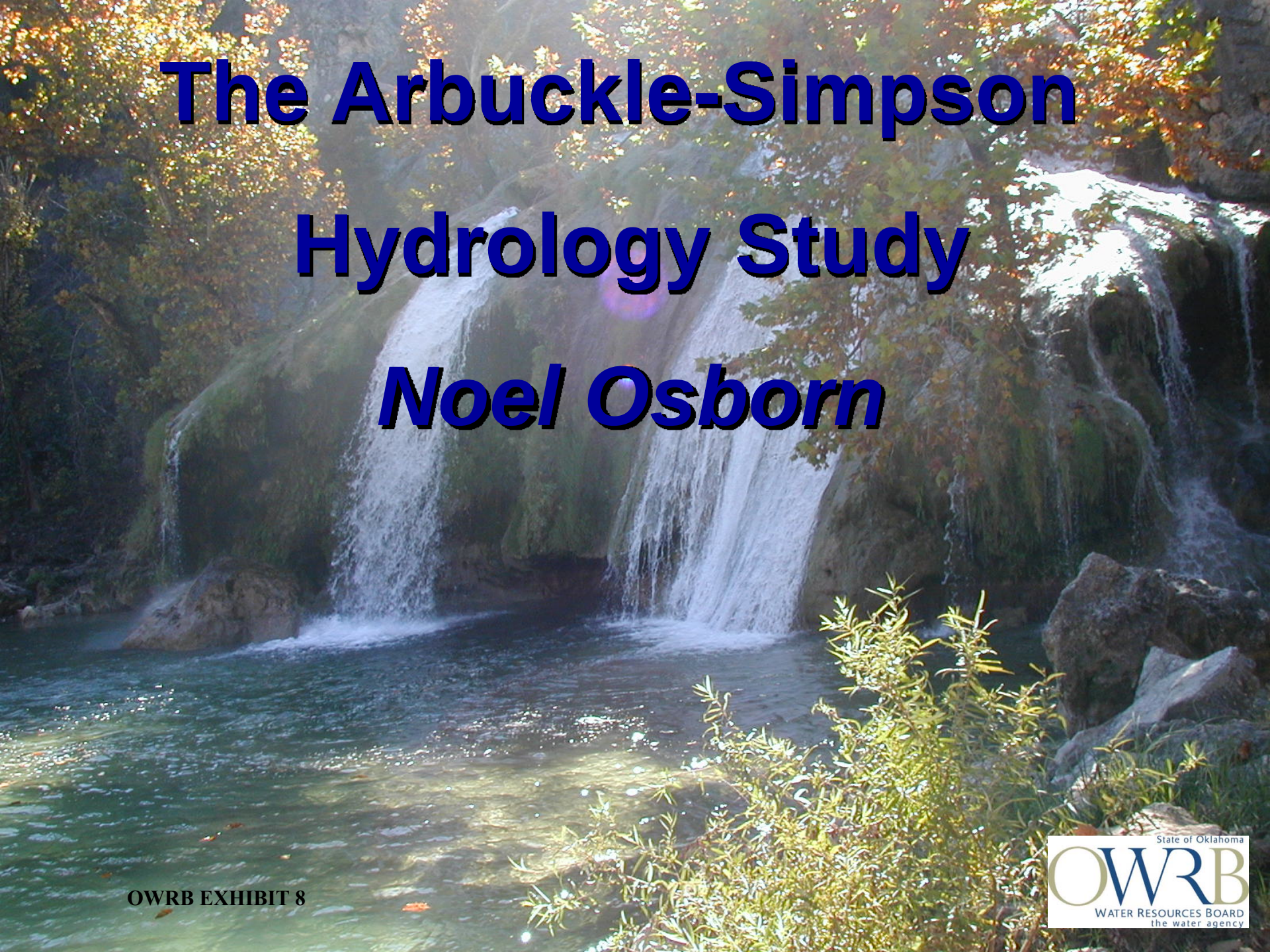

The Arbuckle-Simpson Hydrology Study

Noel Osborn

OWRB EXHIBIT 8

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Arbuckle-Simpson Hydrology Study

- Study area
- Study overview
- Describe hydrologic concepts and define terms
- Hydrogeologic setting of the Arbuckle-Simpson aquifer
- Examples

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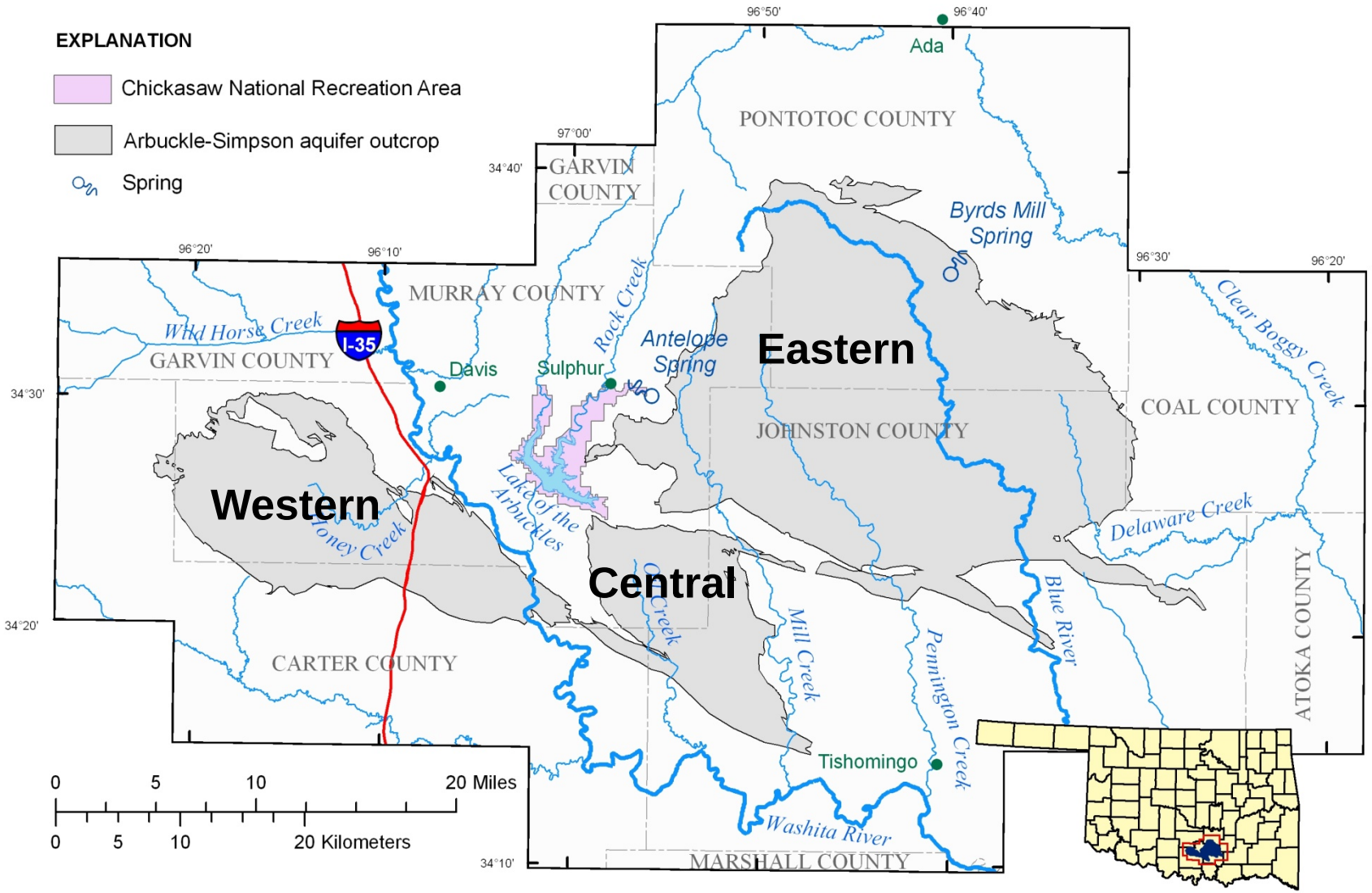

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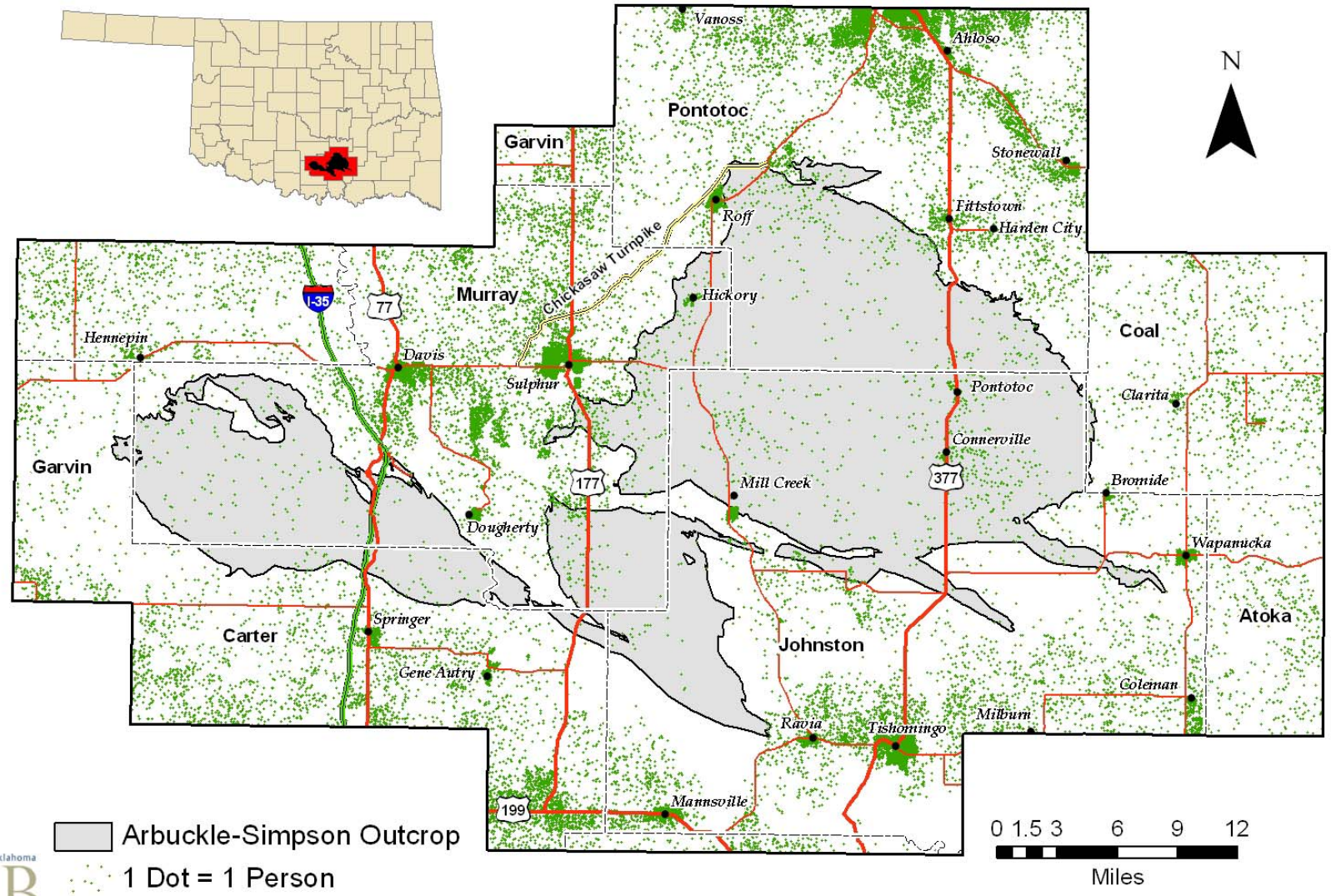
Population Density



