cleaner water.

4. The flow of rainfall down a hill to the stream without any riparian zone present. Assume the riparian zone is mowed right up to the stream. Show how pollutants on the ground are washed quickly into the stream without any filtering or slowing down of the flow. The nonpoint pollution from the surface is washed directly into the stream.

5. The function of a healthy riparian zone as a pre-stream filter for nonpoint pollution running down the hill. The "Plinko" game from "The Price is Right" is an excellent example. The disc in this game slides down a slanted board full of pegs. Those pegs slow the movement of the disc. A riparian zone acts the same as the pegs. The rainfall moving down the hill and picking up pollutants will be slowed by the grass, bushes, trees, and their roots. This slows the rainfall and allows the pollutants to settle into the soil.

6. Explain how this entire system is Mother Nature's way of cleaning water before it enters a stream, lake, or ocean.

BACKGROUND INFORMATION/CONTENT:

Problem Question:

What are the components that make up a stream and what are their functions?

Teachers:

Research local streams including on-campus. Investigate to check if the stream is dry part of the year or contains water the entire year. Ideally, you want the students to visit the stream and explore the components of the stream. Perform searches on-line for diagrams and images of stream components.

Students:

No student preparation is needed.

Key Words (See "Stream Terminology" p. 7 for additional terms and definitions.)

Riffle: shallow, fast water functions: in-stream filter, adds oxygen

Run: transition zone from riffle to pool – no function

Pool: slow moving, deep water functions: slows and spreads water, allows settling of sediment and nutrients

Riparian zone: trees, bushes, grasses on the sides of a stream functions: pre-stream filter, erosion control.

7E'S STREAM ANATOMY & FUNCTION

Elicit

Show images of streams in your area and of major rivers in the world. The Mississippi River is an excellent river to view. Google Earth will show images of streams and some will look muddy while some look blue. Have students discuss what they observe in and around the streams that may cause the differences.

Engage

Draw/diagram what these streams look like, then draw what they observe in the stream and surrounding the stream.

Explore

Observe and diagram on-campus or nearby ditches, creeks, or streams. Identify riffles, runs, pools, and riparian zone. An additional option is to set up a field lab practicum for a quick quiz to assess learning. Form teams and produce small presentations. Investigate streams from respective students' home neighborhoods or around town.

Explain

Display drawings and give presentations upon return to classroom.

Elaborate

What areas are more prone to damage? What kind of damage can happen to a stream and its components? How is the ditch or small creeks components different from a larger stream?

Evaluate

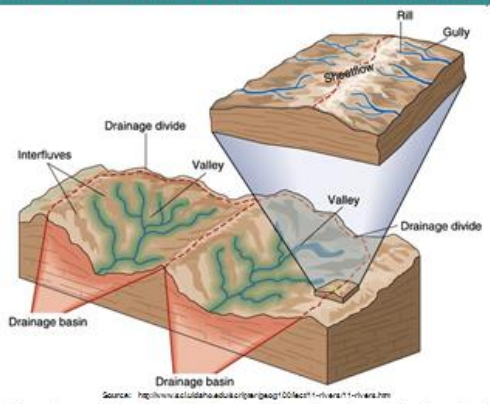
Drawings/diagrams can be evaluated. Assessment also takes place in a unit test or field lab practicum.

Extensions

What happens with geomorphology in the stream if the riparian zone is depleted? What happens with chemical or biological testing of the water if the components are damaged or missing? What is a large, low area of land that floods called? This is a wetland and is a backup component for cleaning the water in heavy rain events.

FACTORS THAT SHAPE STREAMS & WATERSHEDS

WATERSHED = CATCHMENT = DRAINAGE BASIN



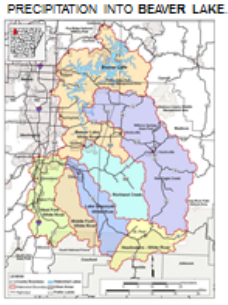
Source: http://www.acs.uidaho.edu/scripts/geog100/lect/1-rivers/1-rivers.htm

A **watershed** is an "area of land that drains water, sediment, and dissolved materials" to the lowest elevation point within it, such as a common water body or "outlet along a stream channel." (Paraphrased from Dunne and Leopold 1978).

Source: http://www.epa.gov/owow/watershed/wacademy/acad2000/streams/stream11.html

WATERSHEDS & Sub-Watersheds

THE BEAVER LAKE WATERSHED IS AN AREA OF LAND THAT COLLECTS AND DRAINS PRECIPITATION INTO BEAVER LAKE.



