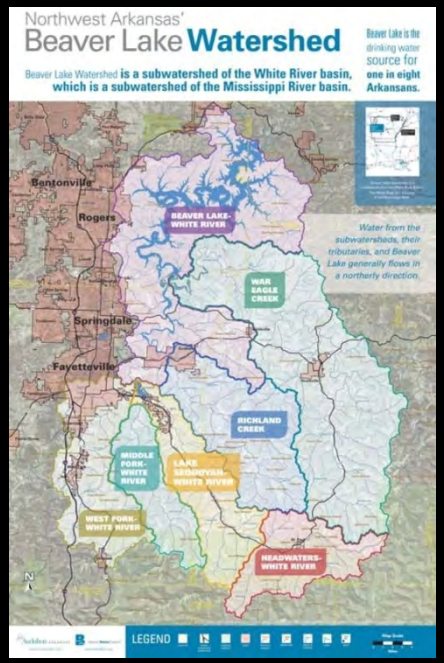
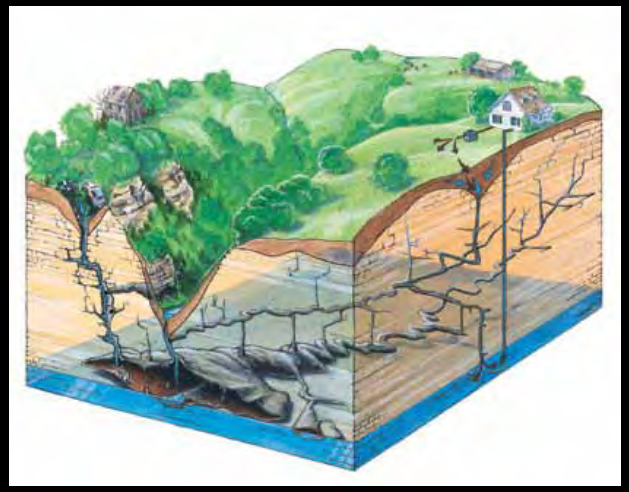
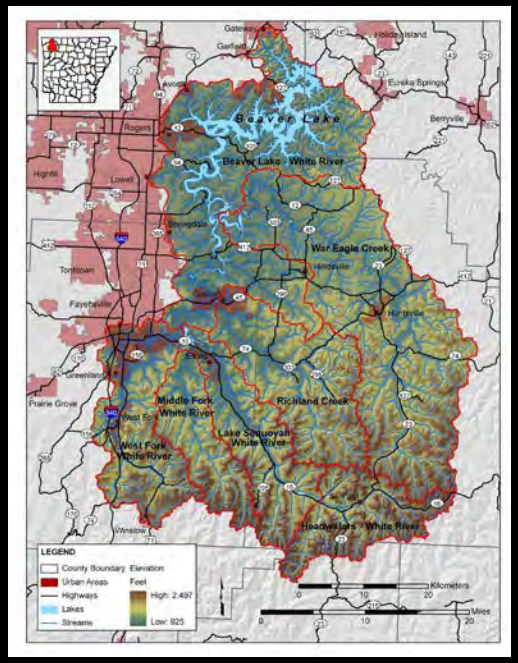
PROFESSIONAL DEVELOPMENT SERIES





www.bwdh2o.org/index.php?fuseaction=p0007.&mod=42



BEAVER LAKE IN OUR BACKYARD

THE WATERSHED & DRINKING WATER TREATMENT

Beaver Water District

education@bwdh2o.org

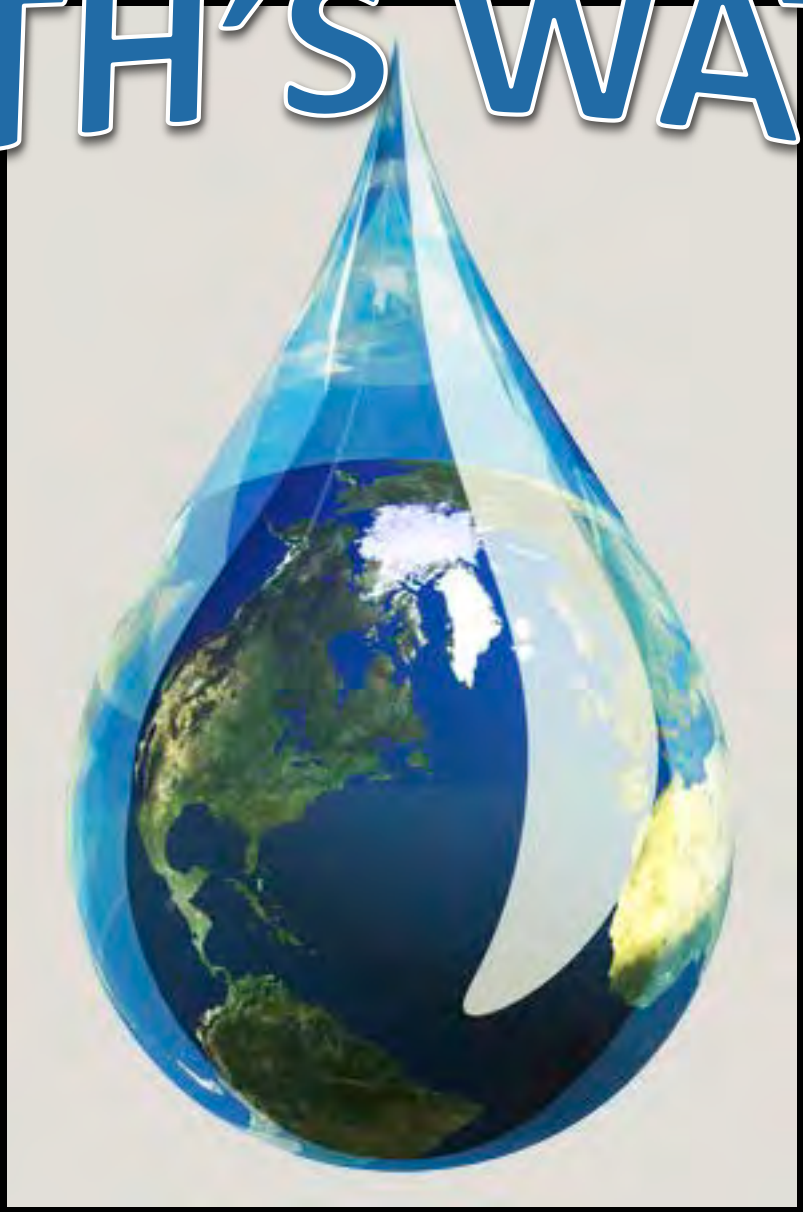
www.bwdh2o.org

NORTHWEST ARKANSAS
Education Service Cooperative

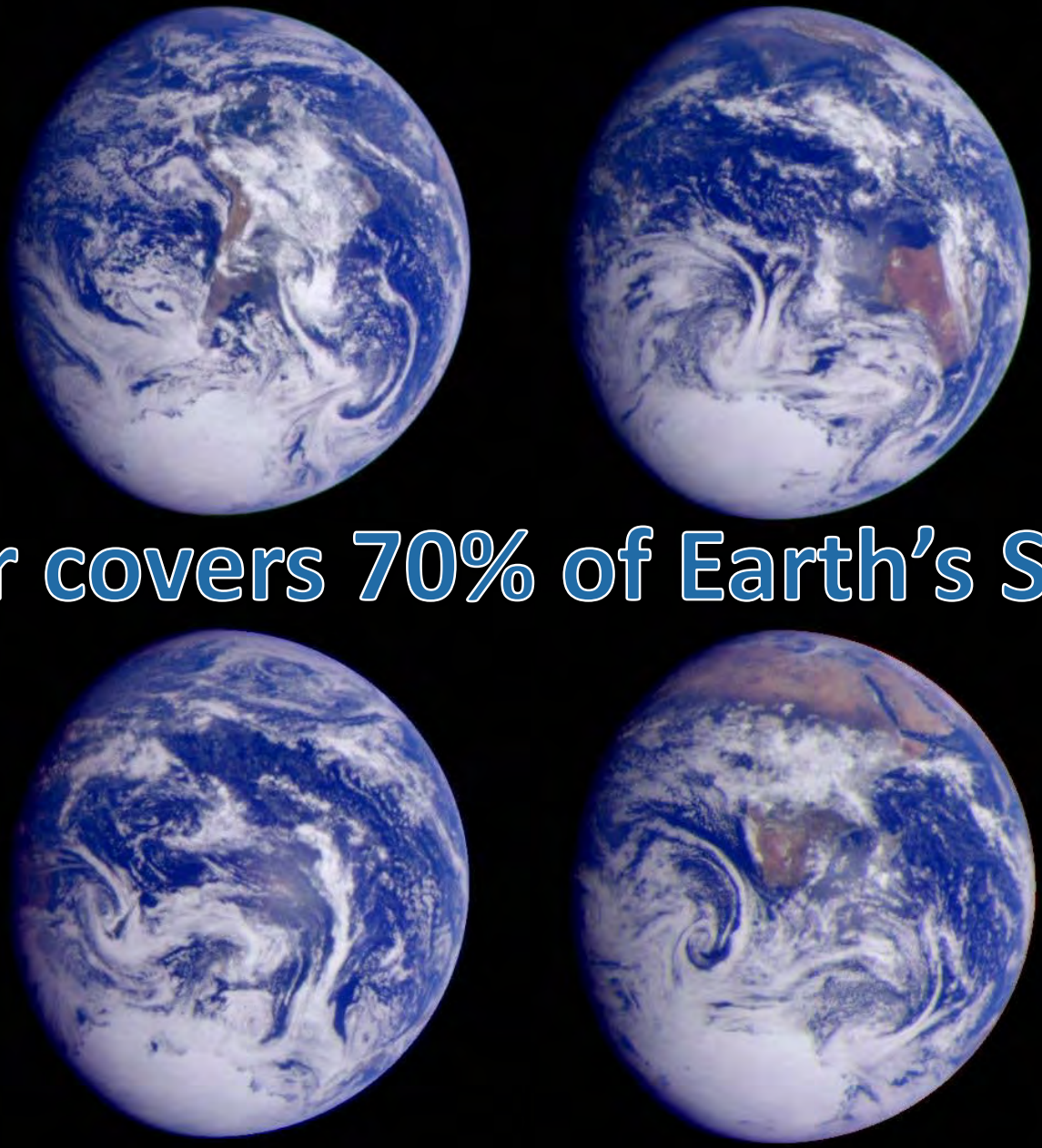
vrhame@starfishnw.org

starfish.k12.ar.us

EARTH'S WATERS



http://www.ge-energy.com/content/multimedia/_files/photos/Water2_Spotlight.jpg



Water covers 70% of Earth's Surface

http://photojournal.jpl.nasa.gov/jpeg/PIA00728.jpg

97.5%
of the water on Earth is salty. Around one per cent of that is brackish groundwater.

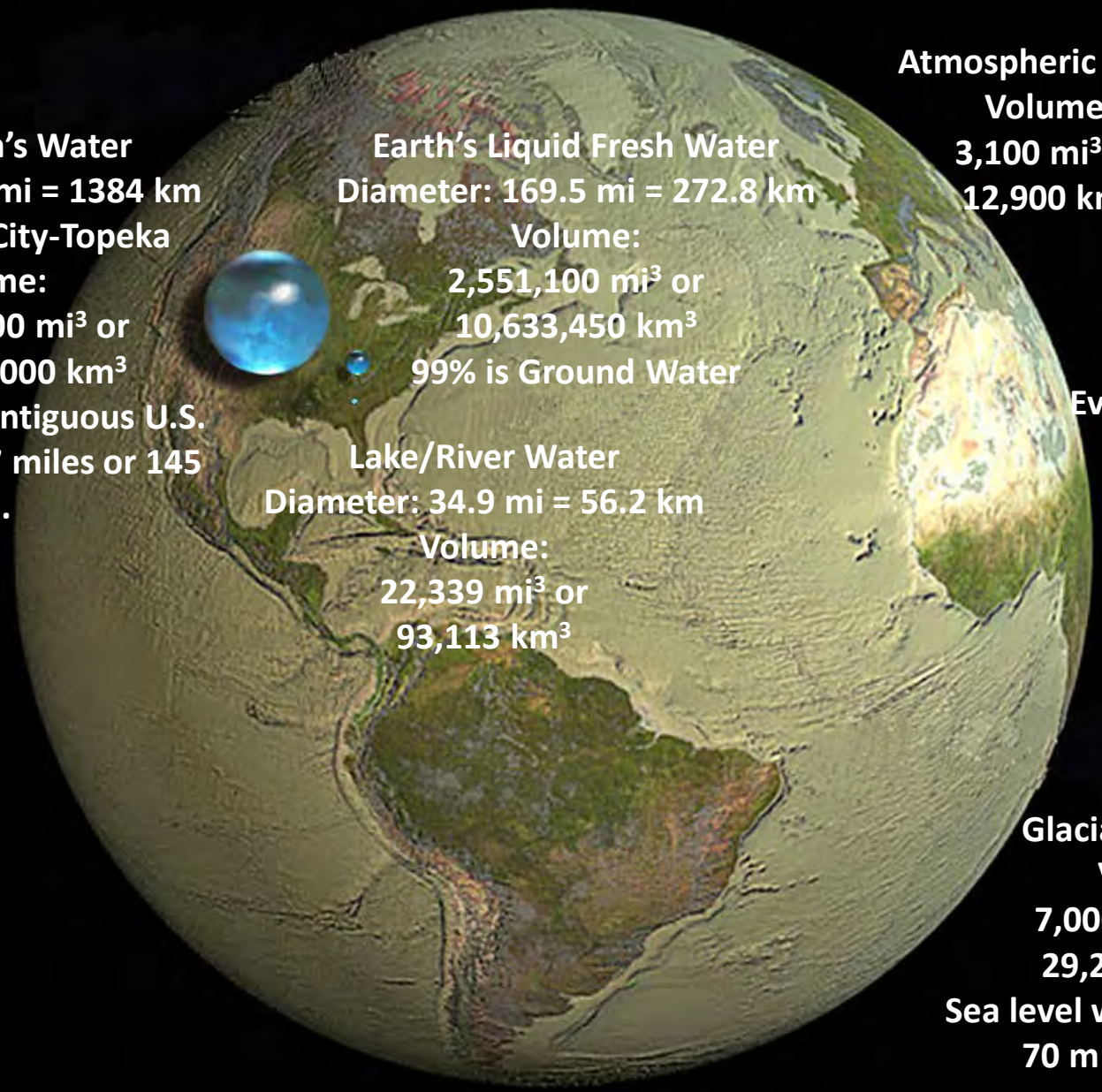
2.5%
of the Earth's water is fresh. About two-thirds of that is frozen; the rest is liquid surface water and groundwater.