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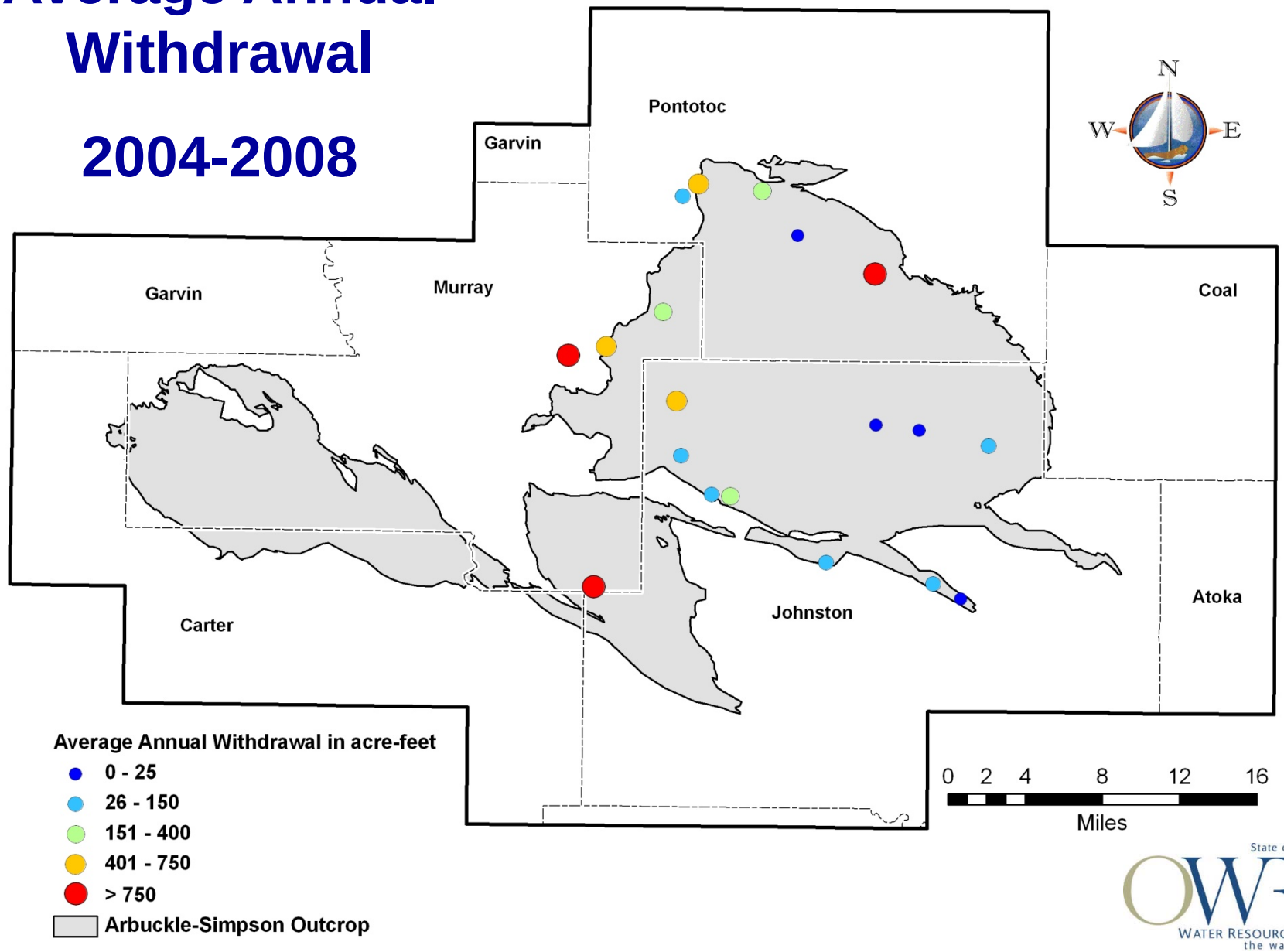
Average Annual Withdrawal

2004-2008



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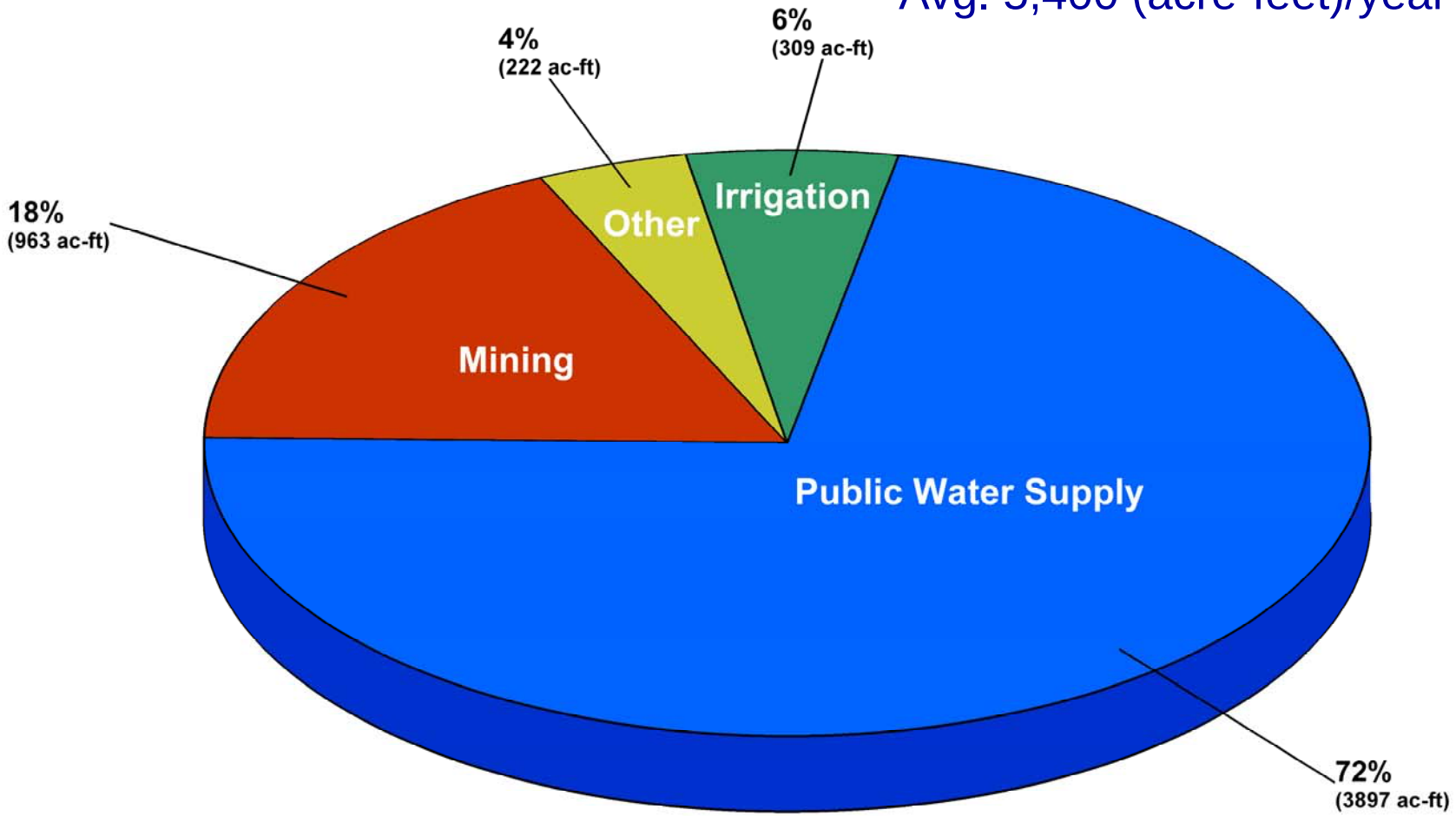
Eastern Arbuckle-Simpson Aquifer

Average Annual Withdrawal 2004-2008

Avg. 5,400 (acre-feet)/year



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Senate Bill 288

- Moratorium
- Conducts and completes a hydrological study
- Approves a maximum annual yield that will not reduce the natural flow of water from springs or streams emanating from the basin

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Purpose

To acquire sufficient understanding of the hydrology of the Arbuckle-Simpson aquifer to enable development and implementation of a comprehensive water resource management plan that protects the flow of springs and streams in the region.

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Scope of investigation

- Aquifer-scale assessment for determination of the maximum annual yield
- Information can be applied to many water management and hydrological issues (permits, water supply planning, well drilling, environmental issues)

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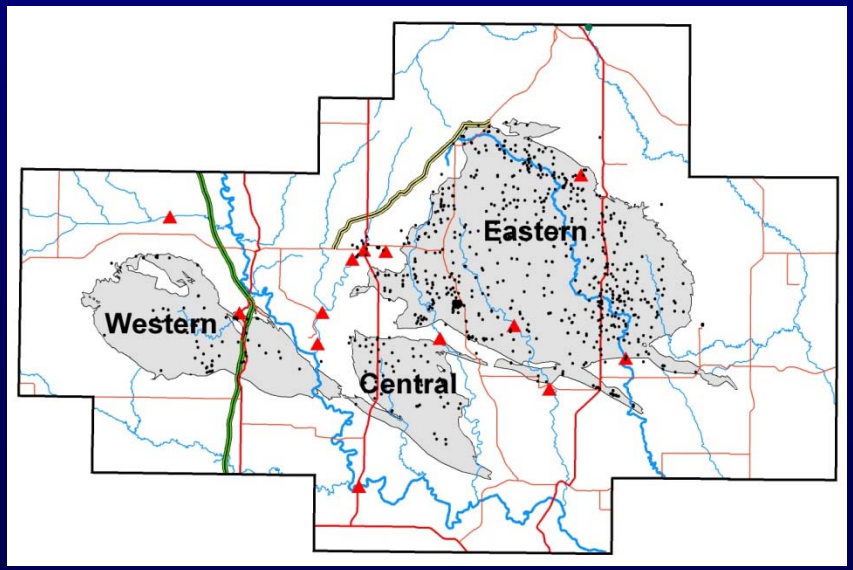
Eastern Arbuckle-Simpson Aquifer

- Largest part of the aquifer
- Most of the current groundwater permits and withdrawals
- Hydrogeologic data (wells and stream gages)
- Accessible
- Budget and time constraints



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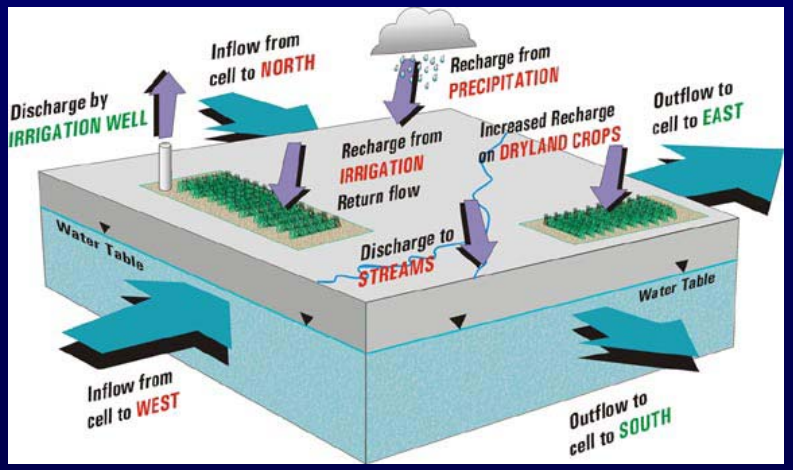
Digital Groundwater Flow Model

- Test our understanding of the aquifer
- Predict the consequences of groundwater withdrawals on streamflow
- Evaluate allocation of water rights
- Simulate management options



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Protection of Springs and Streams

- Approve a maximum annual yield that will not reduce the natural flow of water from springs or streams emanating from the basin.