THE BEAVER LAKE WATERSHED IS A SUB-WATERSHED OF THE WHITE RIVER WATERSHED.

SOURCE: hillholler.files.wordpress.com/2013/07/white-river-watershed.png

Like stacking bowls, a WATERSHED may be part of one that is larger and also have other smaller "SUB-WATERSHEDS" inside it.

THE BEAVER LAKE WATERSHED INCLUDES 7 SUB-WATERSHEDS OF 7 MAJOR STREAMS:

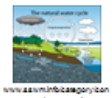
1) White River Headwaters
2) West Fork of the White River
3) Middle Fork of the White River
4) White River/Lake Sequoyah
5) Richland Creek
6) War Eagle Creek
7) Beaver Lake/White River

SOURCE: www.bwdh2o.org/files/KS2010_FINAL_Beaver_Lake_Watershed_Report.pdf

THE WHITE RIVER WATERSHED IS A SUB-WATERSHED OF THE MISSISSIPPI RIVER DRAINAGE BASIN.

SOURCE: www.mississippiriveradventures.com/pics/Mississippi-map.gif

3 MAJOR FACTORS THAT SHAPE WATERSHEDS & STREAMS



www.asvm.info/category/icon/cagh/water-cycle

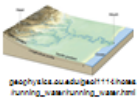
1. CLIMATE / WATER CYCLE

The average weather (including rainfall, temperature, wind) over a long time period that is characteristic of a region

earthobservatory.nasa.gov

2. GEOLOGY: "EARTH STUDY"

Science focused on the study of rock chemistry, composition, features, forms, and locations in order to gain understanding about Earth's dynamics, physical history, processes, shape, and structures



geophysics.ou.edu/geol1114/notes/running_water/running_water.html

3. SLOPE

An inclined surface of which one end or side is at a higher level than the other

SOILS & VEGETATION ARE ALSO SIGNIFICANT CONTROLLING FACTORS IN THE DEVELOPMENT OF WATERSHED & STREAM CHARACTERISTICS.

CLIMATE:

THE AVERAGE WEATHER (INCLUDING RAINFALL, TEMPERATURE, WIND) OVER A LONG TIME PERIOD THAT IS CHARACTERISTIC OF A REGION

DESERTS: Rainfall Negligible

Arid: <0-10 centimeters = <0-4 inches per year
Semi-Arid: <10-30 centimeters = <4-12 inches

GRASSLANDS: Rainfall Minimal

Temperate: <25-75 centimeters = <10-30 inches per year
Tropical: <64-150 centimeters = <25-60 inches per year

WOODLANDS: Rainfall Moderate

>75-150 centimeters = >30-60 inches per year

RAINFORESTS: Rainfall Maximum

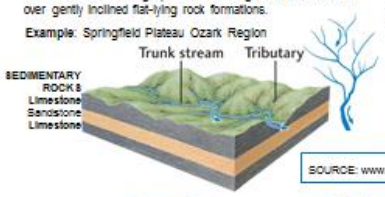
>175-200 centimeters = >68-79 inches per year

GEOLOGY & DRAINAGE PATTERNS

Shape of the stream systems draining a particular region

Dendritic: "Tree Trunk & Branches"
Most common drainage pattern resulting from flow of water over gently inclined flat-lying rock formations.

Example: Springfield Plateau Ozark Region



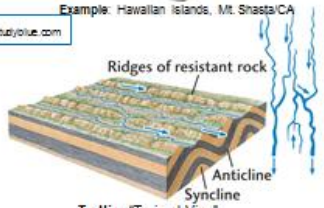
Radial: "Wheel Spokes"
Develops on a large single peak, such as a salt dome or volcano.

Example: Hawaiian Islands, Mt. Shasta/CA

SOURCE: www.studyblue.com

Rectangular: "Square-Corners"
Forms on rocks with well-developed joint system.

Example: Canadian Shield

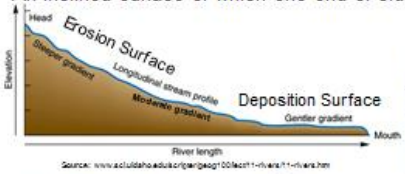


Trellis: "Trained Vine"
Streams flowing on "folded" SEDIMENTARY rock units follow valleys bounded by ridges of erosion resistant rock.