Wholesale water cost in southern California (per 1,000 gallons)

Better technology has driven desalination costs down–closer to the price of fresh water—though lately they've risen again with energy and materials prices.

16 billion
gallons are produced daily by the world's 14,450 desalination plants. Persian Gulf countries rely mostly on seawater.

WATER ON EARTH



All of Earth's Water
Diameter: 860 mi = 1384 km
Distance: SL City-Topeka
Volume:
332,500,000 mi^3 or
1,386,000,000 km^3
Would cover contiguous U.S. to depth of 107 miles or 145 km.

Earth's Liquid Fresh Water
Diameter: 169.5 mi = 272.8 km
Volume:
2,551,100 mi^3 or
10,633,450 km^3
99% is Ground Water

Lake/River Water
Diameter: 34.9 mi = 56.2 km
Volume:
22,339 mi^3 or
93,113 km^3

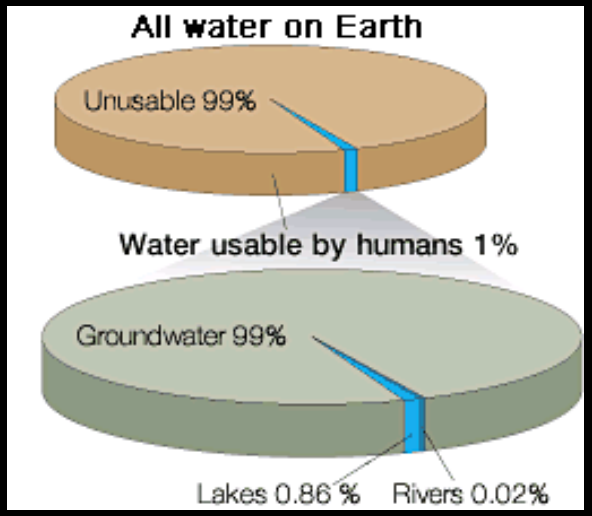
Atmospheric Water Volume:
3,100 mi^3 or
12,900 km^3

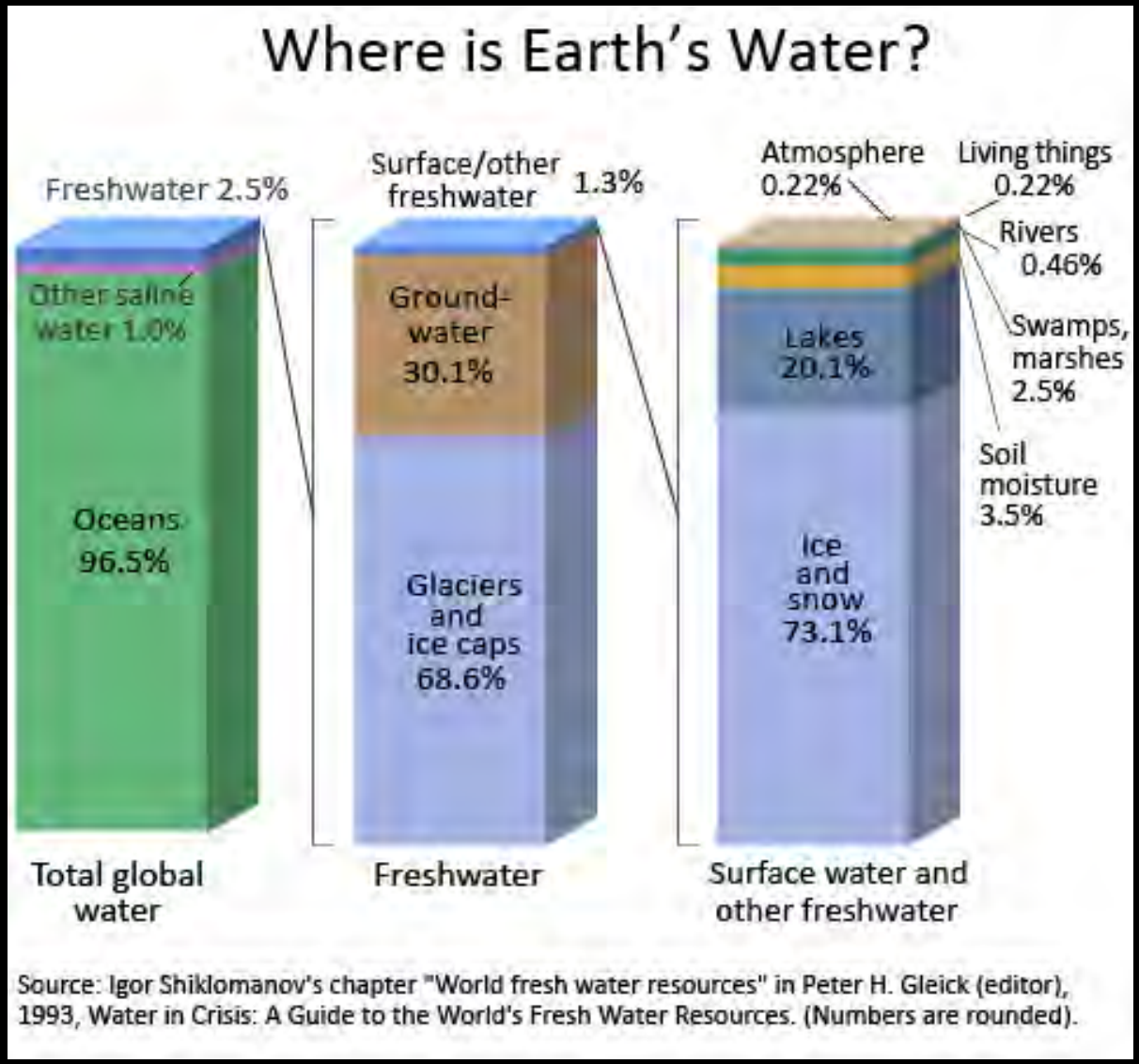
Daily Evaporation/Transpiration Volume:
280 mi^3 or
1,170 km^3

Glacial & Polar Ice Volume:
7,000,000 mi^3 or
29,200,000 km^3
Sea level would rise 230 ft = 70 m if all melted.

http://ga.water.usgs.gov/edu/2010/gallery/global-water-volume.html
http://ga.water.usgs.gov/edu/earthhowmuch.html

DISTRIBUTION OF EARTH'S WATERS





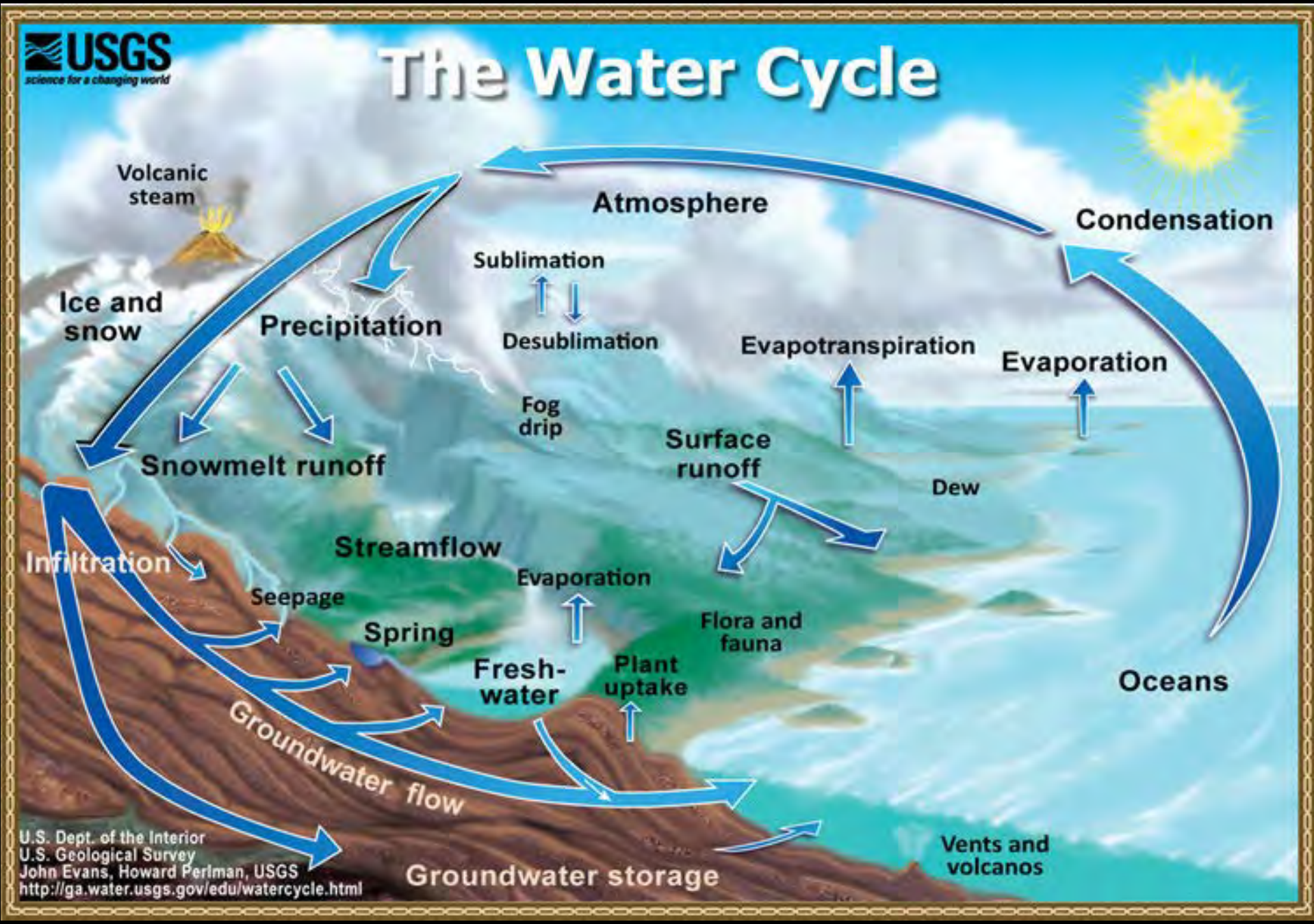
http://ga.water.usgs.gov/edu/earthwherewater.html

One estimate of global water distribution:

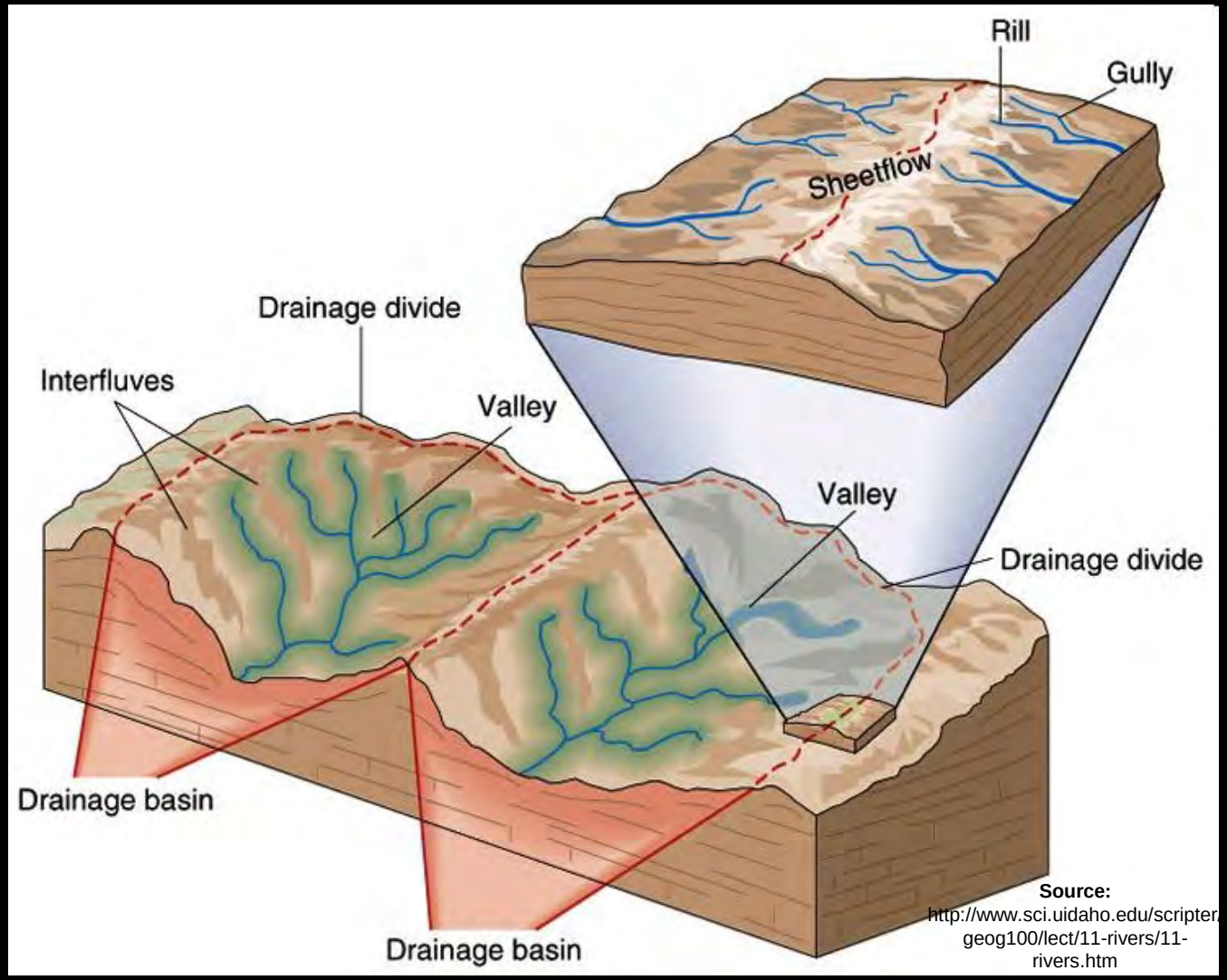
Water source	Water volume, in cubic miles	Water volume, in cubic kilometers	Percent of fresh water	Percent of total water
Oceans, Seas, & Bays	321,000,000	1,338,000,000	--	96.5
Ice caps, Glaciers, & Permanent Snow	5,773,000	24,064,000	68.7	1.74
Groundwater	5,614,000	23,400,000	--	1.7
Fresh	2,526,000	10,530,000	30.1	0.76
Saline	3,088,000	12,870,000	--	0.94
Soil Moisture	3,959	16,500	0.05	0.001
Ground Ice & Permafrost	71,970	300,000	0.86	0.022
Lakes	42,320	176,400	--	0.013
Fresh	21,830	91,000	0.26	0.007
Saline	20,490	85,400	--	0.006
Atmosphere	3,095	12,900	0.04	0.001
Swamp Water	2,752	11,470	0.03	0.0008
Rivers	509	2,120	0.006	0.0002
Biological Water	269	1,120	0.003	0.0001
Total	332,500,000	1,386,000,000	-	100

Source: Gleick, P. H., 1996: Water resources. In Encyclopedia of Climate and Weather, ed. by S. H. Schneider, Oxford University Press, New York, vol. 2, pp.817-823.

http://ga.water.usgs.gov/edu/earthwherewater.html


USGS
science for a changing world
The Water Cycle
Volcanic steam
Atmosphere
Condensation
Sublimation
Desublimation
Ice and snow
Precipitation
Evapotranspiration
Evaporation
Fog drip
Surface runoff
Snowmelt runoff
Dew
Infiltration
Streamflow
Evaporation
Seepage
Spring
Flora and fauna
Fresh-water
Plant uptake
Oceans
Groundwater flow
Vents and volcanos
Groundwater storage
U.S. Dept. of the Interior
U.S. Geological Survey
John Evans, Howard Perlman, USGS
http://ga.water.usgs.gov/edu/watercycle.html

CATCHMENT / DRAINAGE BASIN / WATERSHED



A **watershed** is an "area of land that drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel"
(Dunne and Leopold 1978).