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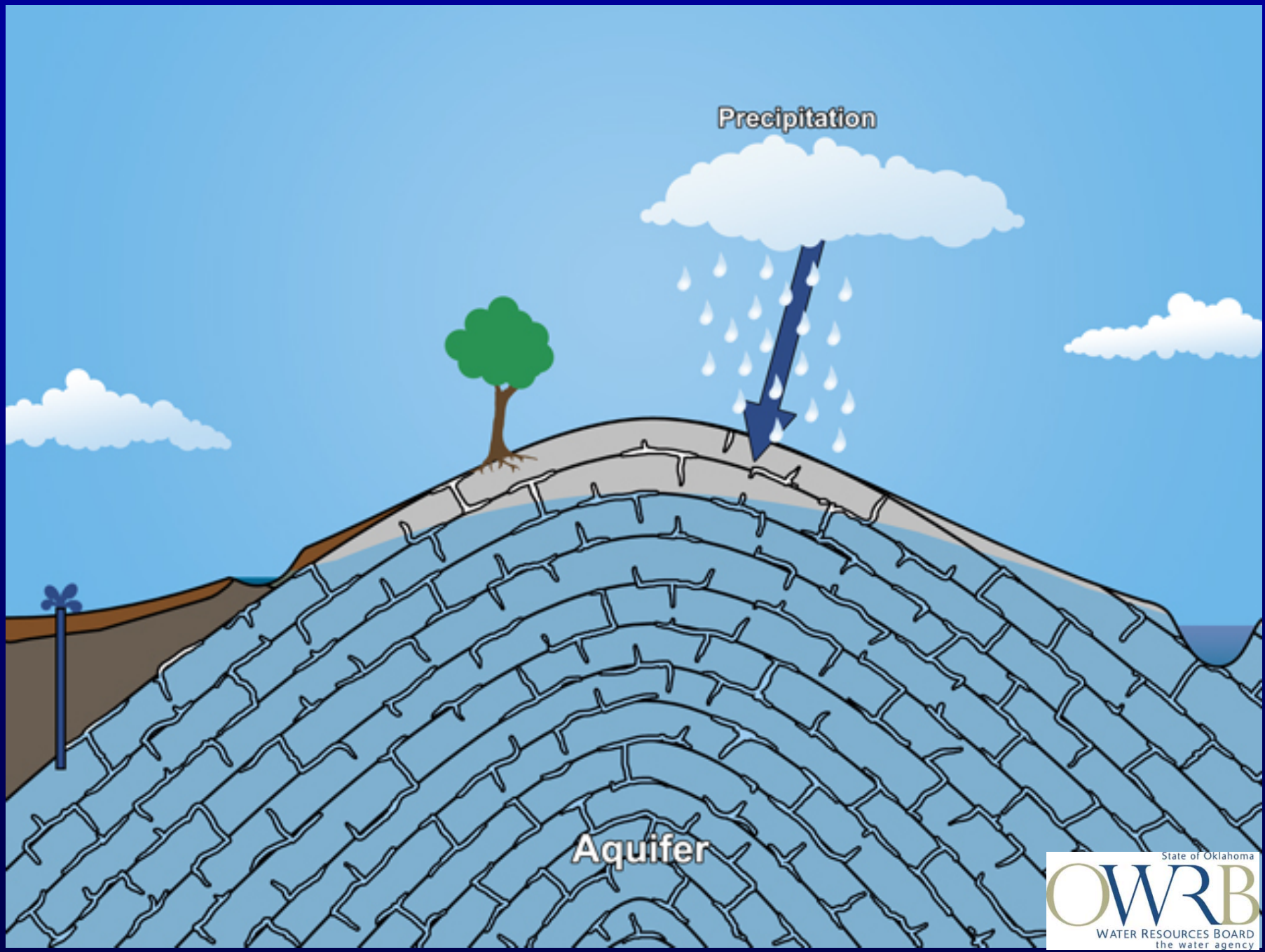
Precipitation
Aquifer
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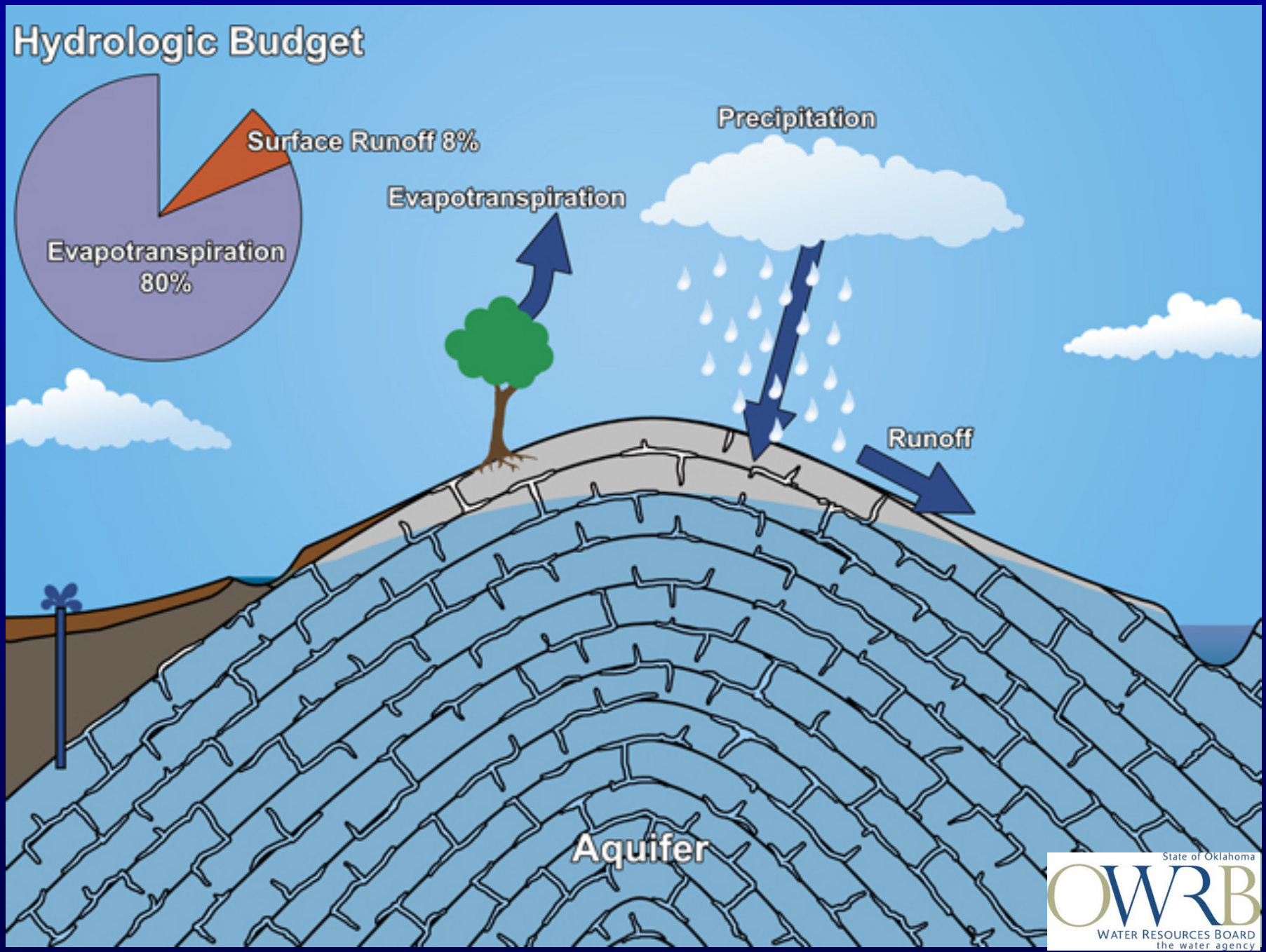
Hydrologic Budget
Surface Runoff 8%
Evapotranspiration 80%
Precipitation
Evapotranspiration
Runoff
Aquifer
State of Oklahoma
OWRB
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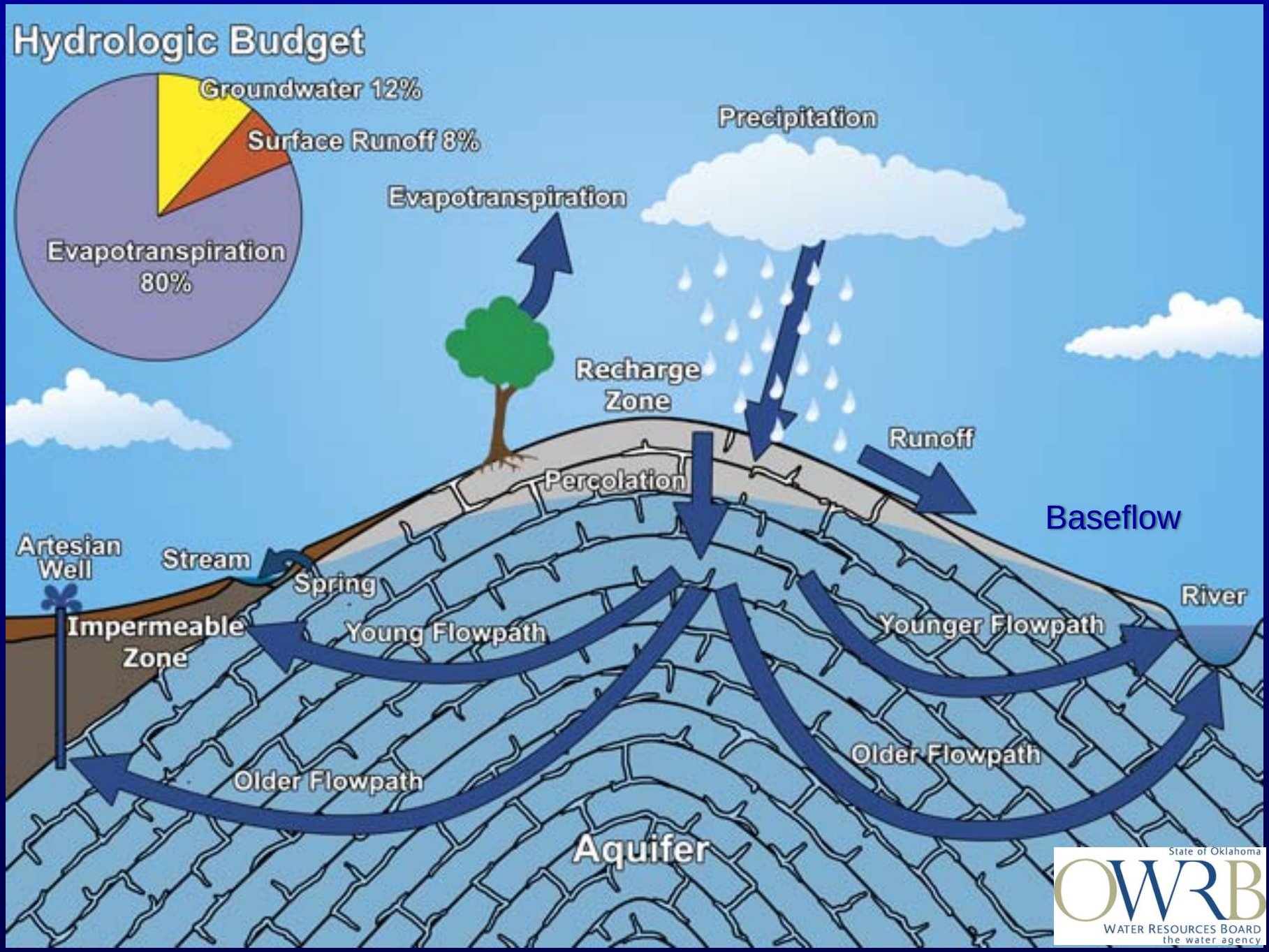
Hydrologic Budget
Groundwater 12%
Surface Runoff 8%
Evapotranspiration 80%
Precipitation
Evapotranspiration
Recharge Zone
Runoff
Percolation
Baseflow
Artesian Well
Stream
Spring
River
Impermeable Zone
Young Flowpath
Younger Flowpath
Older Flowpath
Older Flowpath
Aquifer
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Putting the pieces together