Example: Appalachian Mountains Virginia & Pennsylvania

SLOPE

An inclined surface of which one end or side is at a higher level than the other



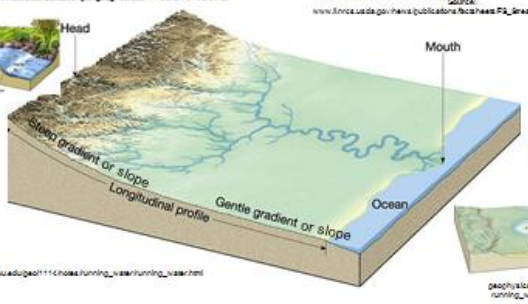
Source: www.acs.uidaho.edu/scripts/geog100/lect/1-rivers/1-rivers.htm

Over many years, streams develop their patterns and characteristics of transporting water and sediment from upland areas, through floodplains, and on to larger streams and rivers, and eventually, oceans.

Source: www.fsnrcs.usda.gov/news/publications/fsc/hsess/FS_StreamDynamics.html

Headwater stream on steep slope

Source: www.acs.uidaho.edu/scripts/geog100/lect/1-rivers/1-rivers.htm



Meandering stream on nearly level or flat surface

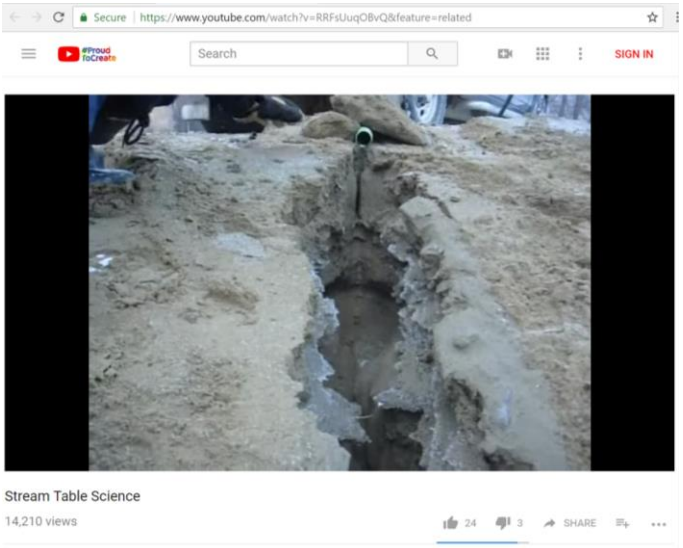
Source: geophysics.ou.edu/geol1114/notes/running_water/running_water.html

Source: geophysics.ou.edu/geol1114/notes/running_water/running_water.html

LINKS TO STREAM DYNAMICS VIDEOS

G6-12 A Stream Story by Devin and Pete – Science project on meandering rivers, sedimentary deposits and water erosion.

http://www.youtube.com/watch?v=RRFsUuqOBvQ&feature=related



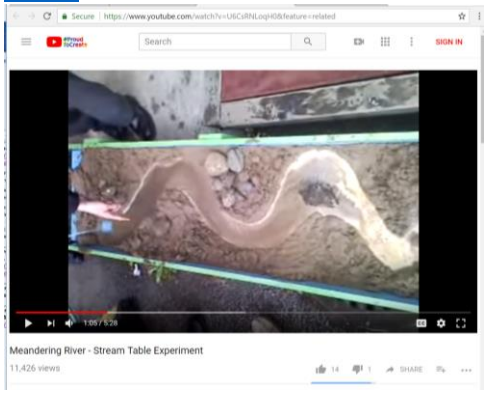
1) **Canyons** – Flow over flatland picks up/erodes rocks and sediment, banks collapse, form v-shaped channel

2) **Waterfalls** – Plunge pools, undercutting, overhang collapse, headward erosion

3) **Meanders & Oxbows** – Rapid flow side of channel erodes forming cutbank, slow flow side of channel forms depositional point bars, erosion progresses on upstream side of point bar, new channel forms, deposition occurs at entrance and exit of former meander