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

PRECIPITATION ON & FLOW IN A WATERSHED

Source: http://www.bwdh2o.org/index.php?fuseaction=p0007.&mod=42

WATERSHED SIZES & SHAPES

Where in the World is BLWS?

3 MAJOR FACTORS THAT AFFECT WATERSHED & STREAM DEVELOPMENT ARE:

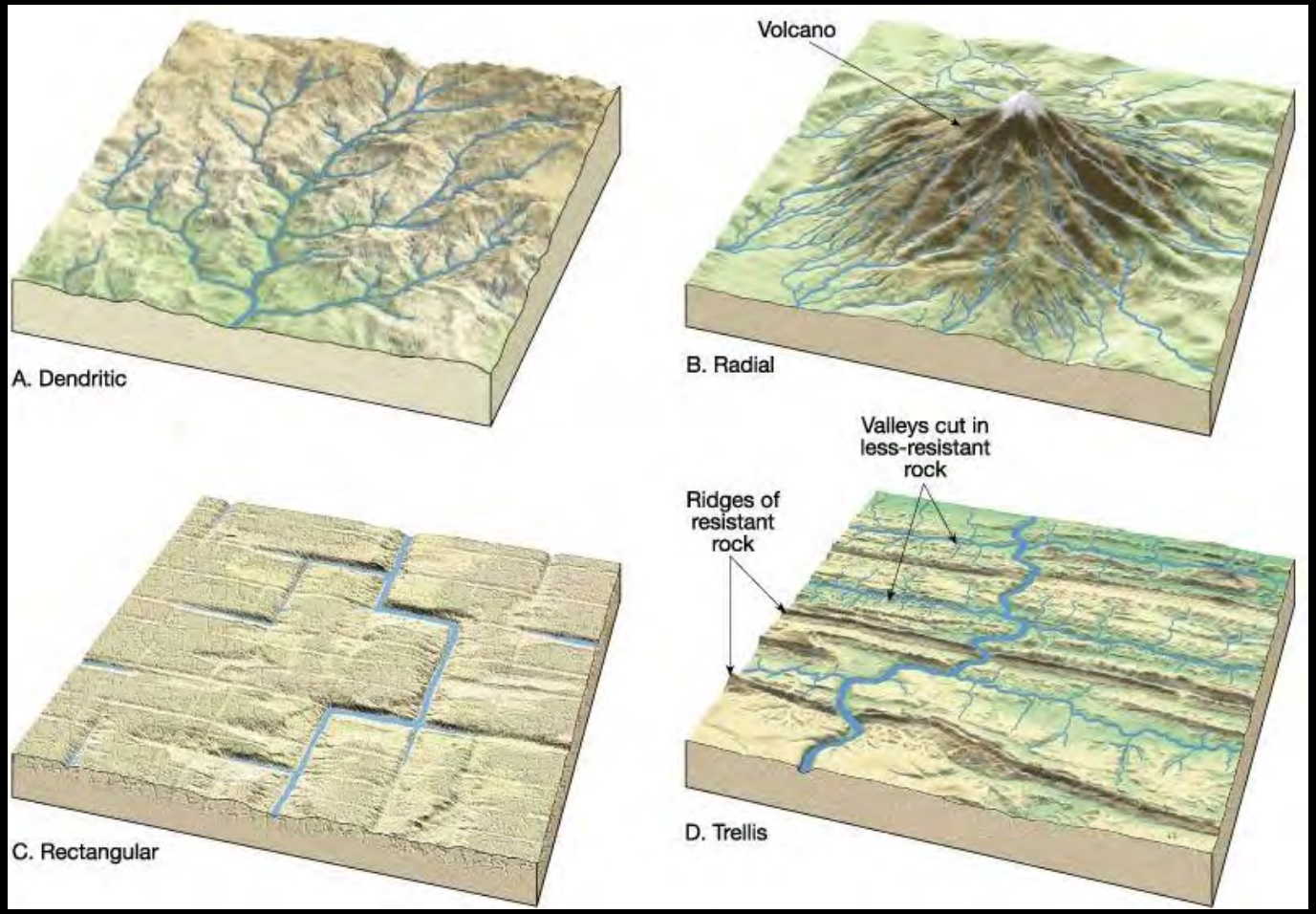
1. GEOLOGY/GEOMORPHOLOGY
2. CLIMATE / WATER CYCLE
3. SLOPE

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

GEOLOGY & DRAINAGE PATTERNS

DENDRITIC DRAINAGE, THE MOST COMMON TYPE,
results from the flow of water over Flat-Lying Rock Units
Example: Ozark Region Springfield Plateau

RADIAL DRAINAGE
is created by surface flow off a raised circular Volcanic or rounded Plutonic landform
Example: Mt. Shasta in California



RECTANGULAR DRAINAGE
forms on rock units with perpendicular fracture planes.
Example: Canadian Shield

TRELLIS DRAINAGE
develops on Folded/Faulted Rock Units
Example: Appalachian Mountains Virginia & Pennsylvania

Source: http://blank005.tripod.com/geology/runningwater.html

CLIMATE: THE TYPE OF WEATHER 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

Source:
www.weaselinthebarley.com/scenic_wallpapers/desert.htm

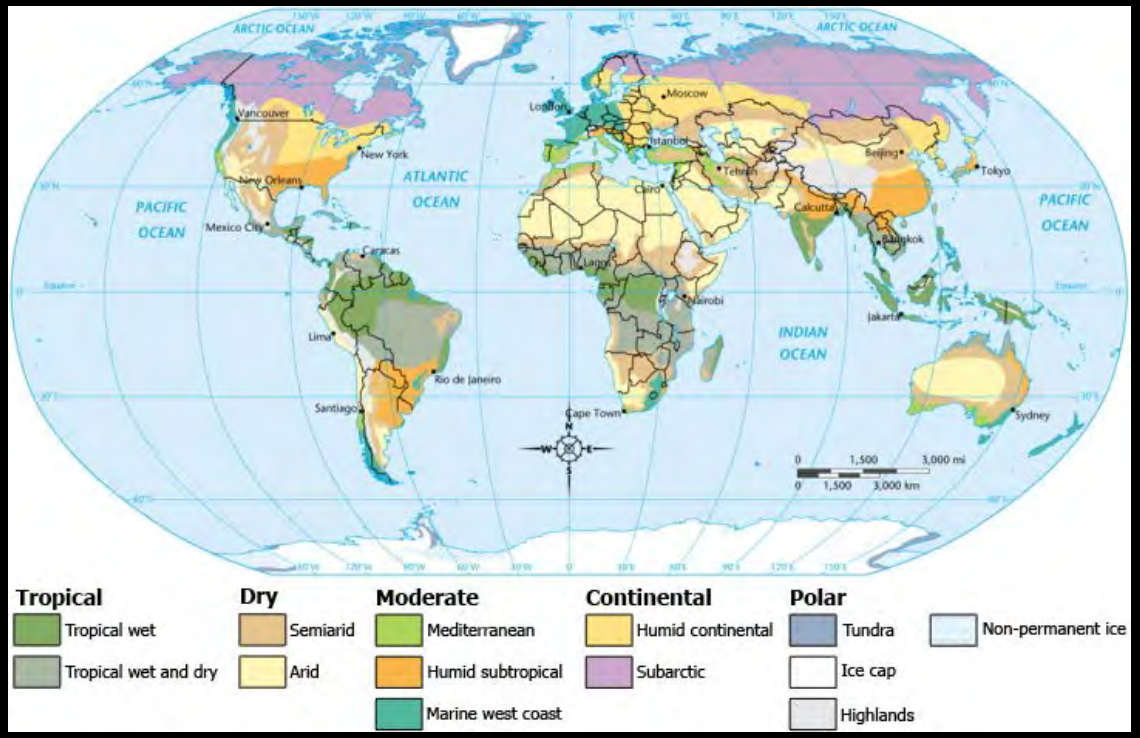
Source:
www.airphotona.com/image.asp?imageid=1742

GRASSLANDS: Rainfall Minimal

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

http://www.americansouthwest.net/wyoming/yellowstone/pelican-grasslands.html

http://www.kidcyber.com.au/topics/biomegrass.htm



WOODLANDS: Rainfall Moderate

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

Source:

Source:
http://www.geograph.org.uk/photo/2427529

RAINFORESTS: Rainfall Maximum

<175-200 centimeters = <69-79 inches per year

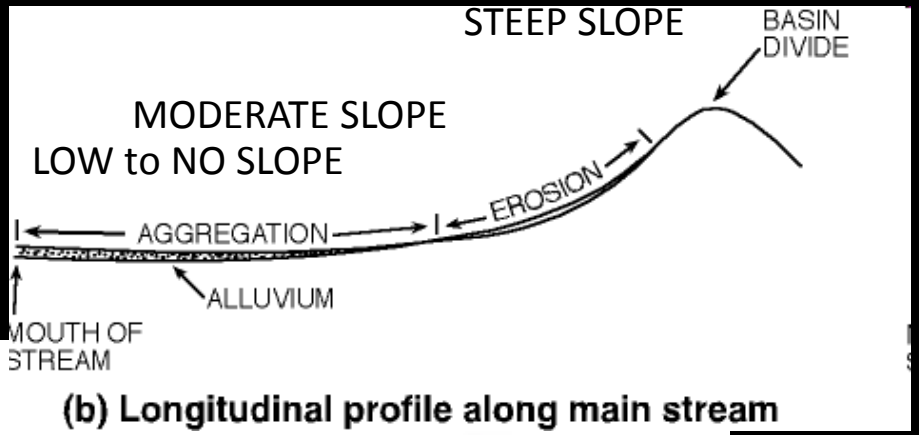
Source:
http://burns1.wikispaces.com/Southeast+Asian+Rainforest

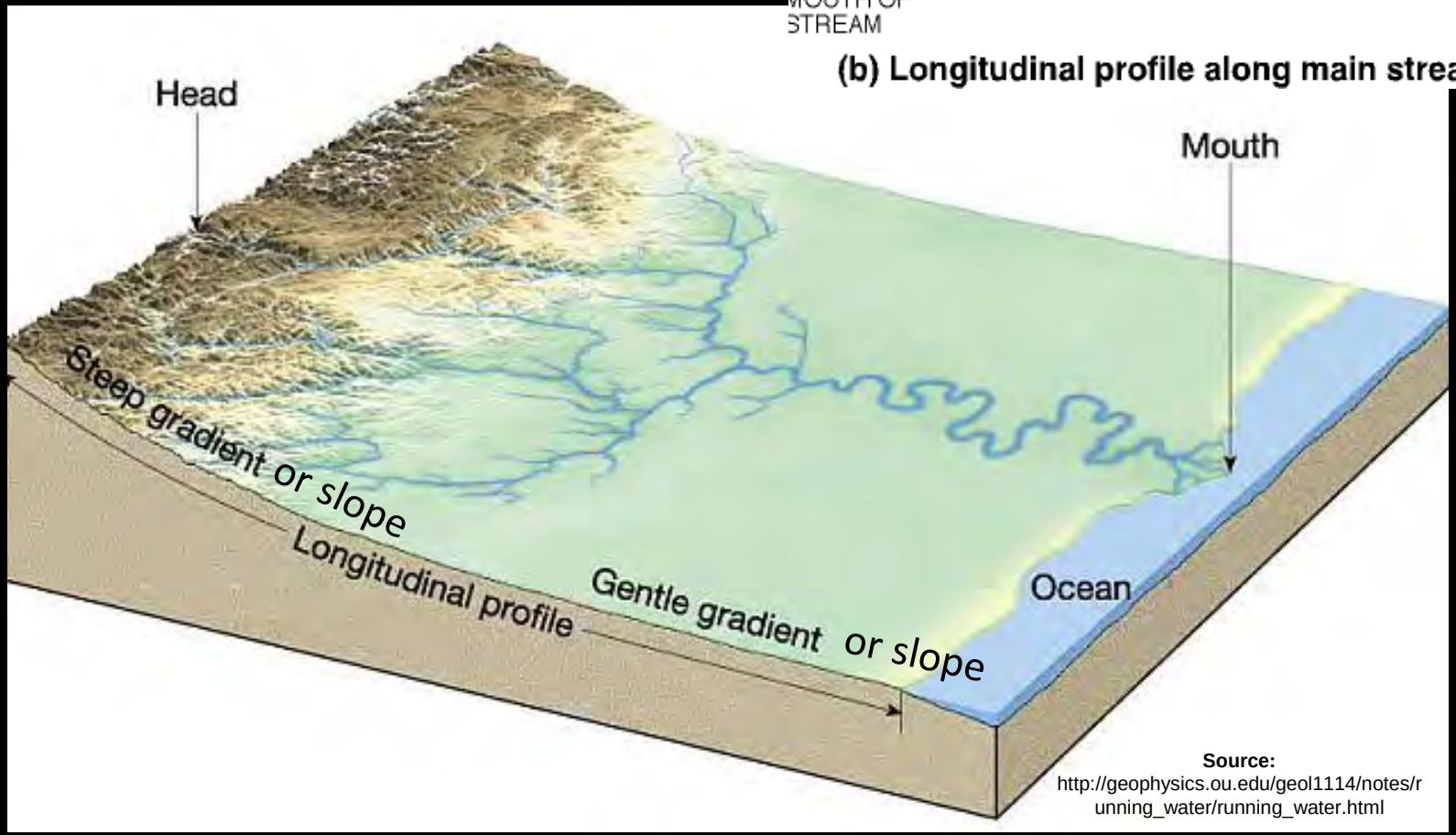
Source:
http://photos.igougo.com/pictures-photos-p211084-rain_forest.html