Geology:

- Petroleum information
- Fracture properties
- Geophysics
- Deep test well
- 3-D geologic modeling

Surface Water:

- 3 USGS gages
- Baseflow monitoring
- Rainfall-runoff modeling
- Instream flow study

Climate:

- Fittstown Mesonet station
- Hydrologic budget
- Tree-ring analysis

Ground Water:

- Water-level monitoring
- Water chemistry
- Age-dating
- Aquifer tests
- Water use
- Ground-water modeling

Arbuckle-Simpson Regional Geology

Participants

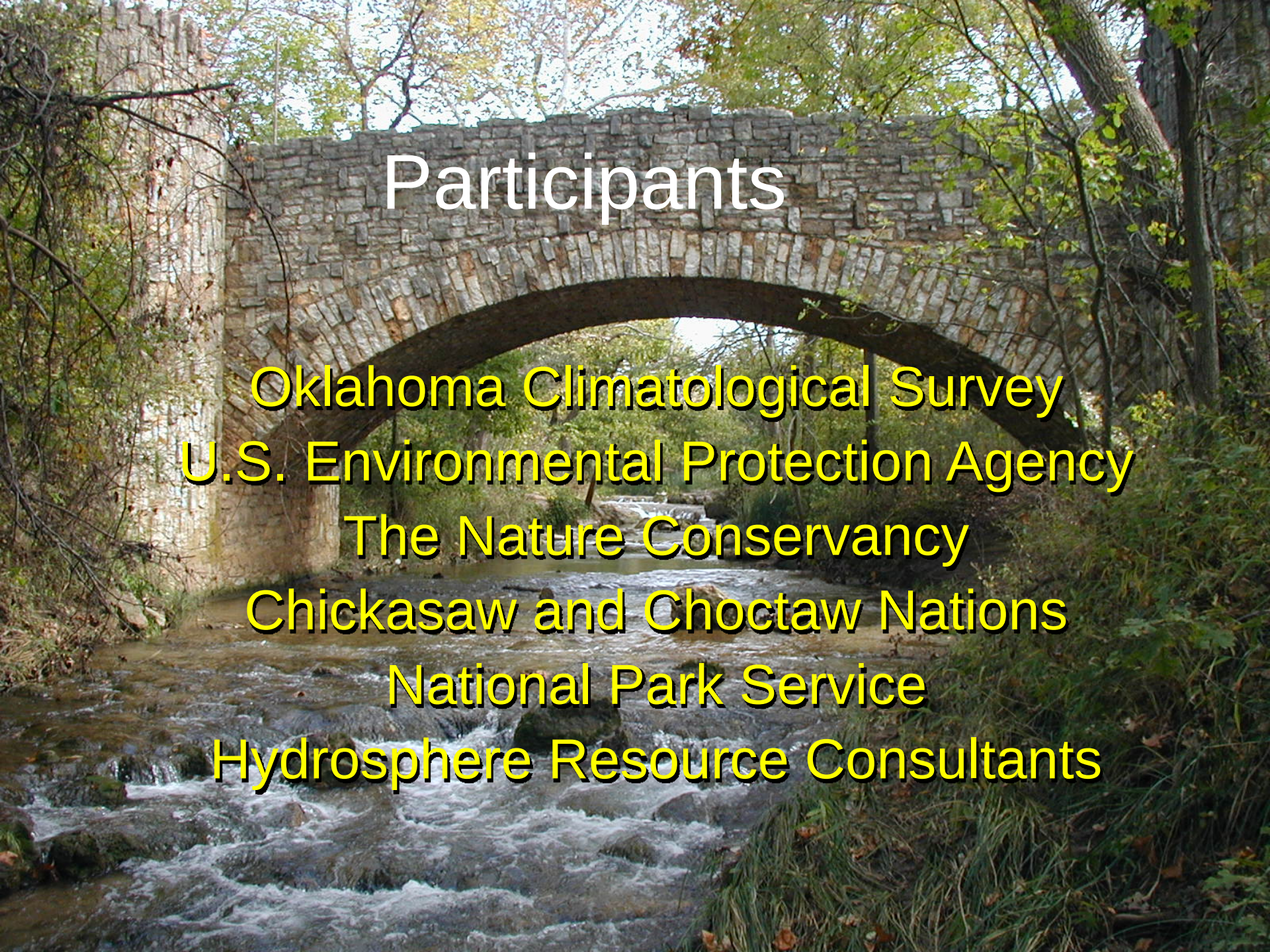
U.S. Bureau of Reclamation

U.S. Geological Survey

Oklahoma State University

University of Oklahoma

Oklahoma Geological Survey



Participants

Oklahoma Climatological Survey
U.S. Environmental Protection Agency
The Nature Conservancy
Chickasaw and Choctaw Nations
National Park Service
Hydrosphere Resource Consultants

Participants

Oklahoma Department of Environmental Quality

Oklahoma Department of Wildlife Conservation

Citizens for the Protection of the Arbuckle-Simpson Aquifer

Municipalities

Landowners

Hydrogeologic Framework

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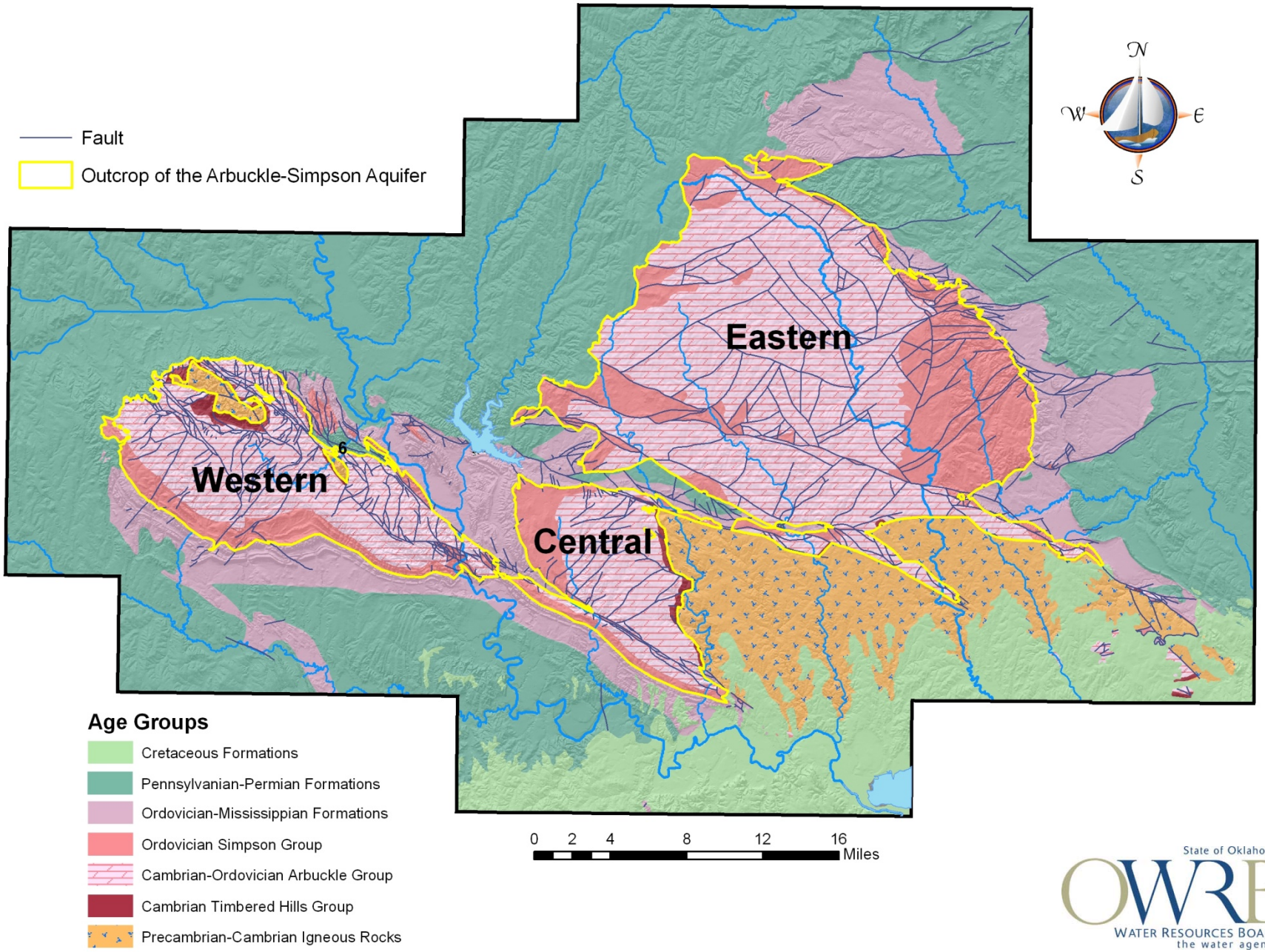
Hydrostratigraphic Units

Time-Stratigraphic Unit	Rock-Stratigraphic Unit		Hydrogeologic Unit	Model Hydrostrati-graphic Unit
Pennsylvanian to Late Ordovician	Post-Simpson Geologic Units, Undifferentiated		Upper Confining Unit	Post-Simpson
Middle Ordovician	Simpson Group	Bromide Formation	Arbuckle-Simpson Aquifer	Simpson
		Tulip Creek Formation		
		McLish Formation		
		Oil Creek Formation		
		Joins Formation		
Early Ordovician	Arbuckle Group	West Spring Creek Formation		Arbuckle-Timbered Hills
		Kindblade Formation		
		Cool Creek Formation		
		McKenzie Hill Formation		
Late Cambrian		Signal Mountain Formation Butterly Dolomite		
		Fort Sill Limestone Royer Dolomite		
	Timbered Hills Group	Honey Creek Limestone		
		Reagan Sandstone		
Middle Cambrian	Colbert Rhyolite		Basement Confining Layer	Basement
Precambrian	Tishomingo Granite, Troy Granite, granodiorite, and granitic gneiss			