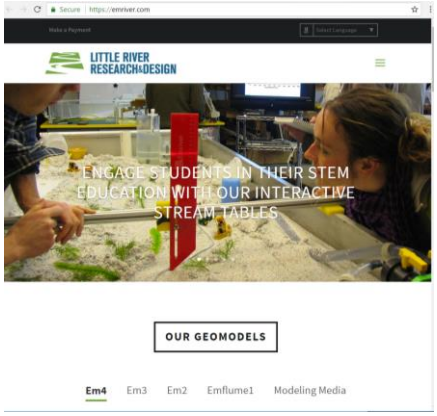
G6-12 Meandering River – Stream Table Experiment (SJS 2008-2009. Geography 12. Byron's River Design)

http://www.youtube.com/watch?v=U6CsRNLoqH0&feature=related



G6-12 Emriver river gravel mining demonstration (www.emriver.com) 12/02/2007

http://www.youtube.com/watch?v=0tb5may-Ghw



G6-12 Stream Channel Demo – Meander Cutoff During Flood 09/25/2011

http://www.youtube.com/watch?v=qszdUx6zNag

G6-12 Winona State University (MN) Em4 Delta Building and Analysis (www.emriver.com) 09/01/2011

http://www.youtube.com/watch?v=zbdM5Kjoxaw&feature=related

STREAMBANK, CHANNEL, & RIPARIAN ZONE RESTORATION PROJECTS

Watershed Conservation Resource Center (WCRC) Osage Creek Streambank Restoration at Gibbs Ranch: vimeo.com/185823849

A stream restoration project along Osage Creek, a major tributary to the Illinois River in Arkansas. This stream restoration project helped the landowner to reduce the amount of land loss during floods, increase riparian areas to protect the banks, increase fish habitat and apply conservation to working land.

Watershed Conservation Resource Center (WCRC) White River Streambank Restoration Off Wyman Road near Fayetteville AR: www.watershedconservation.org/projects/white-river-streambank-restoration/

Before | Riparian Zone Restoration | 1-Year Later

Watershed Conservation Resource Center (WCRC) West Fork White River Streambank & Channel Restoration at Brentwood AR: www.watershedconservation.org/projects/brentwood-restoration/

Before 2007 | After Restoration 9/10/2017

STREAM TERMINOLOGY



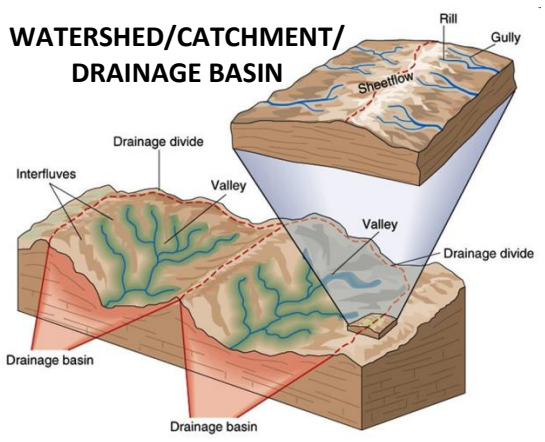
TERM	DEFINITION	STREAM TABLE PROXY
Alluvium	Weathered, eroded Earth materials carried by flowing water & deposited as flow velocity decreases.	
Aquifer	An underground bed of saturated soil or rock that yields significant quantities of water	Fill media - Plastic sand
Cut Bank	The side of the stream in contact with higher velocity flow that erodes & transports bank materials.	
Delta	The fan or bird-foot shaped sediment depositional feature that forms at the mouth or terminus of a stream.	
Discharge	An outflow of water from a stream, pipe, ground water system, or watershed	Flow Cylinders
Erosion	The removal & transport of rock or soil by ice, water, or wind.	Fill media - Plastic sand
Flood	Channel flow which overtops natural or artificial stream banks.	
Floodplain	Normally dry, but inundation prone lowlands adjacent to coastal areas or streams.	
Gravity	The natural force of attraction that tends to draw materials on Earth's surface towards its center or objects in Space towards each other.	
Groundwater system	All components of subsurface materials that relate to water, including aquifers, zones of saturation, & water tables.	
Habitat	The environment where an organism grows & lives.	
Headwaters	The source of a stream.	Flow Cylinders
Hydrology	The study of Earth's waters, including water properties, circulation, principles, & distribution.	Water Source/Storage/Flow Dynamics
Impermeable Layer	Non-porous material through which gases or liquids cannot pass, such as a clay layer in an aquifer.	Aluminum Stream Chamber
Meander	(Noun) A bend or curve, as in a stream or river. (Verb) To move or cause to move in a sinuous, spiral, or circular course. Meandering stream channels migrate sideways as higher velocity outer-curve stream channel flow erodes bank materials & slower inner-curve flow velocity allows deposition of sediment which forms a point-bar.	
Permeable Layer	Porous material through which gases or liquids can pass, such as fractured or granular rock, soil, or unconsolidated sediment in an aquifer.	Fill media - Plastic sand
Point Bar	A low, curved ridge of sand &/or gravel that forms as channel flow velocity decreases & deposits sediment on the inner bank of a meandering stream.	
Riparian Area	Land areas adjacent to &/or directly influenced by a body of water (such as stream banks, lake shores, & marshes), within which vegetation & physical characteristics typical to water/land transition zones are present.	
Sediment	Fragmented organic &/or inorganic material derived from the weathering of soil, alluvium, & rock that has been removed by erosion & transported by gravity, ice, water, or wind.	Fill media - Plastic sand
Stream Channel Shape & Age	"V" channel shape in cross-section is characteristic of a young stream, which a "U" channel shape in cross-section is typical of mature river/stream channels. Progressive stages of erosion downcut uplands or mountains to form ridges with intervening valleys, then low hills, and ultimately low-lying relatively level floodplains covered by river sediment.	
Water	An odorless, tasteless, colorless liquid made up of 2 hydrogen & 1 oxygen atoms in a di-polar molecular structure that causes the substance to possess unique chemical & physical properties. Water is a universal solvent, expands as it freezes, & is a major constituent of life forms.	
Watershed	A land area that collects & conveys precipitation along & below the ground surface from highest elevations to a lowest common receiving body such as a stream, lake, reservoir, or ocean.	Stream Chambers
Water Table	The top of an unconfined aquifer, below which soil & rock are saturated with water.	Below fill media surface
Zone of Saturation	The part of the groundwater system in which all spaces between soil & rock materials are filled with water.	
INTERNET RESOURCES	• maps.unomaha.edu/Maher/geo101/tablea.html • watersheds.org/earth/meandering.htm • watersheds.org/earth/streamtable.htm • onelook.com	
PUBLICATIONS	• *Project WET: Curriculum & Activity*, Watercourse: Bozeman, 1995 • Lambert, D. *The Field Guide to Geology*. Facts on File: New York, 1988	