DRAINAGE BASINS & STREAMS

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.

http://www.il.nrcs.usda.gov/news/publications/factsheets/FS_StreamDynamics.html





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

DYNAMIC EQUILIBRIUM

For hundreds of years, where climatic conditions stabilized, only minor changes were made to the landscape, and stream systems developed a balance of size and shape capable of carrying the water and sediment generated within each watershed.

http://throughthesandglass.typepad.com/through_the_sandglass/2009/08/index.html

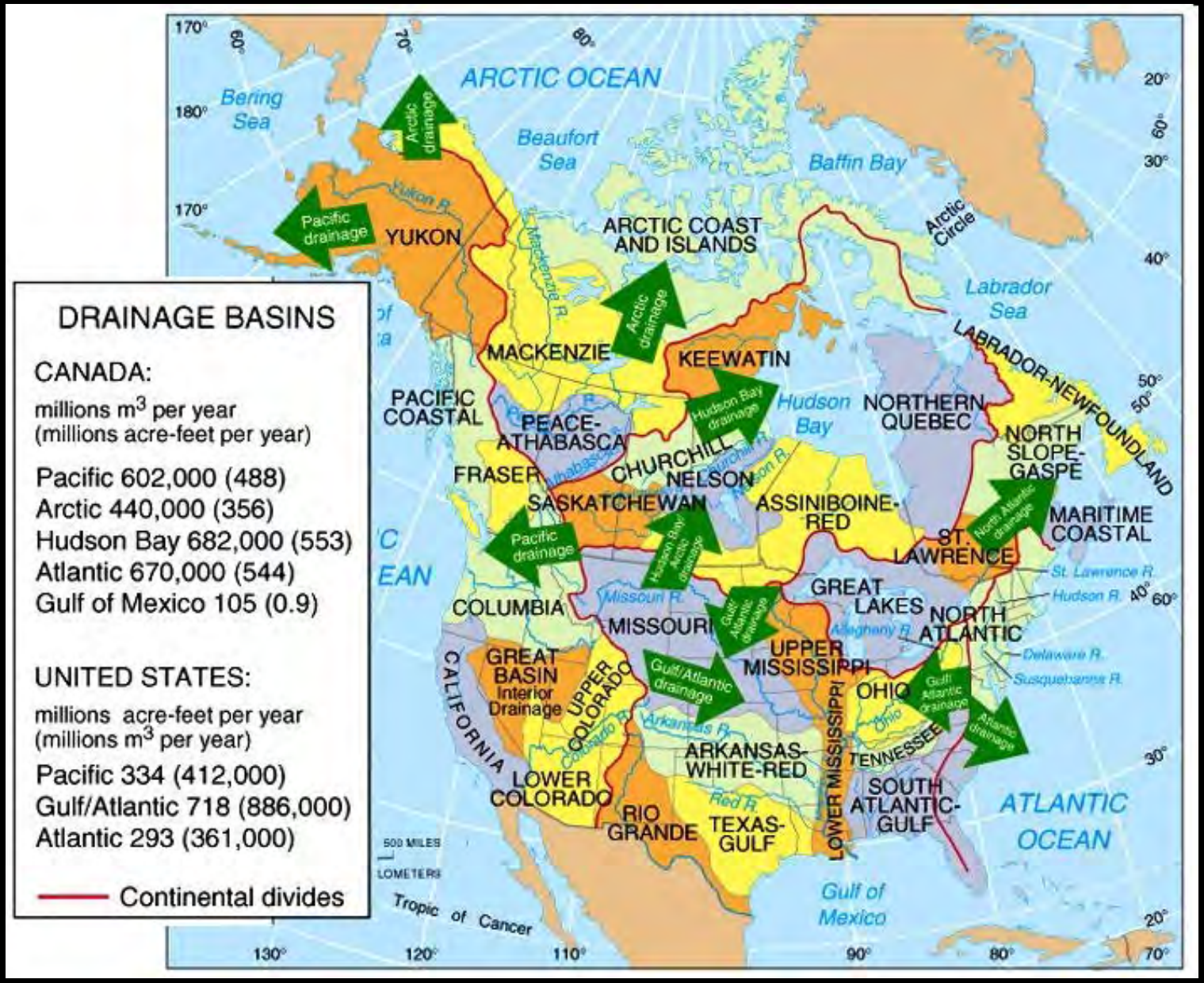
http://forecaster.deltares.nl/index.php?title=Widen_water_courses

http://littlerock.about.com/od/outdoorrecreation/ig/Cossatot-River-State-Park/Cossatot-River-State-Park.-2qT.htm

http://www.ouraaa.com/traveler/images/mag0105/ST16A.jpg

This balance is known as a state of DYNAMIC EQUILIBRIUM in which stream channels, in a stable climatological setting, continue to shift and change slowly while maintaining their overall shape and size.

MAJOR NORTH AMERICAN DRAINAGE BASINS

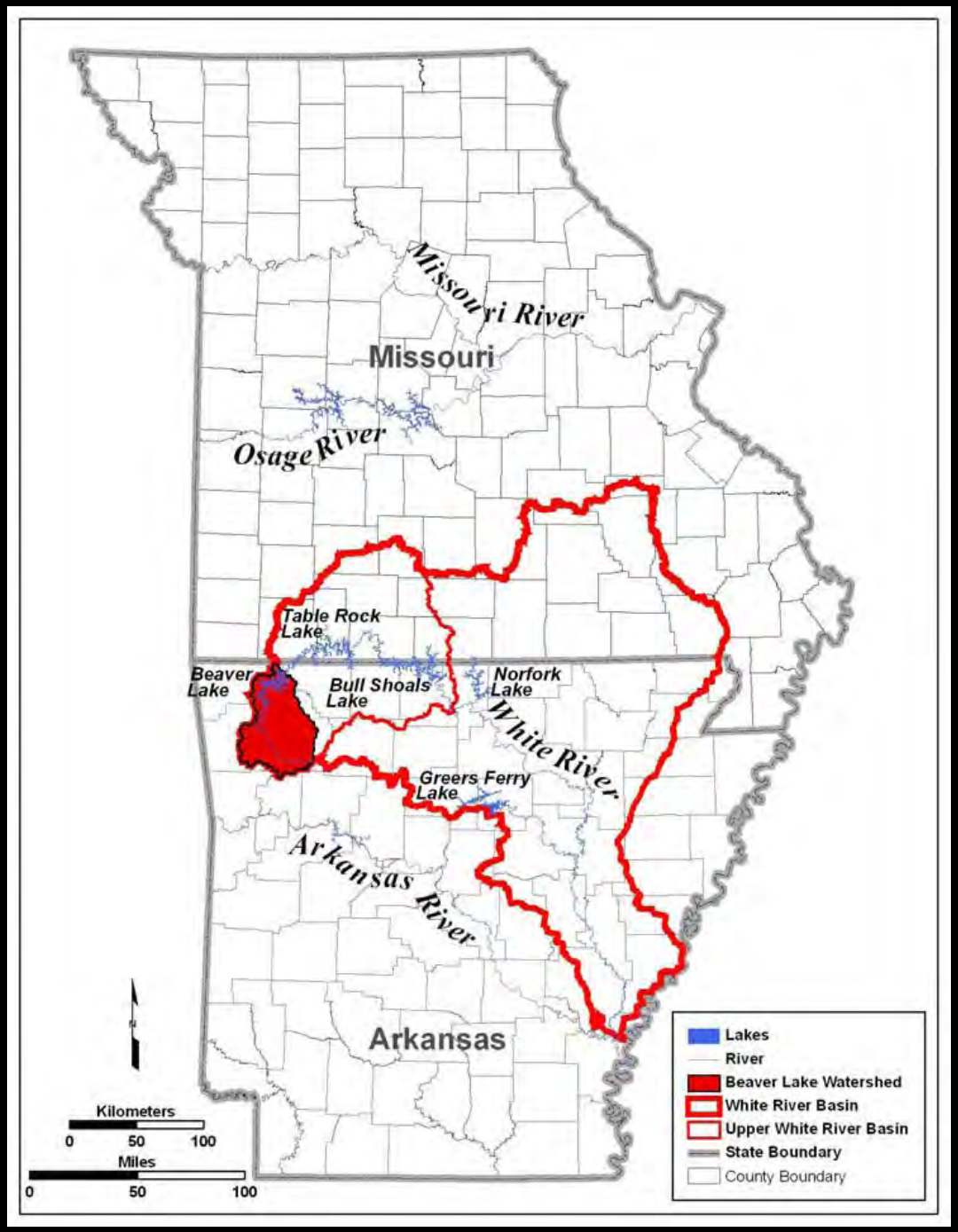


Source: http://www.sci.uidaho.edu/scripter/geog100/lect/11-rivers/11-rivers.htm

Natural Drainage Patterns

Shape of the stream systems draining a particular region

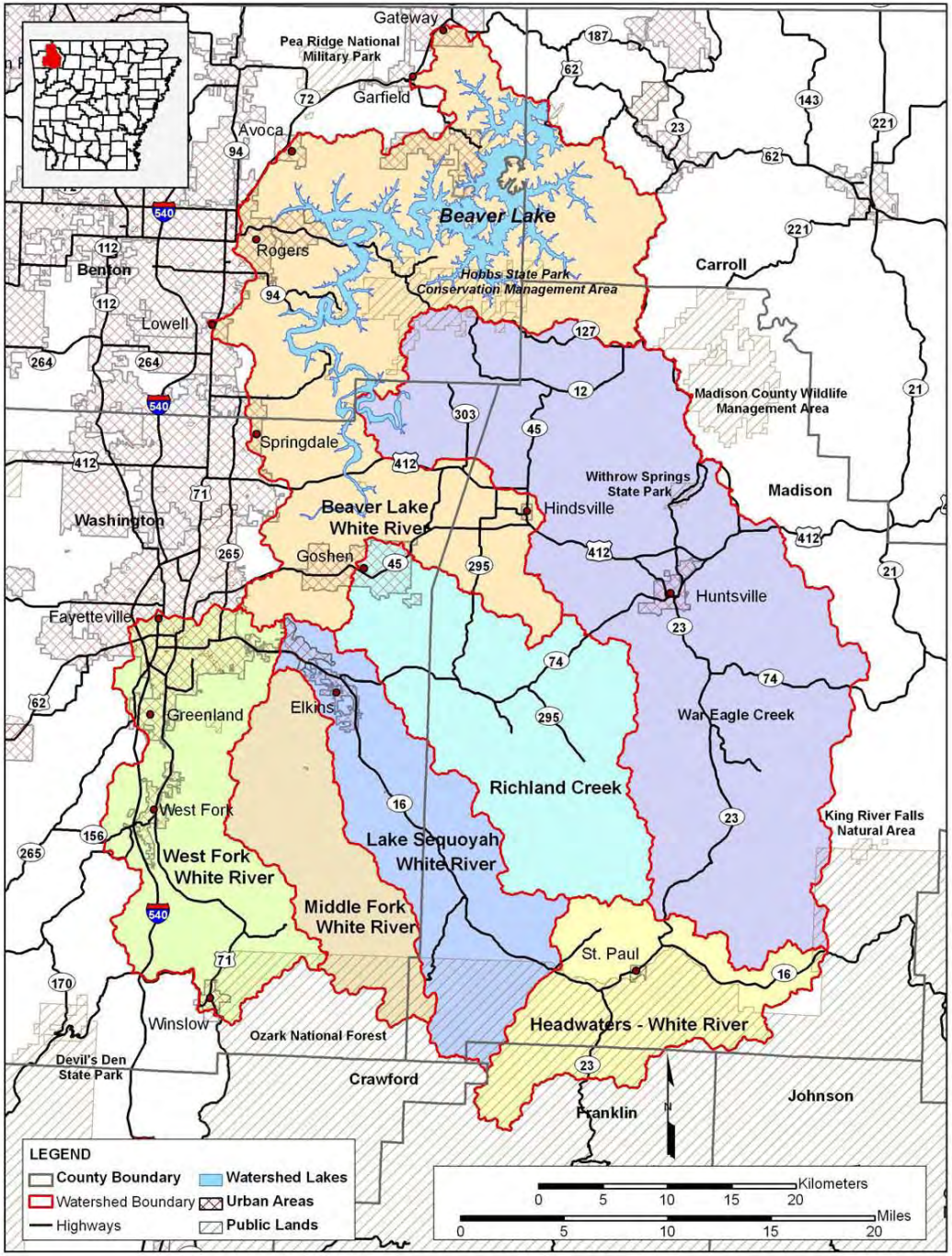
Source: http://geophysics.ou.edu/geol1114/notes/running_water/running_water.html



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

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

Source:
http://www.bwdh2o.org/files/45/2010_FINAL_Beaver_Lake_Watershed_Report.pdf



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

THE BEAVER LAKE WATERSHED INCLUDES THE 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