Fault
Outcrop of the Arbuckle-Simpson Aquifer
N
W
E
S
Eastern
Western
Central
6
Age Groups
Cretaceous Formations
Pennsylvanian-Permian Formations
Ordovician-Mississippian Formations
Ordovician Simpson Group
Cambrian-Ordovician Arbuckle Group
Cambrian Timbered Hills Group
Precambrian-Cambrian Igneous Rocks
0 2 4 8 12 16
Miles
State of Oklahoma
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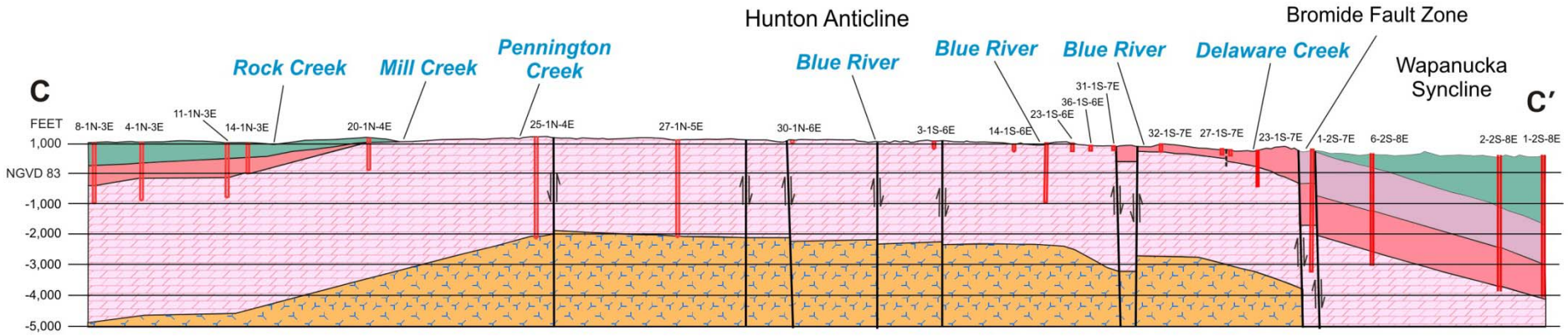
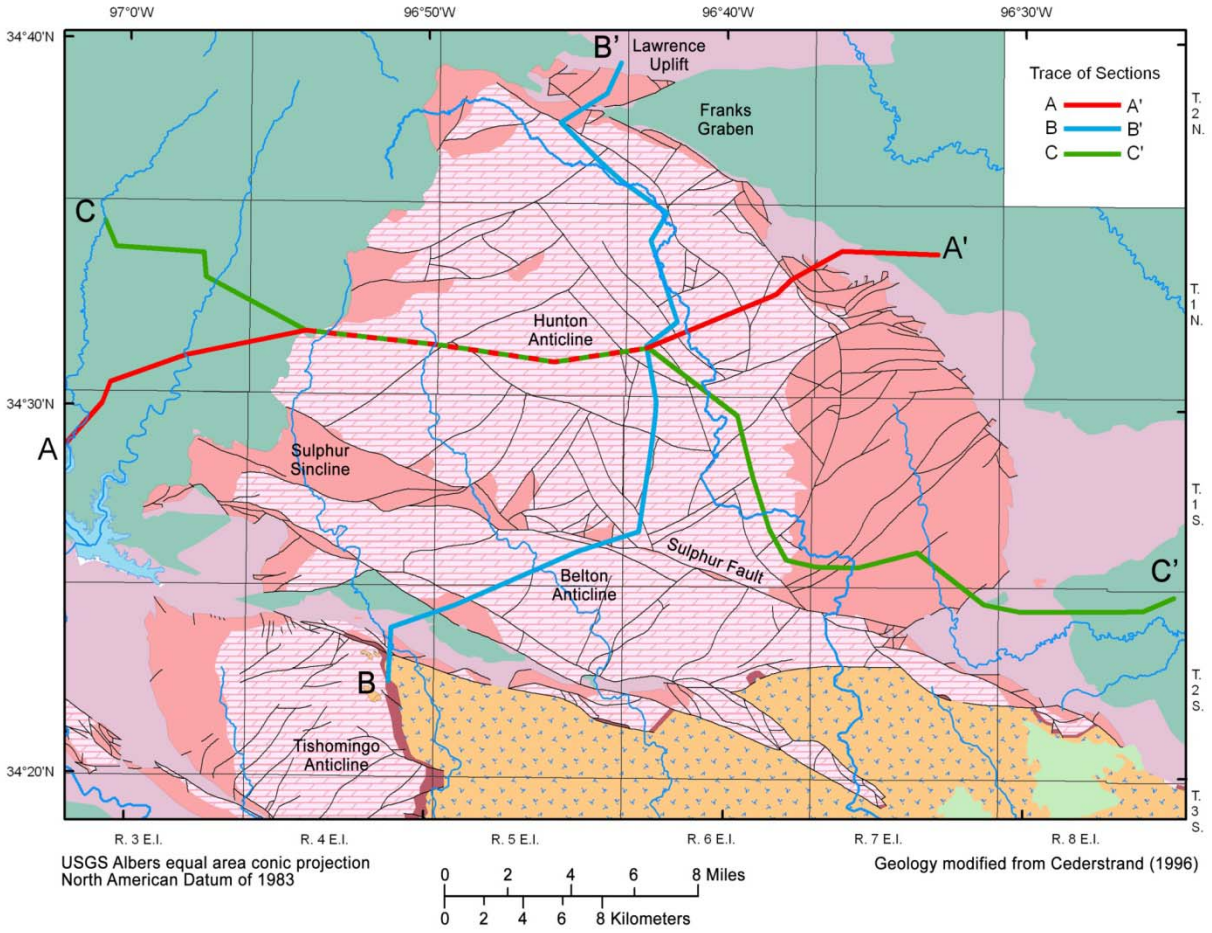


Vertical Exaggeration x4.28

EXPLANATION

- Pennsylvanian units
- Ordovician-Mississippian units
- Ordovician Simpson Group
- Cambrian-Ordovician Timbered Hills & Arbuckle Groups
- Precambrian-Cambrian igneous rocks
- Water supply or oil & gas exploration well
- Fault: relative displacement shown by arrows



USGS Albers equal area conic projection
North American Datum of 1983

Geology modified from Cederstrand (1996)