STREAM TABLE DEMONSTRATION

BACKGROUND INFORMATION/FLOOD PLAIN PREPARATION & OPTIONAL ACCESSORIES

STREAM TABLE:
- Build a basic flow path
- Place Flood Plain Features In "Landscape"
  - Natural - Trees (with root mass), boulders
  - Anthropogenic
    - Development/"Gray Infrastructure" - bridge, buildings, cemeteries, parking lots, roads, etc
    - Agriculture – cows, "crops," pigs, etc . . .

SPEAKER: Define/Describe/Explain:



Source: sci.uidaho.edu/scripter/geog100/lect/11-rivers/11-rivers.htm

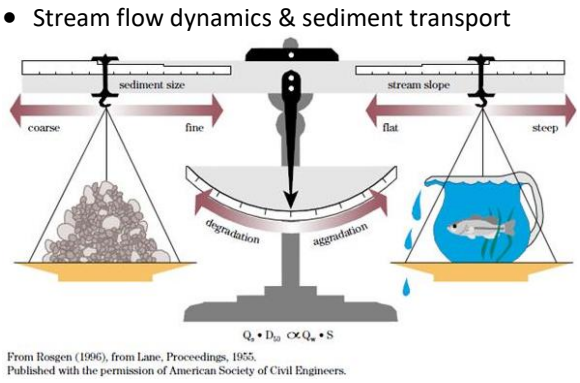
- **WATERSHED** - An "area of land that drains water, sediment, & dissolved materials to a common outlet at some point along a stream channel" (Dunne and Leopold 1978).
- **DYNAMIC EQUILIBRIUM** – A state of balance achieved by two forces in motion (Dictionary.com). Over long periods of time (100s to 1000s of years) under established/relatively stable climatic conditions, regional landscapes & streams develop characteristic features, which change constantly, while retaining overall size & shape characteristics.
- **CLIMATE** - Enduring average regional weather conditions over centuries or millennia.
  - **EXAMPLE: Ozark Plateau** - Humid sub-tropical with mean temperature range of 34.9 °F-79.1 °F, four distinct seasons, & an average 45.20 inches annual precipitation (Source: encyclopediaofarkansas.net)
- **GEOLOGY** – 1. The scientific study of the Earth; 2. Earth's crust or a specific region's structure & characteristics, including rock formations, soils, & topography.
  - View/describe a local stream or regional river watershed