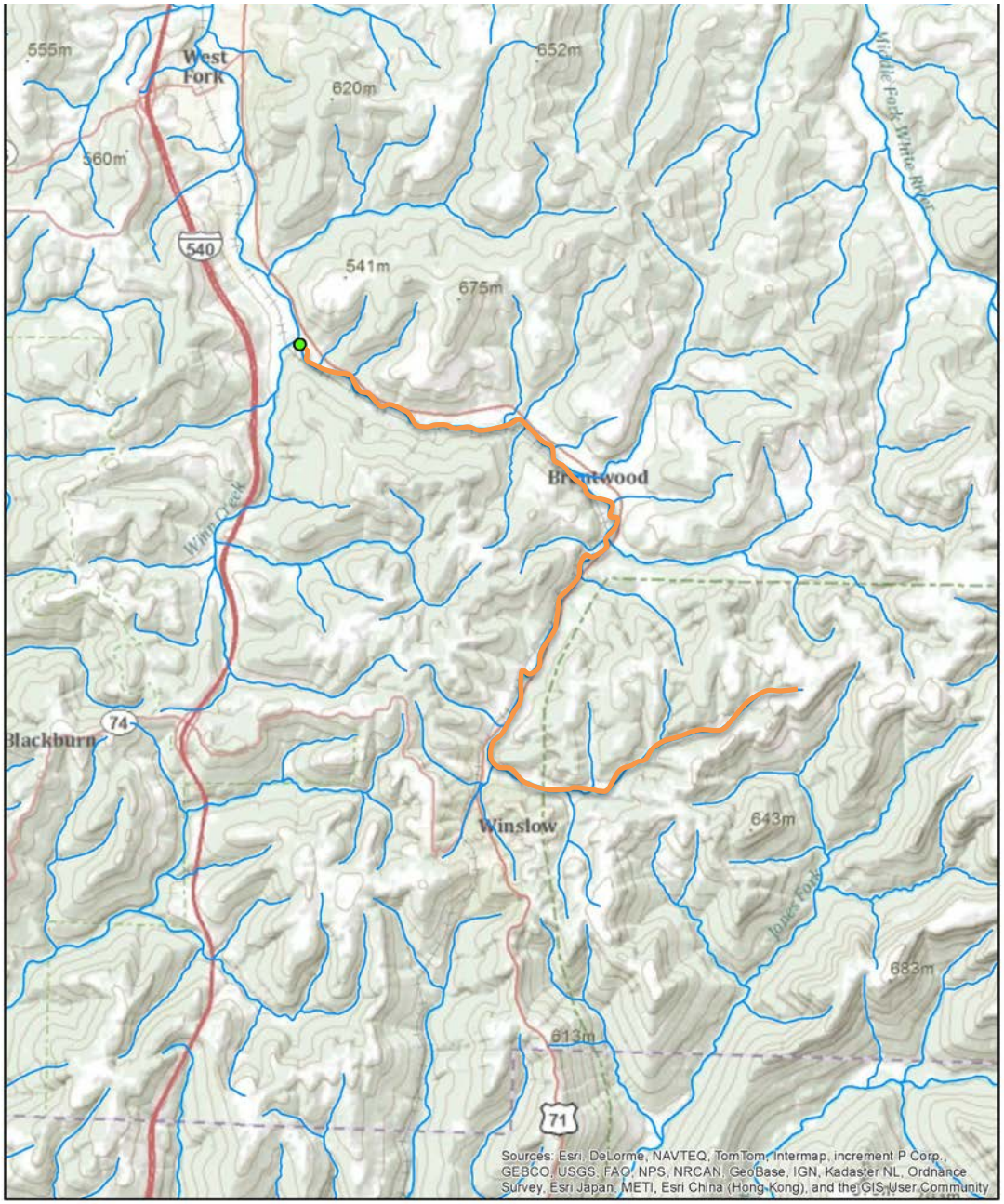
Source:
http://www.bwdh2o.org/files/45/2010_FINAL_Beaver_Lake_Watershed_Report.pdf

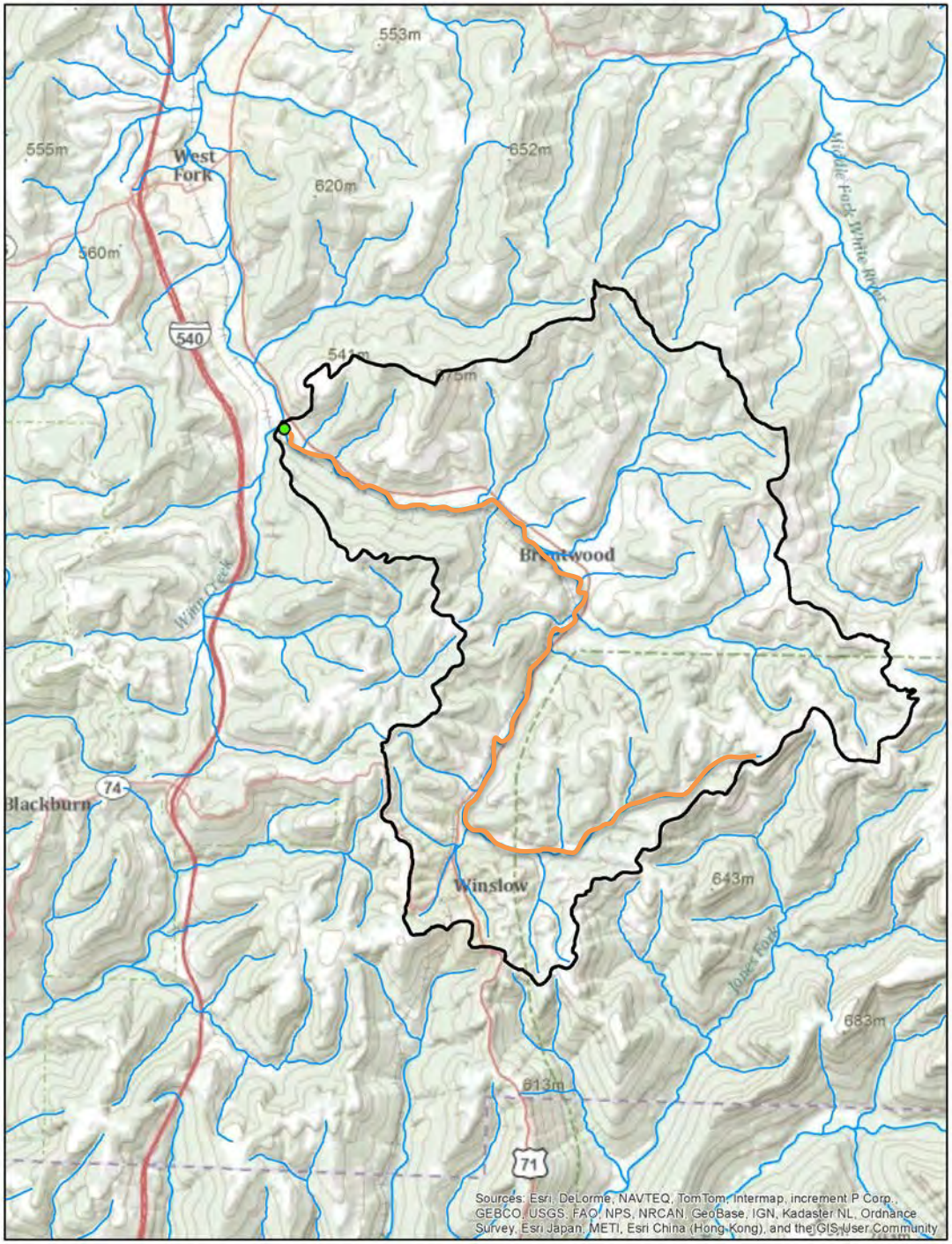
WATERSHED SIZES & SHAPES "POOL" VISUALIZATION ACTIVITY

Anticipation Activity
Watershed Delineation Exercise
(Topo Map Sets provided on next 4 pages)

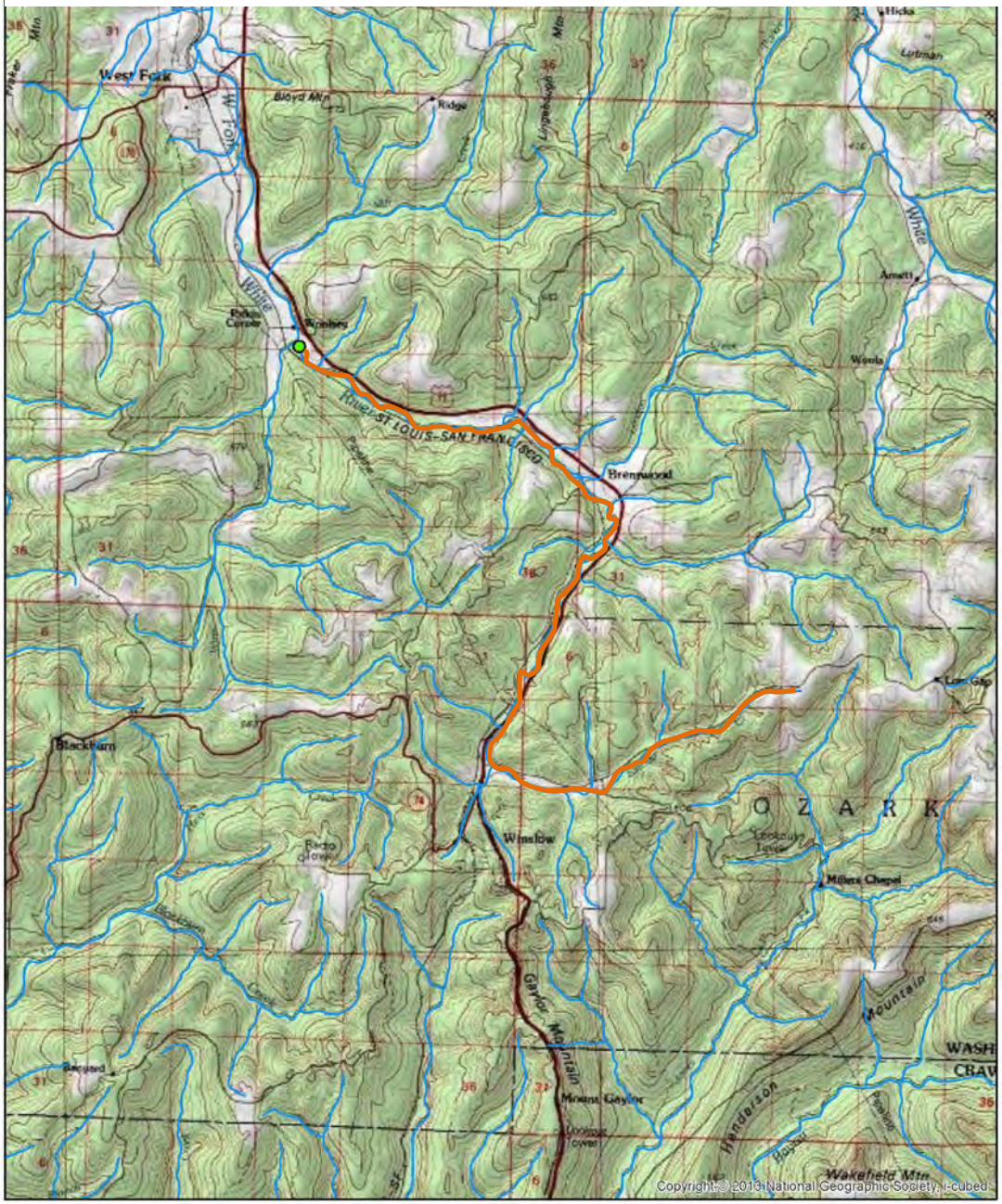
BLWS Map & Passport

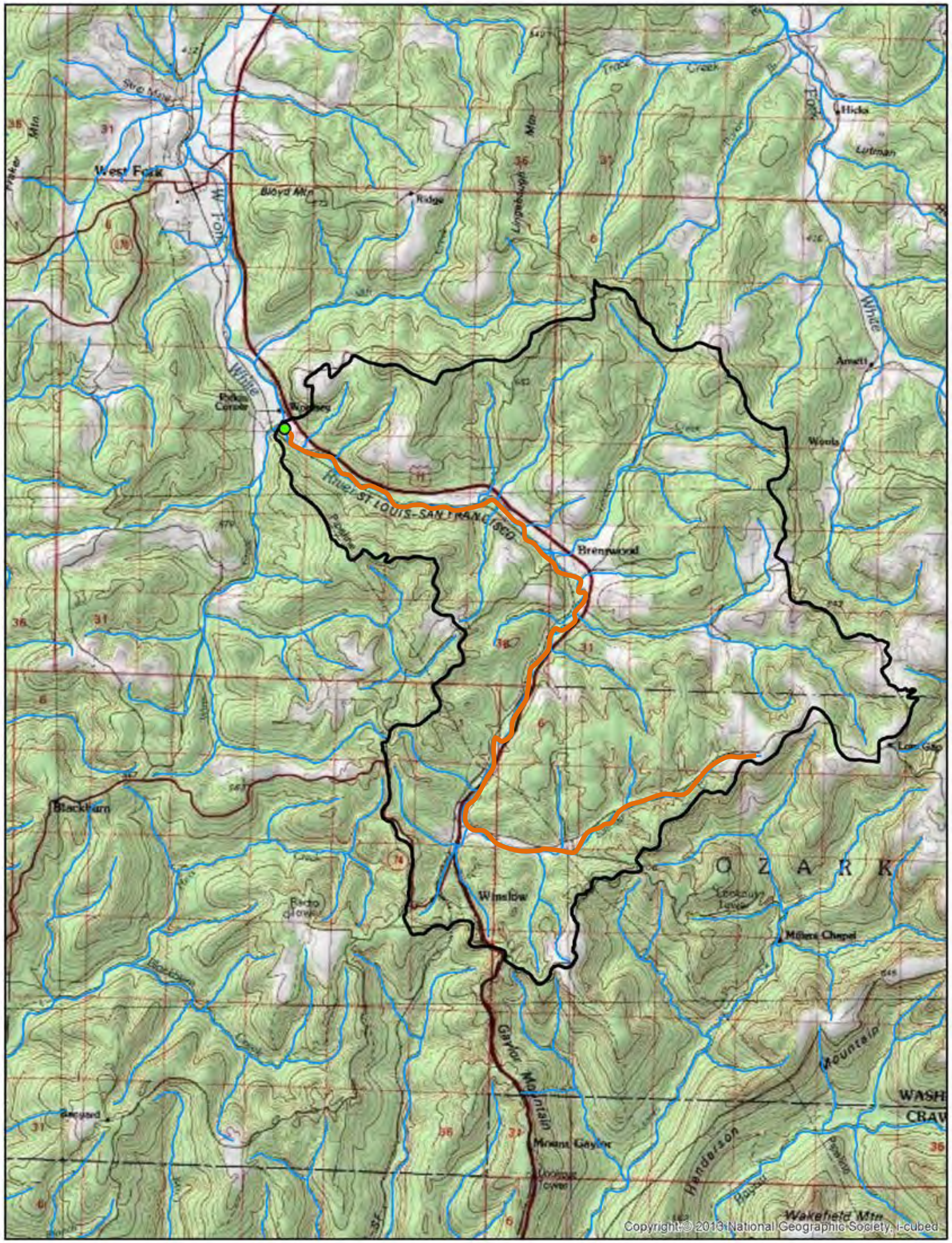
Delineate watershed of "orange" stream starting at green dot (mouth of stream = lowest elevation in watershed)