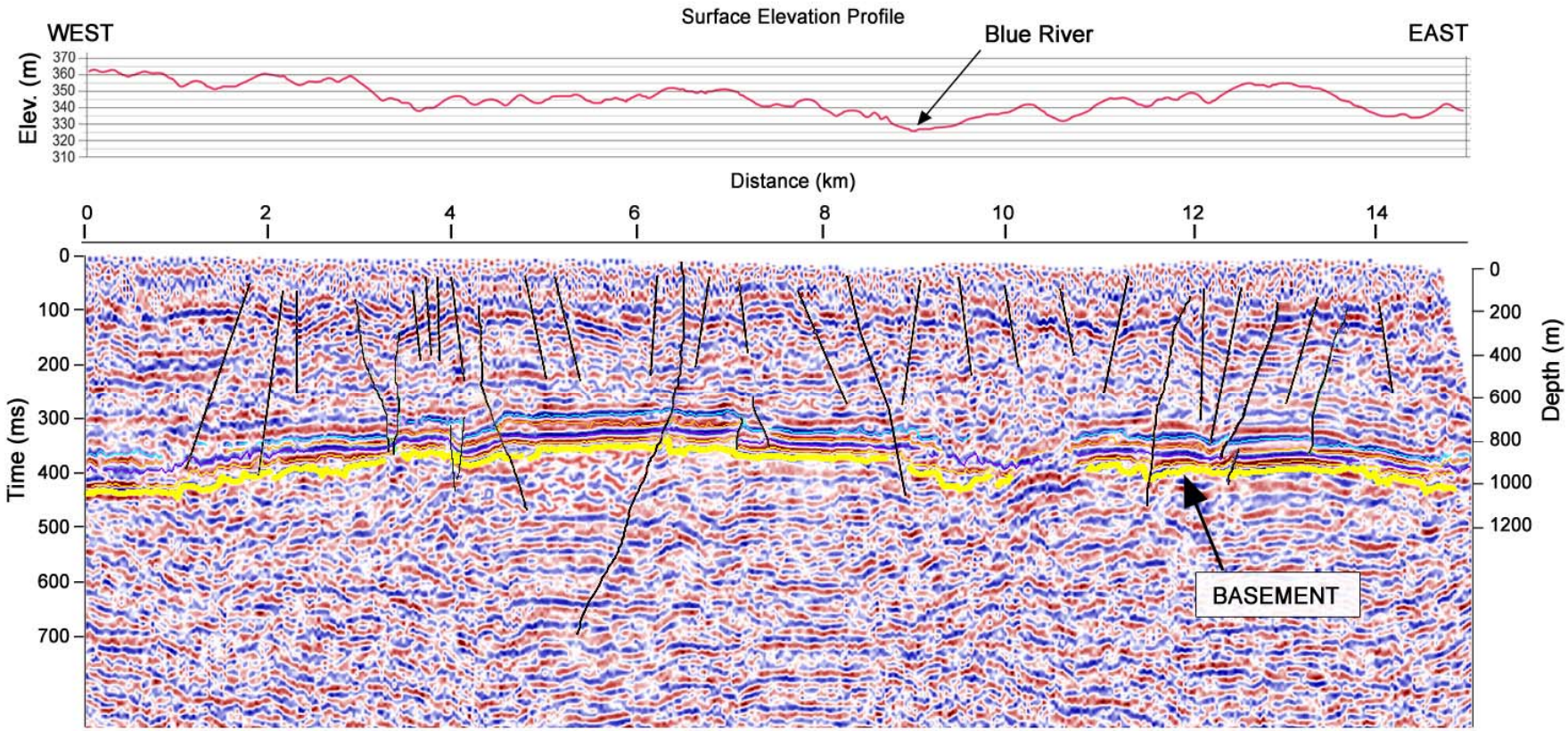
Deep Test Hole

Ground Penetrating Radar

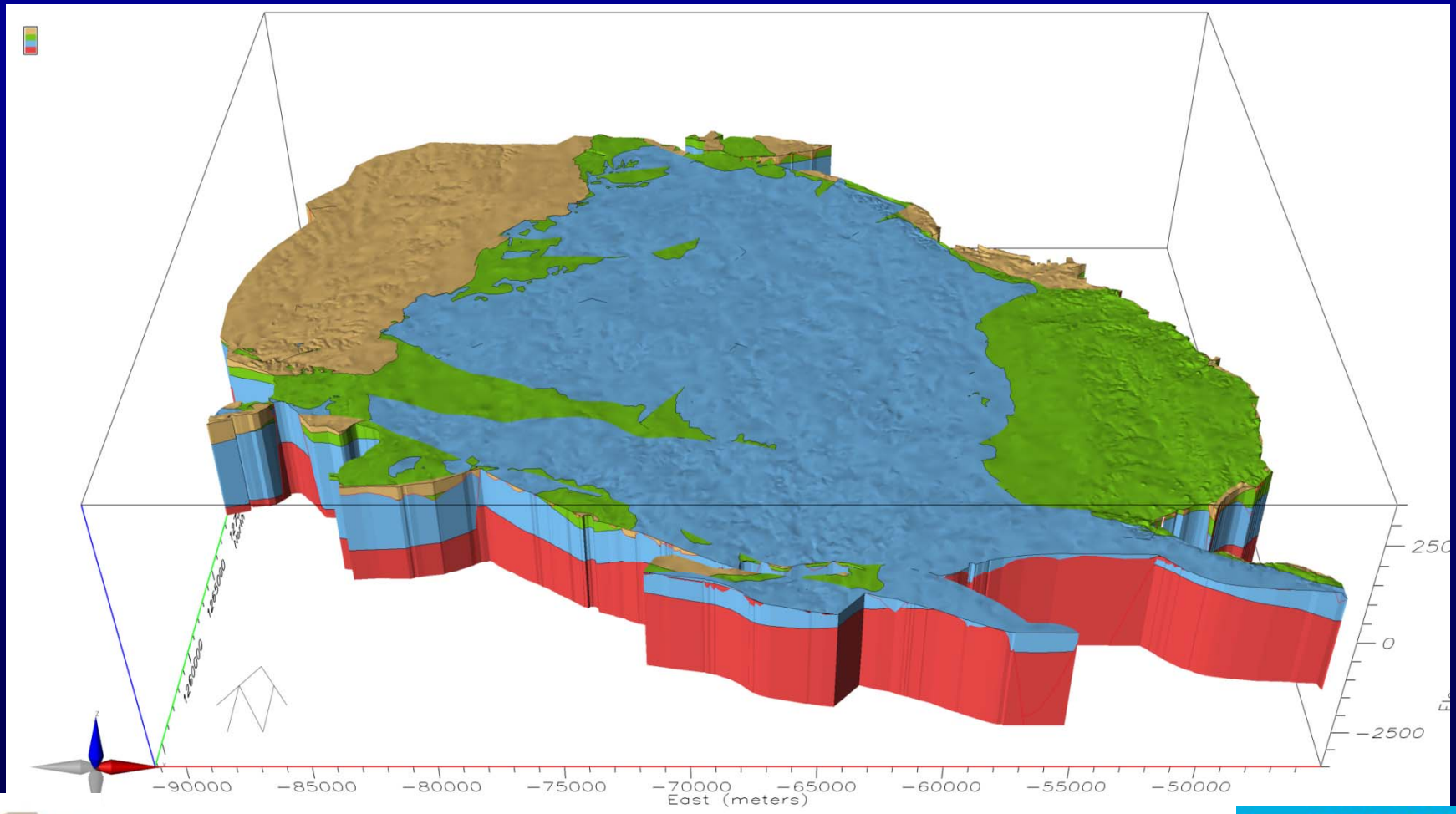
Helicopter Electromagnetic

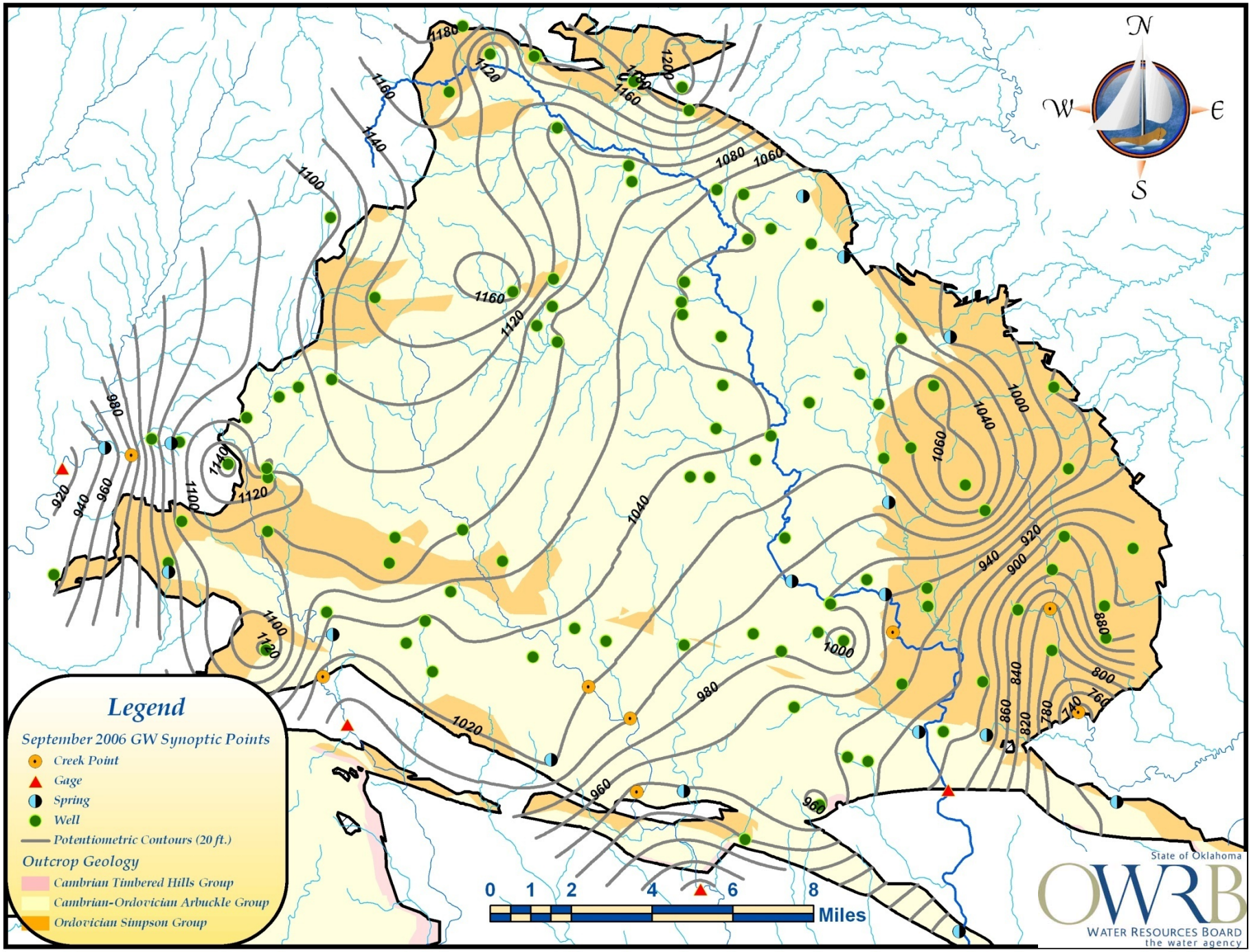
Gravity

Seismic Survey



3D Geologic Model




N
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1120
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1100
1080
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920
900
880
1100
1120
1000
980
840
860
820
800
780
760
740
1020
960
980
0 1 2 4 6 8
Miles
Legend
September 2006 GW Synoptic Points
Creek Point
Gage
Spring
Well
Potentiometric Contours (20 ft.)
Outcrop Geology
Cambrian Timbered Hills Group