SEASONAL STREAM FLOW SCENARIOS

NORMAL STREAM FLOW Season: Winter/Rainfall Moderate

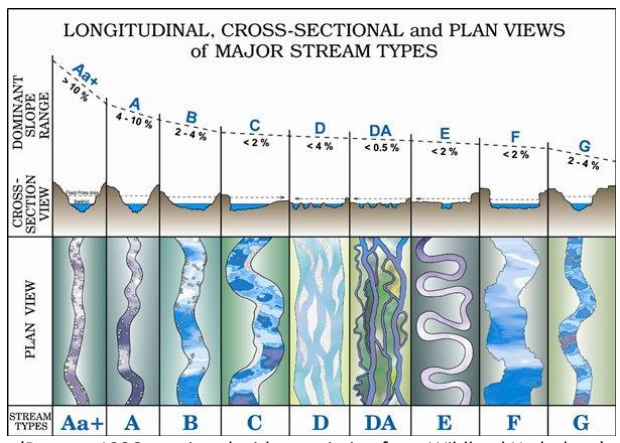
STREAM TABLE: Open valve slowly with moderated (normal) flow

SPEAKER:
- Stream flow dynamics & sediment transport



From Rosgen (1996), from Lane, Proceedings, 1955.
Published with the permission of American Society of Civil Engineers.

- Stream channel characteristics
  - **Shape**
    - Cross-sectional view - "V" (vertical erosion - down cutting) or "U" (lateral erosion - widening)
    - Plan/Bird's Eye view – Entrenched/Step-Pool, Meandering, Braided
  - **Meanders**
    - **Point-Bar:** Slow flow = Deposition inner curve vs. **Cut-Bank:** Fast flow = Erosion outer curve
  - **Flood Plain** development by meander migration
    - Channel Scars/Cut-Offs/Oxbow Lakes
- Riparian Zone/Streambanks



(Rosgen, 1996, reprinted with permission from Wildland Hydrology)

HEAVY STREAM FLOW Season: Spring

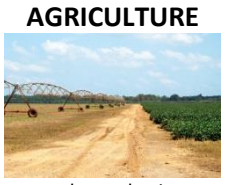
STREAM TABLE: Open valve for faster, higher volume flow

SPEAKER:
- Spring - Increased rainfall frequency/rate/volume
- Runoff/Stream flow & erosion potential greater
- Stream response – Channel/point bar/cut bank changes, sediment load increases
- Nutrient Cycling – Habitat, vegetative detritus, decomposition, dissolved oxygen
- Streambank stabilization – Boulders, soil type, vegetation buffers (Buffer zone width can vary based on stream protection & land management objectives)
- Human Impacts of Land Use/Land Change – ATVs, development, urbanization

RIPARIAN or STREAMBANK BUFFER ZONE

Source: www.aces.edu/natural-resources/water-resources/watershed-planning/stormwater-management/images/img004_000.jpg

AGRICULTURE



Source: arkansasbusiness.com

COMMERCE

Source: nwaonline.com

RESIDENTIAL

Source: aerialphotography arkansas.com

MINING

Source: nwaonline.com

SLOW STREAM FLOW Season: Summer

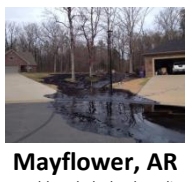
STREAM TABLE: Adjust valve to slow flow

SPEAKER:
- Summer – Rainfall & stream flow diminished
- Ephemeral vs. perennial streams
- Sediment load deposited
- Nutrient loading, hypoxia, toxins

POINT SOURCE POLLUTION

Contaminant dispersal from a specific source or location.

Ft. Smith, AR
Source: thecitywire.com



Mayflower, AR
Source: blog.shaleshockmedia.org

NON-POINT SOURCE POLLUTION

Contamination from diverse sources in a widespread area

Sediment in Beaver Lake
Source: Hawkins Aerial Photography

Pet Waste
Source: web.uri.edu/riss/files/DogPoop.jpg

NORMAL STREAM FLOW Season: Fall-Winter/Rainfall moderate

STREAM TABLE: Open valve to re-establish moderate (normal) flow

SPEAKER:
- Stream/River terminus/mouth at lowest elevation of watershed – ultimately sea level
  - Alluvial Fan/Delta deposition
  - Bird Foot Delta
  - Hypoxic "Dead Zones" – Mississippi River/Gulf of Mexico

MISSISSIPPI RIVER/GULF OF MEXICO DEAD ZONE

Source: science.nasa.gov/media/medialibrary/2010/03/31/Louisiana_delta.jpg