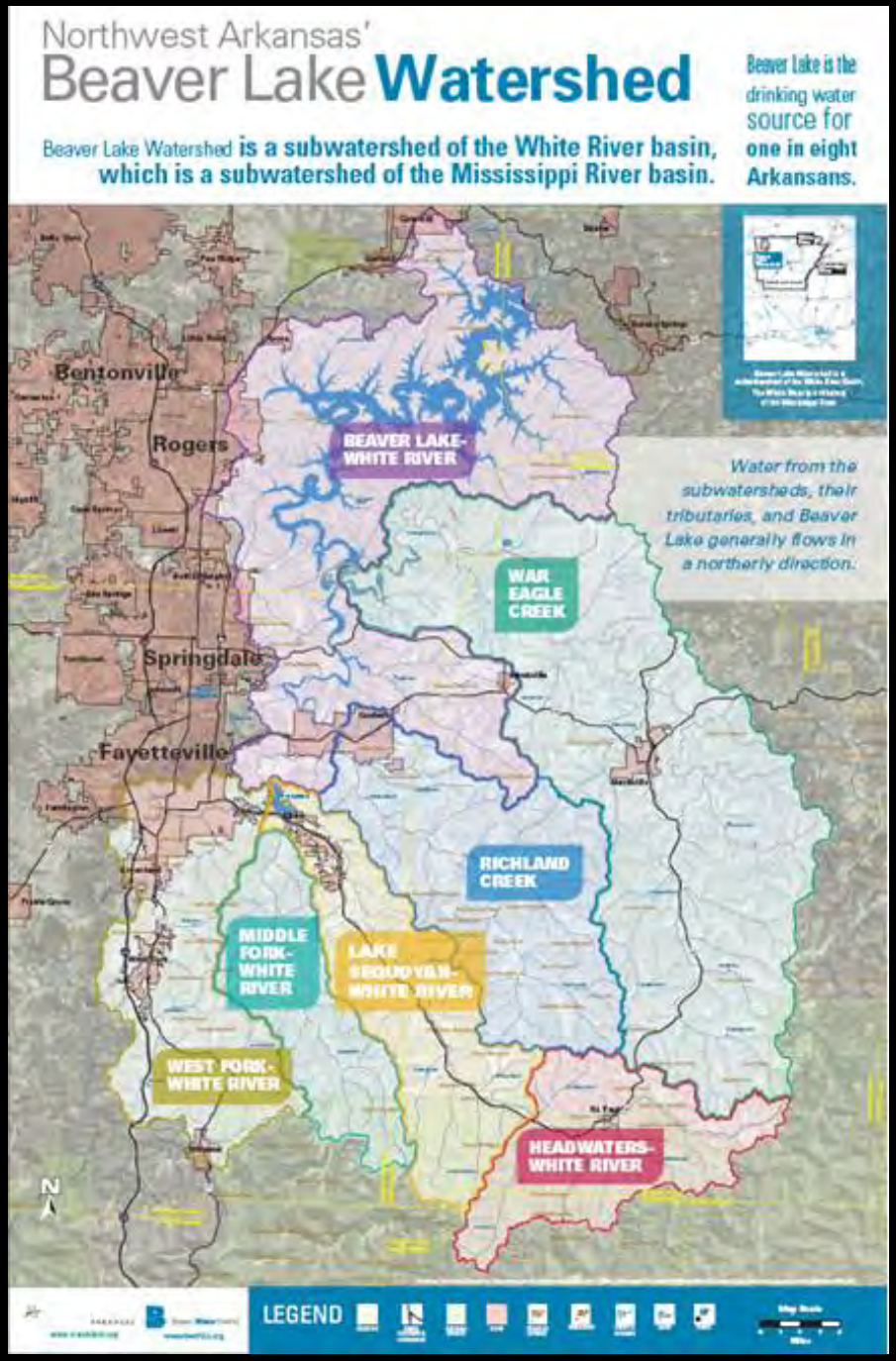



553m
555m
West Fork
620m
652m
560m
540
541m
675m
Middle Fork White River
Brentwood
Winn Creek
74
Blackburn
Winslow
643m
683m
613m
71
Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

Delineate watershed of "orange" stream starting at green dot (mouth of stream = lowest elevation in watershed)



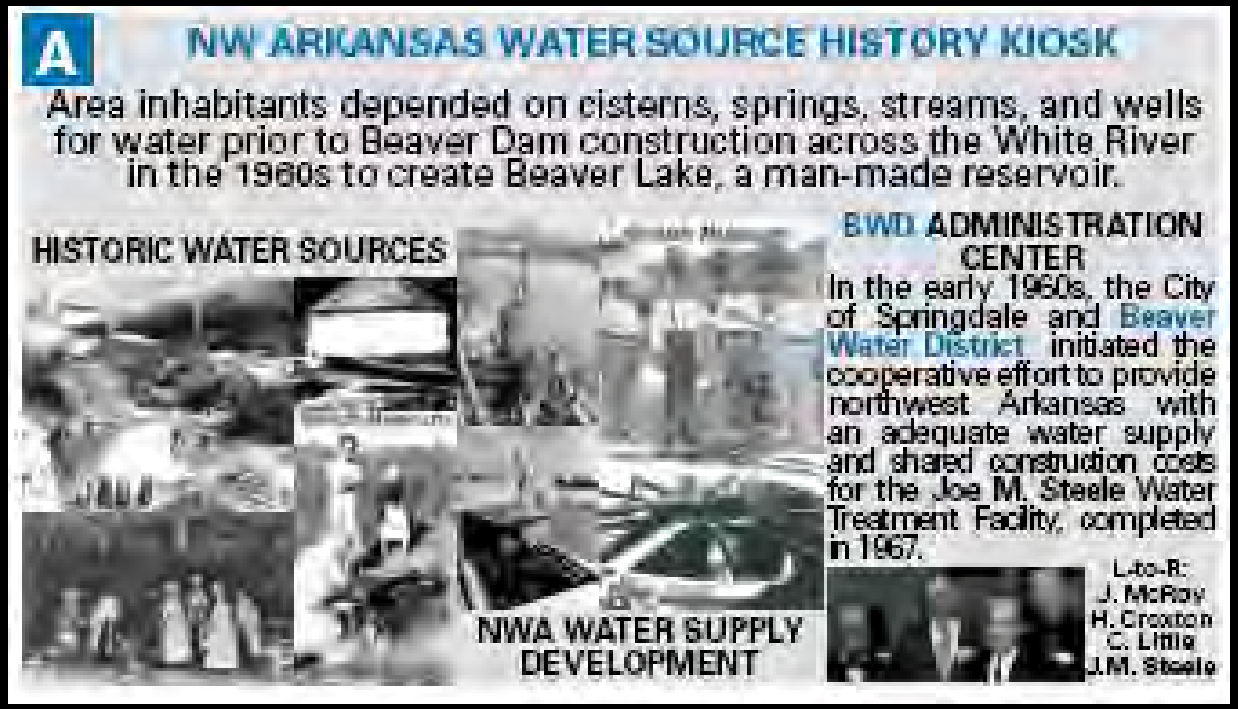

West Fork
Bloyd Mtn
Ridge
Hicks
Lutman
White
Arnett
Woods
River
ST LOUIS-SAN FRANCISCO
Brentwood
Blackburn
Winslow
O Z A R K
Millers Chapel
Gaylor Mountain
Mount Gaylor
Henderson
Mountain
Wakefield Mtn
WASH
CRAW
Copyright © 2013 National Geographic Society, i-cubed



The Beaver Lake Watershed encompasses over 766,026 acres or 1200 square miles.

It is a sub-watershed of the White River Watershed which is a sub-watershed of the Mississippi River Watershed.

Beaver Water District



Beaver Water District

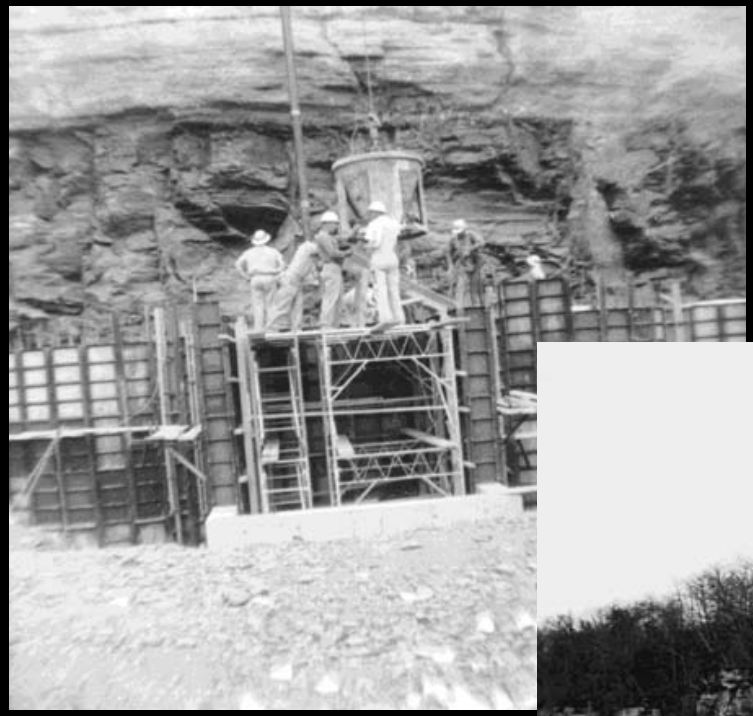
BEAVER LAKE AND BEAVER WATER DISTRICT ORIGINS:

Nearly 50 years ago, visionary community leaders got together to discuss the need for a long-term supply of clean, safe water for Northwest Arkansas. With an eye to the future and conventional understanding that a large lake was the best source of water, these citizens worked to establish Beaver Lake Reservoir.

Congress authorized the construction of **Beaver Dam** in 1954. Construction was delayed until the passage of the the **Water Supply Act** in 1958.
BWD was established by circuit court order on August 27, 1959.

Beaver Water District

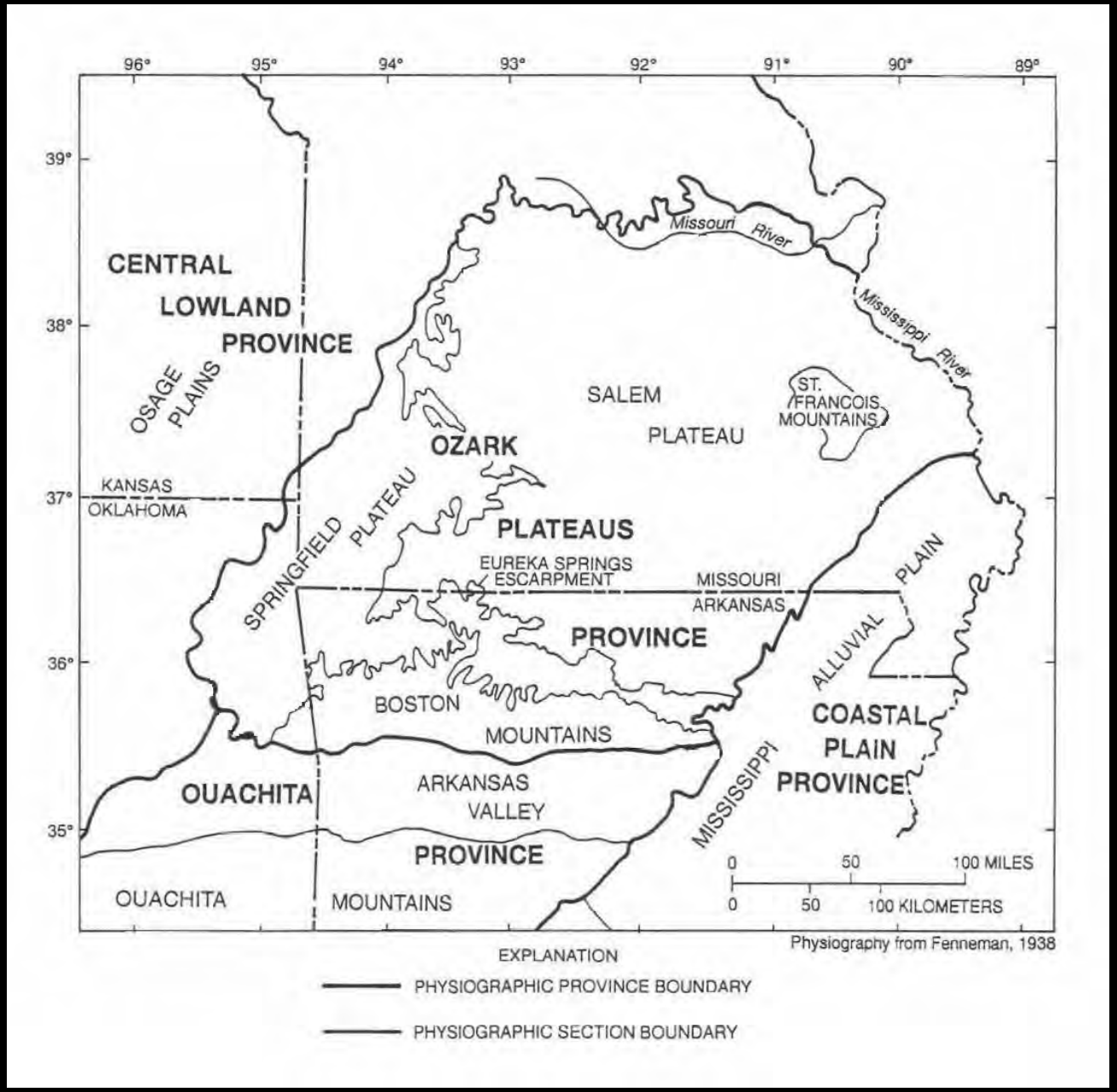
BWD intake construction began on the White River in 1960