Cambrian-Ordovician Arbuckle Group
Ordovician Simpson Group
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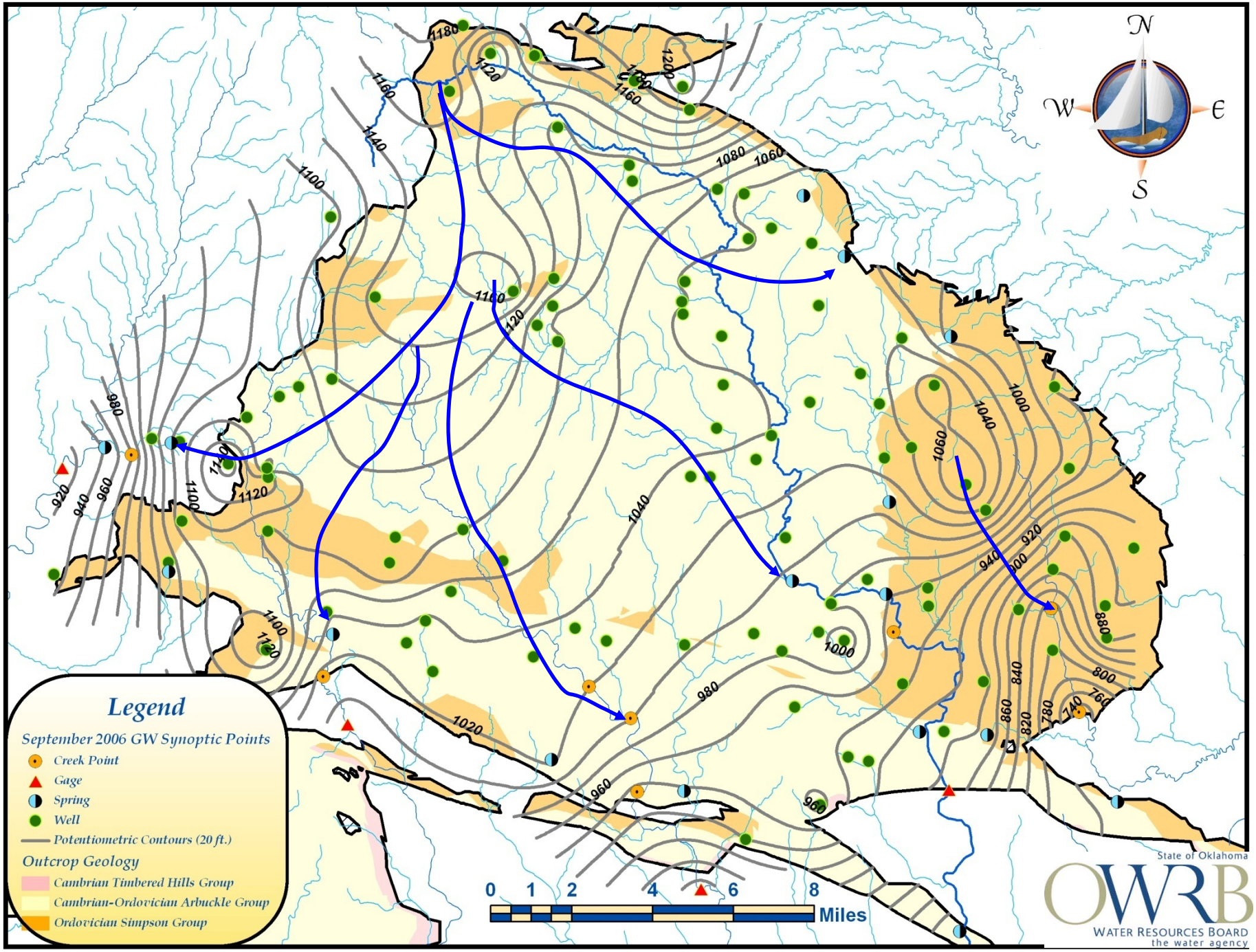
N
W
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S
Legend
September 2006 GW Synoptic Points
Creek Point
Gage
Spring
Well
Potentiometric Contours (20 ft.)
Outcrop Geology
Cambrian Timbered Hills Group
Cambrian-Ordovician Arbuckle Group
Ordovician Simpson Group
0 1 2 4 6 8
Miles
State of Oklahoma
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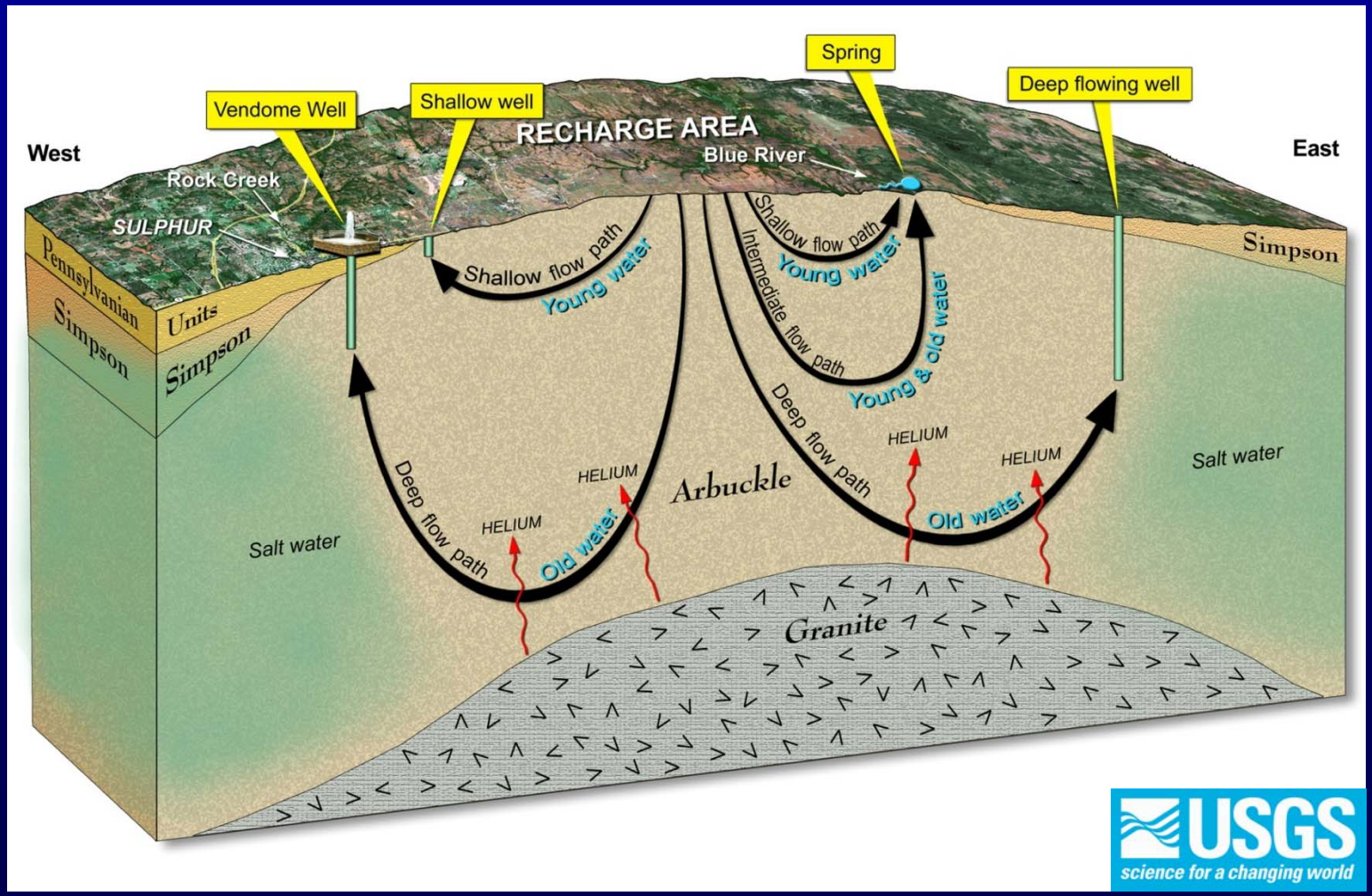
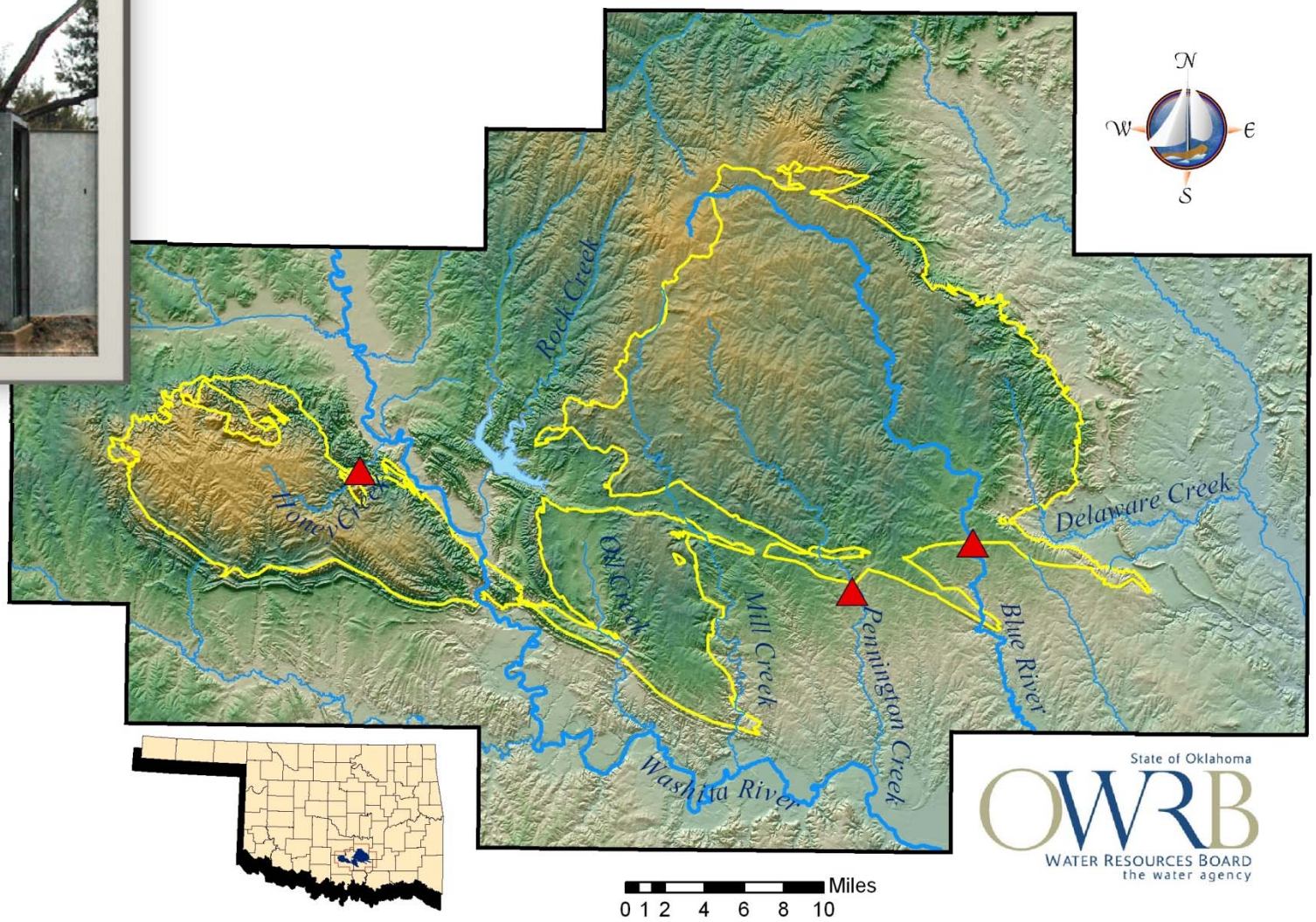
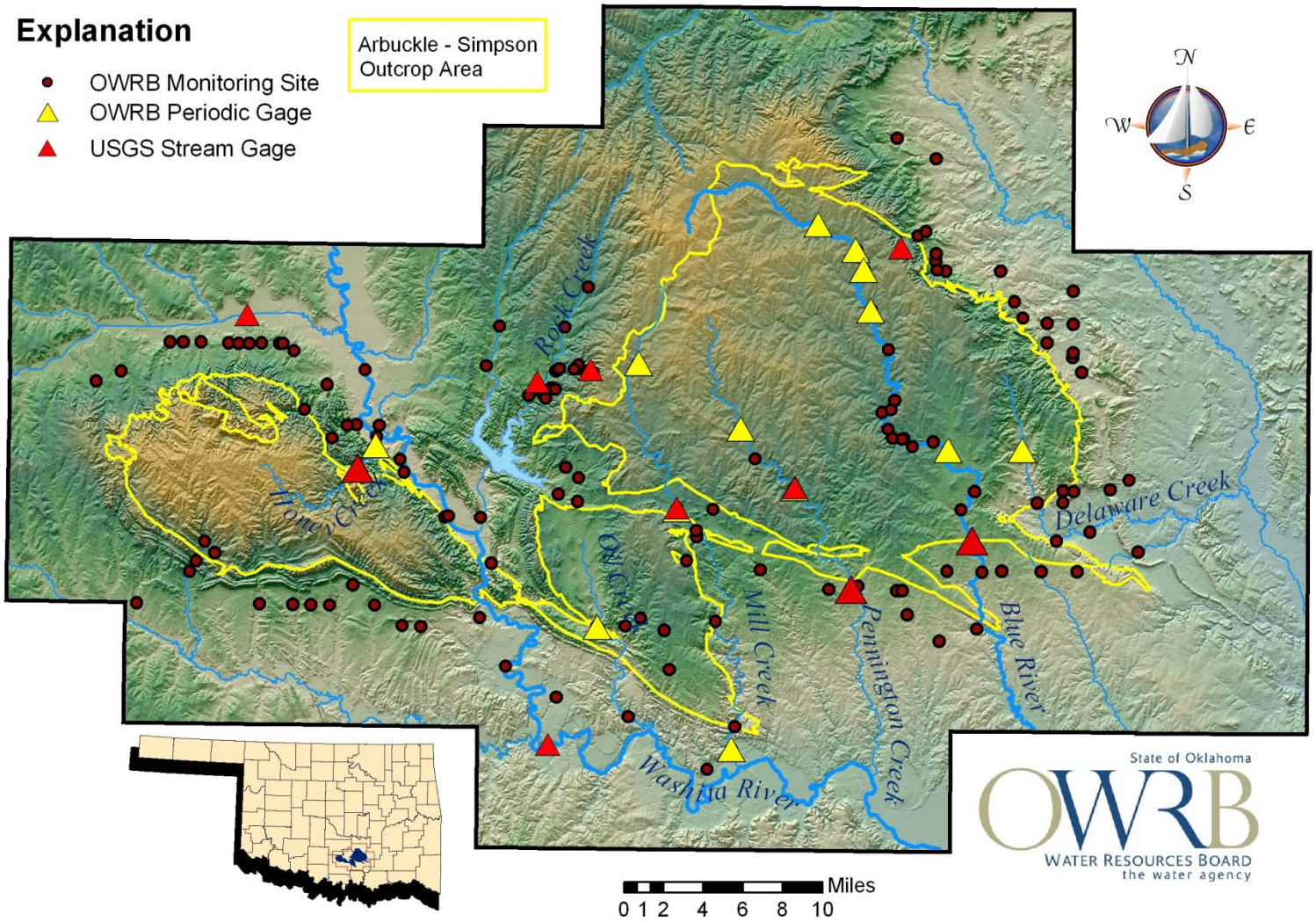
Geochemical Investigation