Beaver **Water** District

www.bwdh2o.org

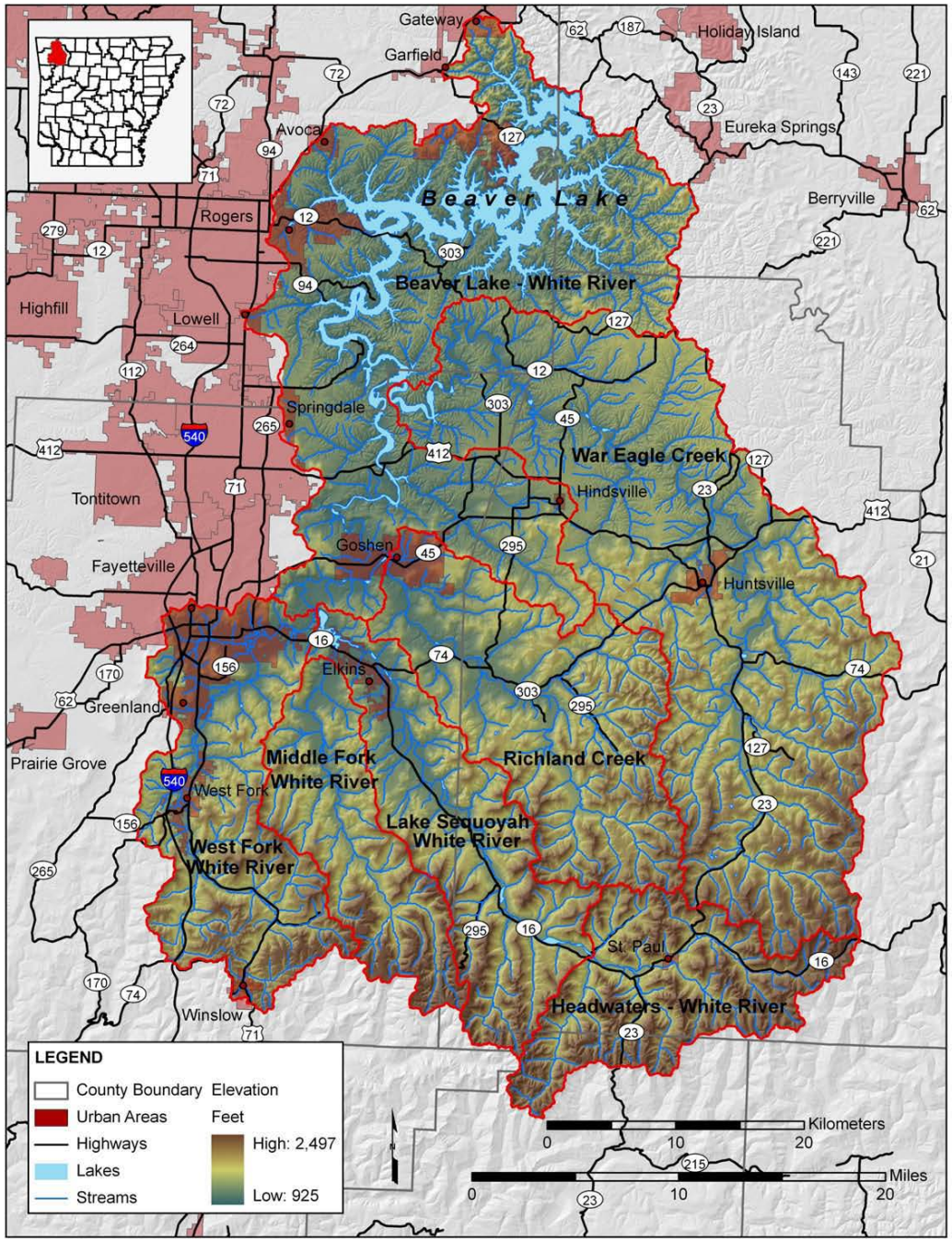
Source: http://www.worldatlas.com/webimage/countrys/namerica/usstates/uslandfm.htm



Source:
http://www.bwdh2o.org/files/45/2010_FINAL_Beaver_Lake_Watershed_Report.pdf

THE WHITE RIVER AND BEAVER LAKE WATERSHEDS ARE PART OF THE OZARK PLATEAU PROVINCE

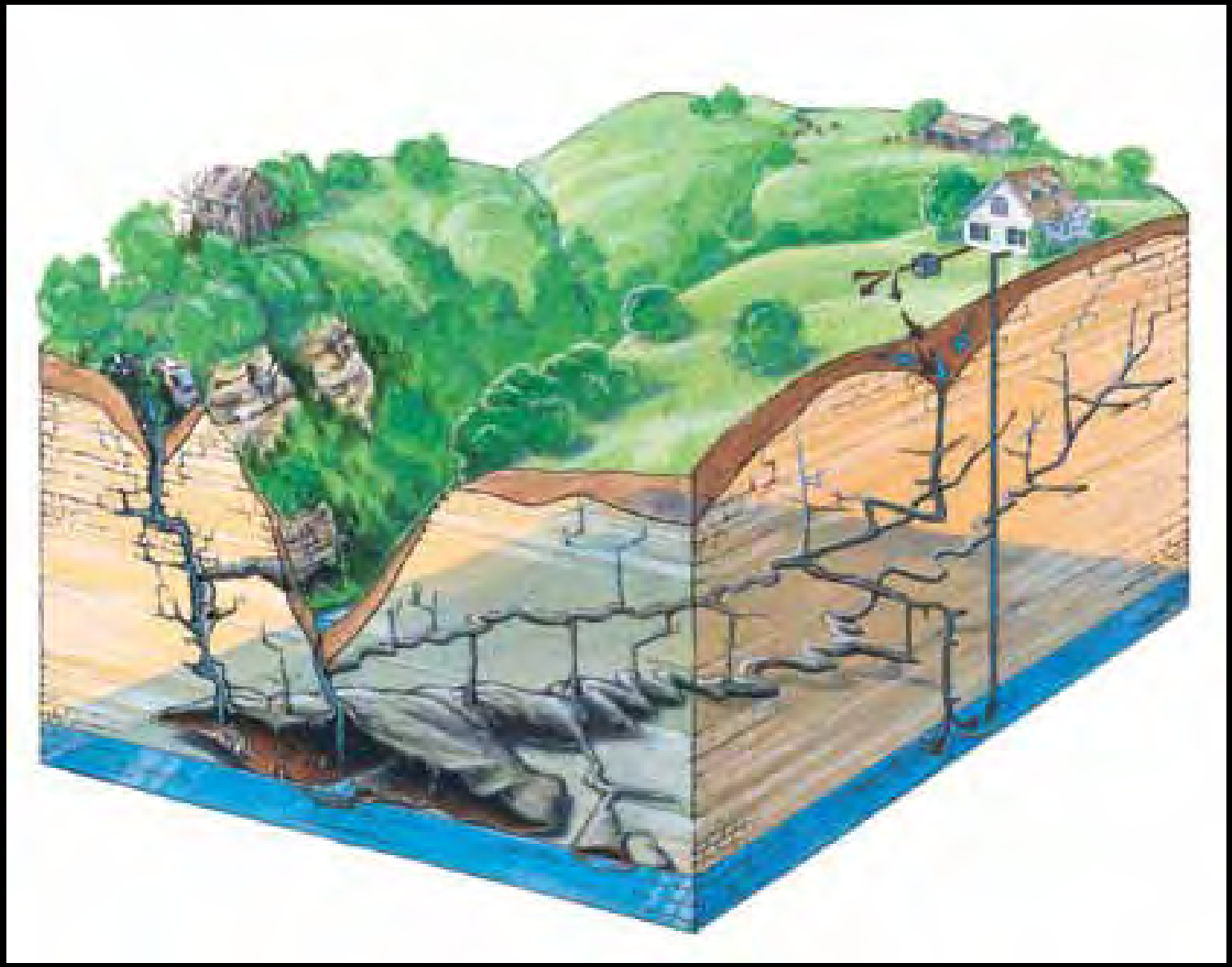
For more information on Characteristic Features of the Ozark/Springfield/Boston Plateaus, go to:
http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=440



The DENDRITIC drainage pattern is characteristic of the Ozark Plateau Province and the Beaver Lake Watershed.

Source:
http://www.bwdh2o.org/files/45/2010_FINAL_Beaver_Lake_Watershed_Report.pdf

WATER FLOW FROM THE SURFACE TO BELOW GROUND IN A WATERSHED WITH LIMESTONE “KARST” TOPOGRAPHY SUCH AS IS FOUND IN THE BEAVER LAKE WATERSHED



Source: http://www.bwdh2o.org/index.php?fuseaction=p0007.&mod=42

HUMAN ACTIVITIES DRAMATICALLY AFFECT THE WATER CYCLE, IMPACT THE LANDSCAPE, and ALTER DRAINAGE PATTERNS

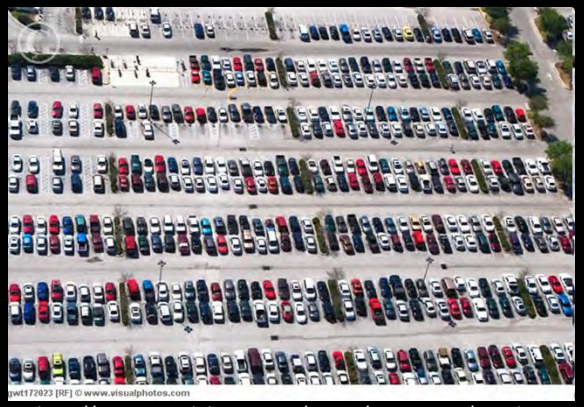
PLOWING

http://kids.britannica.com/comptons/art-56029/An-aerial-view-of-farmland-in-Minnesota-shows-the-unique

CLEAR CUTTING FORESTS

http://fightingfazz.blogspot.com/

PAVING



http://www.visualphotos.com/image/2x3869618/aerial_view_of_cars_parked_in_a_parking_lot

CHANNELIZATION

http://www.portadam.com/cp-projects/channelization/

DEVELOPMENT

http://paulin8.blogspot.com/2011/06/sprawl-repair-manual.html

MINING

http://esl-radmila.blogspot.com/2010/10/mountain-top-removals-in-west-virginia.html

The landscape has been altered dramatically by human activity since the beginning of European settlement over 200 years ago. These alterations are causing our stream systems to change dramatically in an attempt to restore equilibrium.

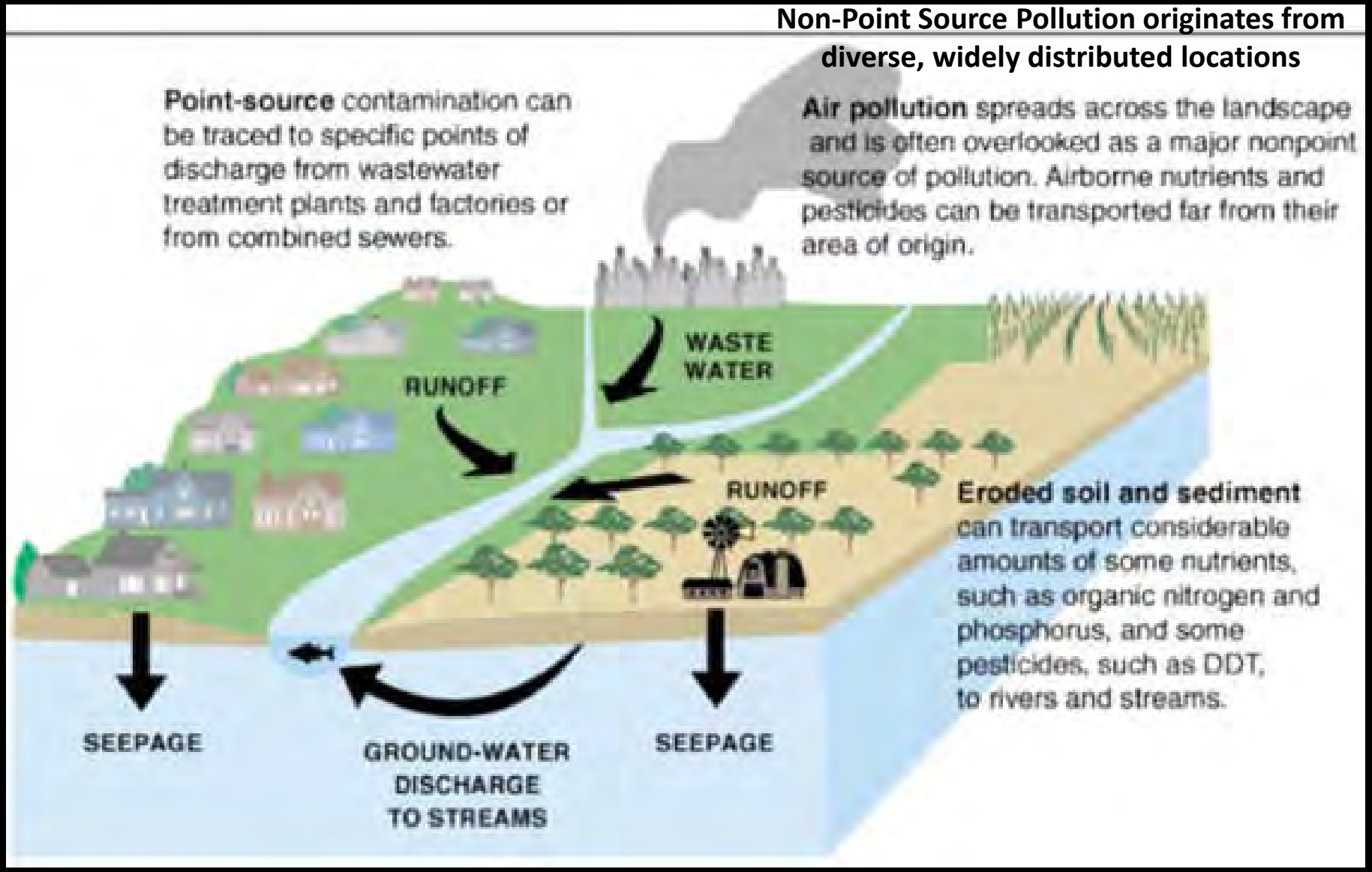
http://www.il.nrcs.usda.gov/news/publications/factsheets/FS_StreamDynamics.html

LAND USE MODULES

POTENTIAL POLLUTION SOURCES?

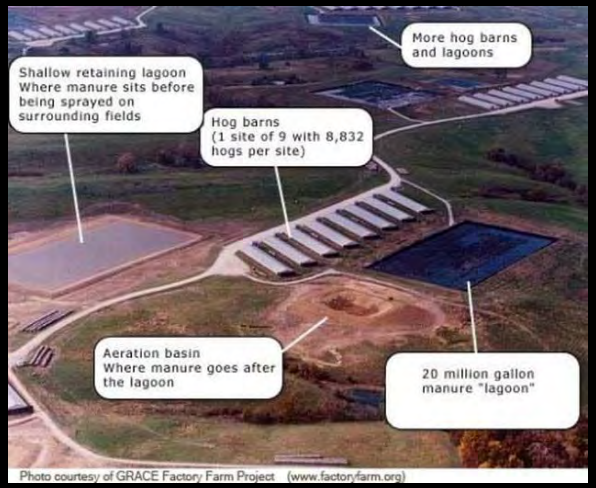
HOW LAND USE AFFECTS WATER CYCLE, WATERSHED, WATER QUALITY?

POLLUTION: Point Source vs. Non-Point Source



http://epg.modot.org/files/thumb/7/7f/127_good_steward_point_source.jpg/590px-127_good_steward_point_source.jpg

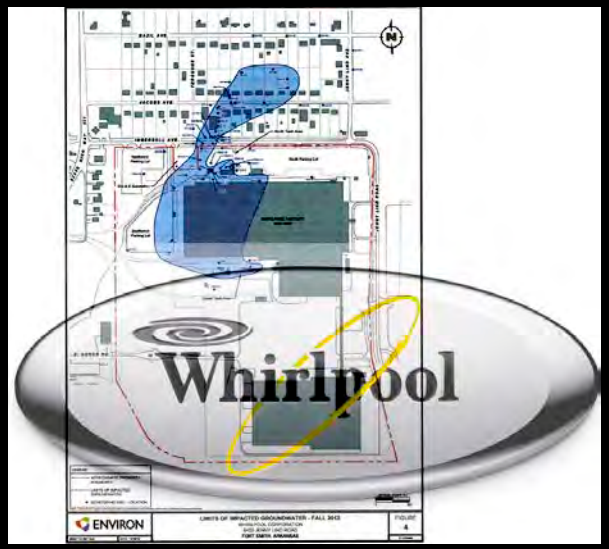
POINT SOURCE



http://www.occupyforanimals.org/uploads/7/7/3/5/7735203/_1332328.jpg?633

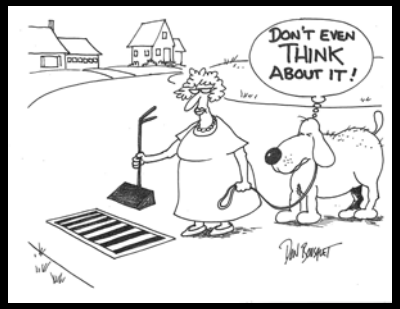
http://www.watershedmedia.org/blog/uploaded_images/313_pink_run_off-763196.jpg

MAYFLOWER, AR
http://blog.shaleshockmedia.org/wp-content/uploads/2013/04/fo2.jpg



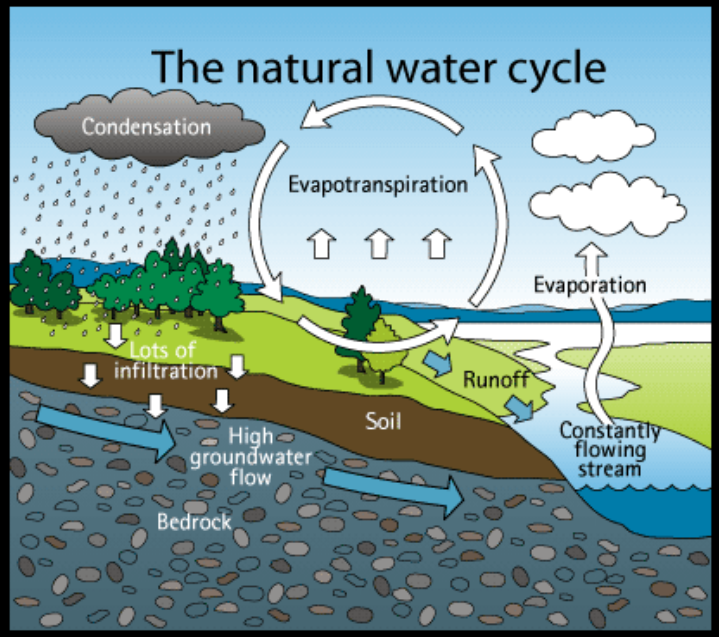
FT. SMITH, AR
http://www.thecitywire.com/sites/default/files/node_files/05-13/Michael%20Tilley/whrtcwlogo.jpg

NON-POINT SOURCE

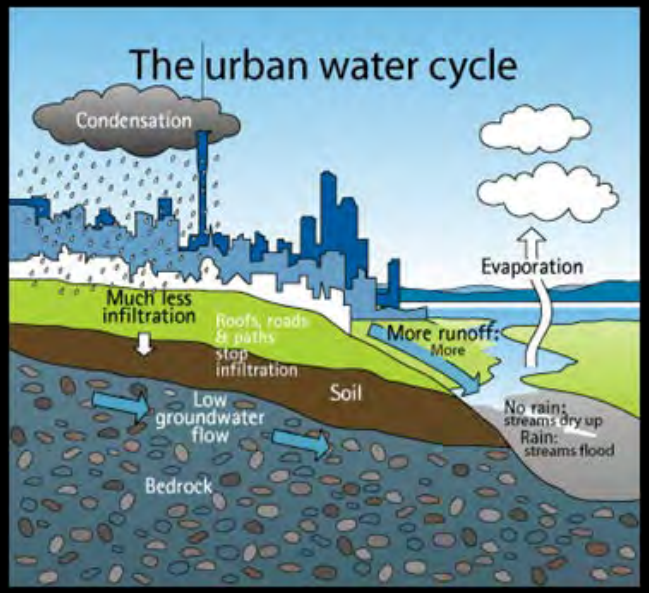


http://web.uri.edu/riss/files/DogPoop.jpg

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



(Source: http://www.sswm.info/category/concept/water-cycle)



(Source: http://www.sswm.info/category/concept/water-cycle)

(Source: http://www.aucklandcity.govt.nz/council/services/stormwater/about.asp)

2012 Isaac Prompts Flash Flood Watch for Arkansas (katv.com)

April 25, 2011 Flash Flood (ulocal.4029tv.com)

(ulocal.4029tv.com)

April 25, 2011 Fvl/College Ave. (nwaonline.com)

Kansas Water Office Photo (kwo.org)

Watershed Conservation Photo (watershedconservation.org)

Austin, TX Photo (crwr.utexas.edu)

EROSION

LOW IMPACT DEVELPOMENT FEATURES & METHODS

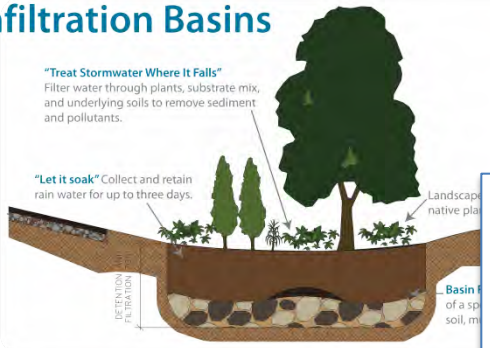
LID TREATS RAIN WATER AS A RESOURCE
NOT A WASTE PRODUCT

SLOW – SPREAD – SOAK

LID @ BWD

Infiltration Basins

1



Infiltration & Bioretention

Infiltration is the movement of water from the earth's surface into the ground. When water is infiltrated, the surplus stormwater runoff from pavement can be captured, preventing damage to downstream property and streams.

Bioretention is holding, or retaining, stormwater where the water contacts plants and the soil. During bioretention, pollutants in stormwater are treated by the bacteria present in the soil and also are utilized by the plants. Cleaner runoff is the result.

Infiltration Basins:

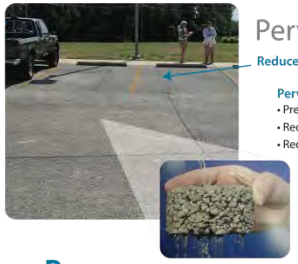
- Large-scale, highly engineeered bioretention
- natural wetland function.
- Customized for site-specific stormwater contr
- reduction requirements.
- Do not support mosquito proliferation due to
- retention period.
- Maximize water infiltration, replenishing grou
- supplies and maintaining soil moisture.
- Return water to atmosphere through leaf surf
- evaporation/plant transpiration.
- Enhance property aesthetics.

Low Impact Paving & Parking

2

Pervious **Paving**

Pervious paving allows vertical flow of water through hard surfaces to infiltrate into underlying soils.



Pervious **Concrete**

Reduce concentrated stormwater flow.

Pervious Concrete:

- Prevents direct runoff.
- Reduces "Heat Island" effect.
- Reduces need for:
  - Piping.
  - Detention Basins.
  - Downstream Structures.

Pervious Concrete allows for infilitration.

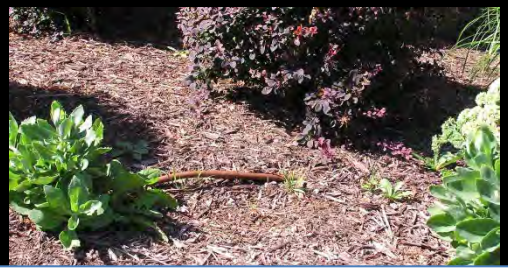
Grass **Pavers**

Plastic Reinforcing Grids increase the loadbearing capacity of a lawn surface.

Grass Pavers:

- Slow and spread runoff.
- Maintain balanced ground water le
- Protect plants by preventing soil co
- Reduce "Heat Island" effect.
- Made of recycled materials.

Accommodate Overflow Parkin



Landscaping with Native Plants

6

Native **Plants**

Native plants may be used to create "Naturalistic Landscapes," installed in bioretention features or set in place following conventional landscape design principles of order, pattern, symmetry, and variety to create more formal, ornatmental or traditional gardens.

Benefits **of** Landscaping

Reduces Runoff

- Slows the flow of water
- Spreads water
- Allows water to soak in

Conserves Water

- Adapted to soils and climate
- Maintains soil moisture
- Little irrigation needed

Removes Pollutants

- Assimilates toxins
- Sequesters CO_2
- Reduces fertilizer needs
- Sustains soil bacteria

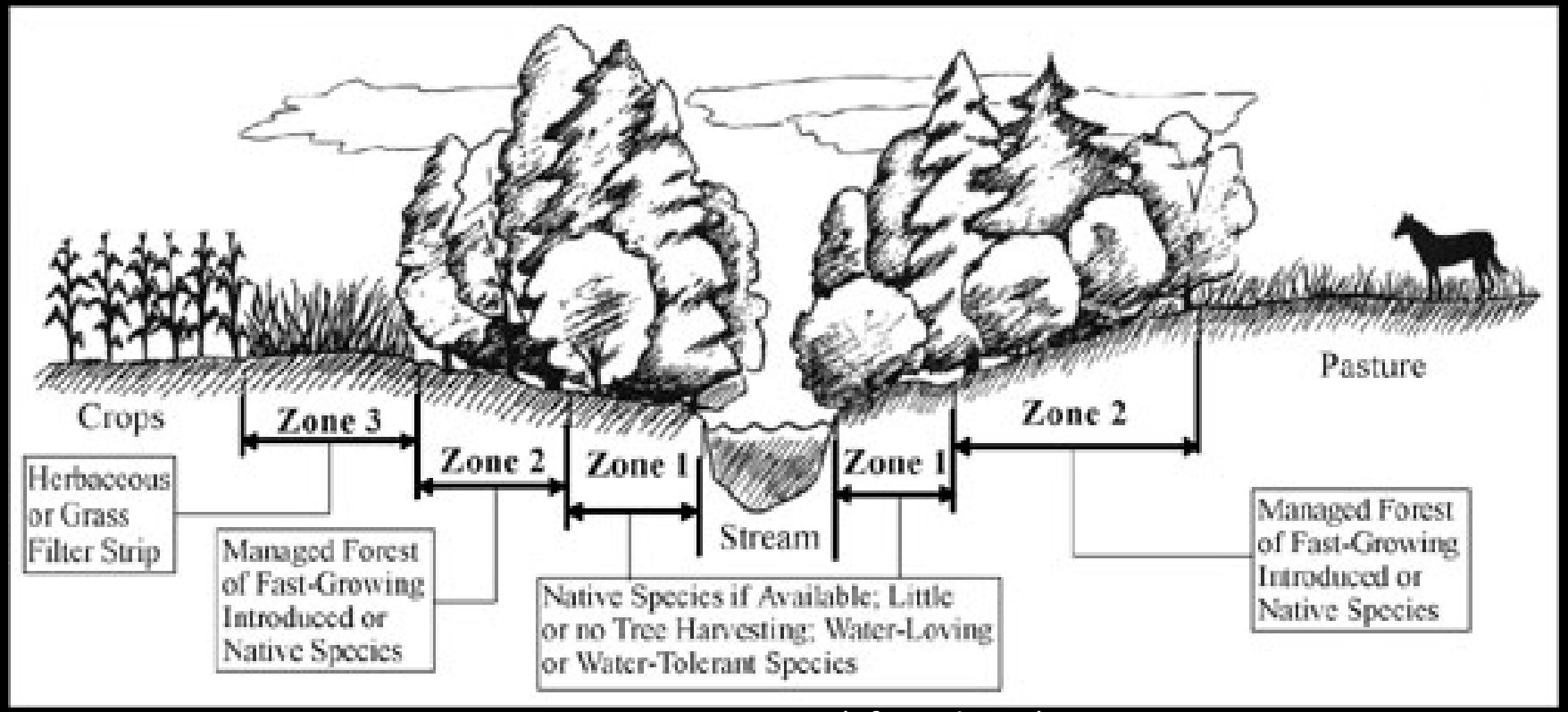
Goal

Reduce quantity of runoff by improving infiltration and evaporation, filtering and storing storm water near its source.

Role

Ensure good water quality by mimicking natural landscape and maintaining ecosystem serivces such as water and air purification.

Beaver Water District



RIPARIAN BUFFER ZONES (aftaweb.org)

Riparian Zone/Streambank Stabilization/Restoration

WATERSHED CONSERVATION RESOURCE CENTER

www.watershedconservation.org

OZARKS WATER WATCH NEWSLETTER June 11, 2012
Vol VI Issue 24
WHITE RIVER BANK STABILIZATION PROJECT SPRING 2012

http://archive.constantcontact.com/fs075/1102224436468/archive/1110191050621.html

WATERSHED BOARD GAME

DRINKING WATER TREATMENT PROCESS

http://upload.wikimedia.org/wikipedia/commons/0/0e/Nasa_earth.jpg

commons.wikimedia.org

http://www.wef.org/uploadedImages/Home_Page_Elements/Flash/images/Awareness.jpg