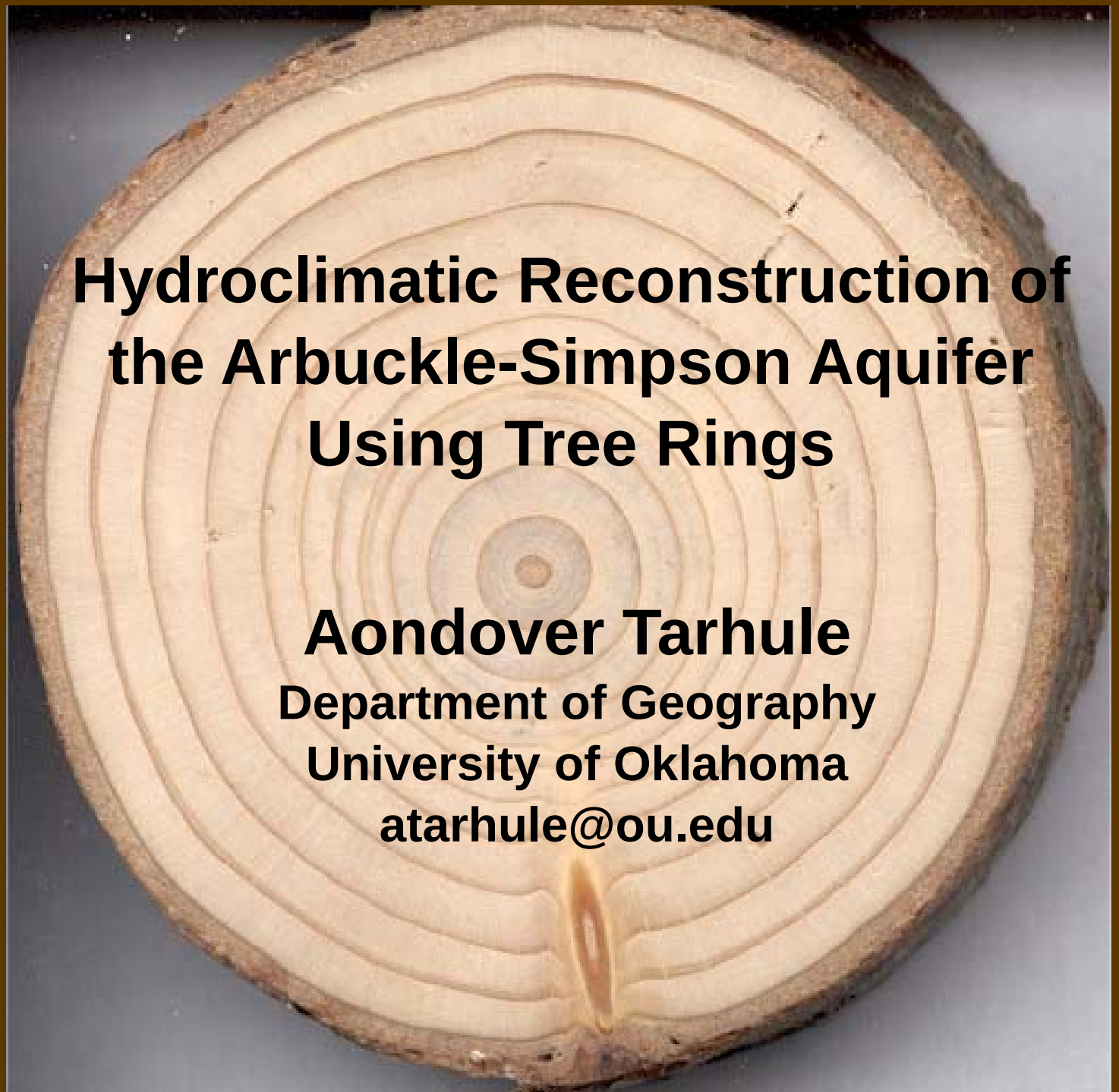


USGS Stream Gages



Stream Monitoring





Hydroclimatic Reconstruction of the Arbuckle-Simpson Aquifer Using Tree Rings

Aondover Tarhule

Department of Geography

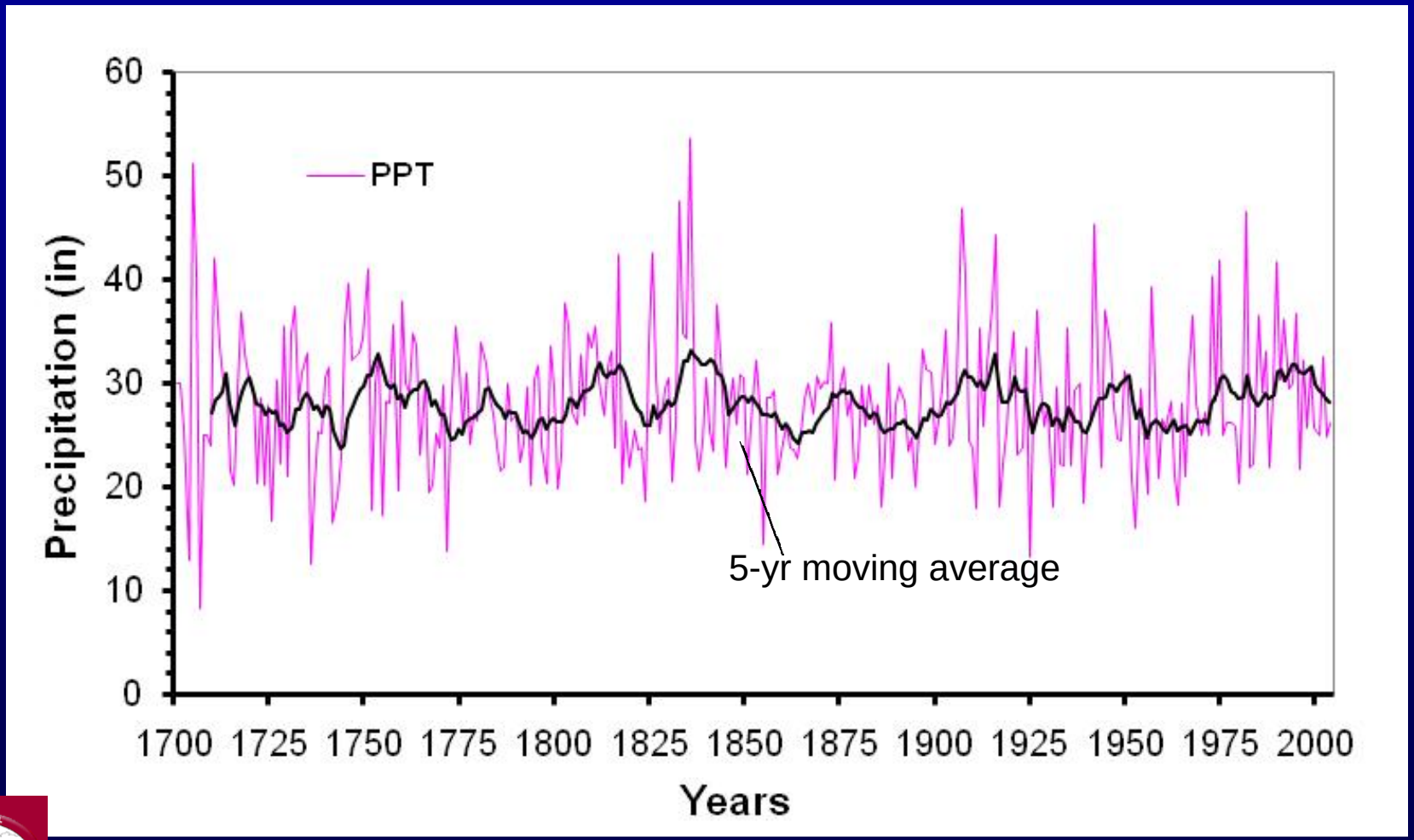
University of Oklahoma

atarhule@ou.edu

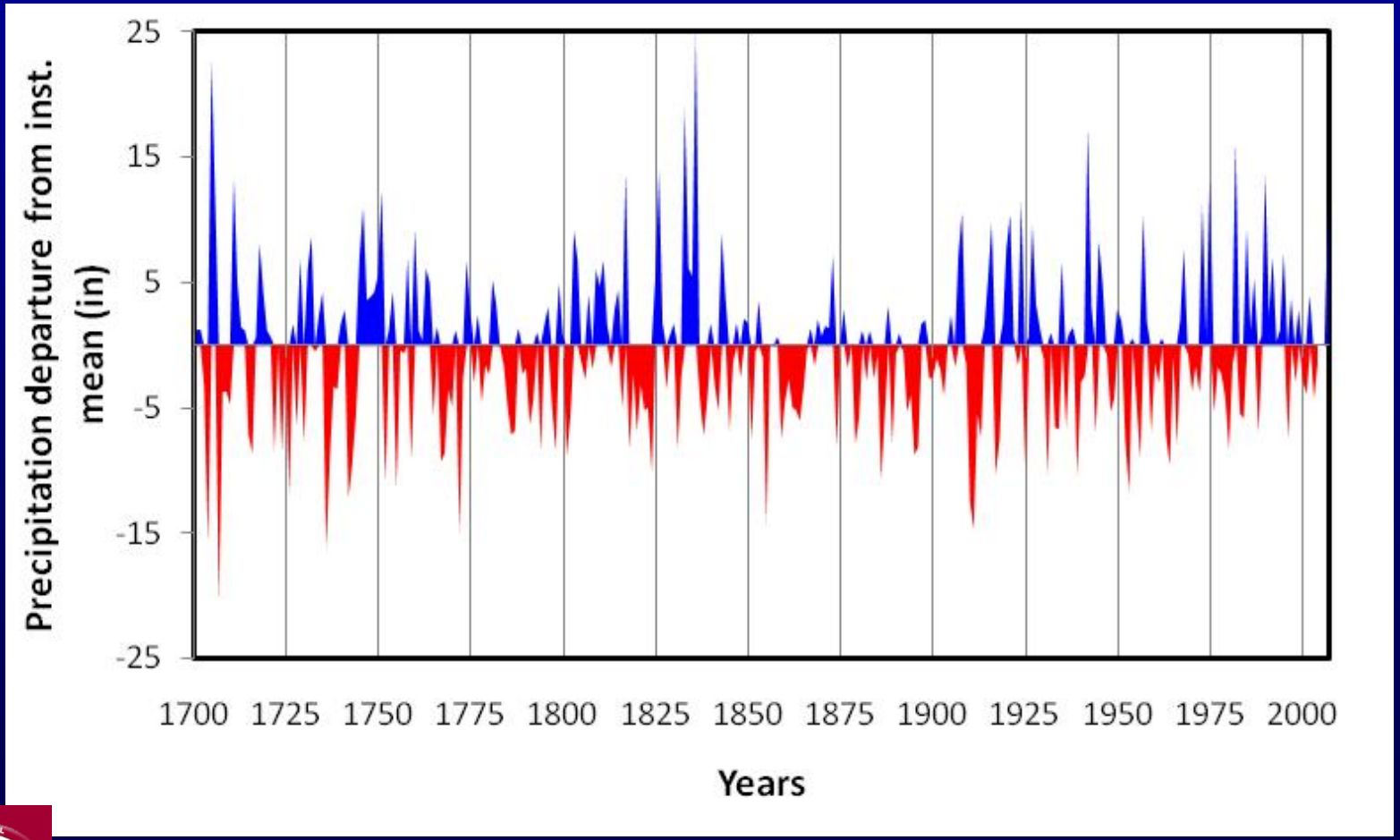
Hydroclimatic Reconstruction

- Developed a 304-year tree-ring chronology from post oak trees.
- Reconstructed precipitation and streamflow
  - to provide a longer term perspective of climatic variability than is possible with instrumental records and
  - to evaluate the risk of drought.

Reconstructed precipitation (1700-2004)



Precipitation Departure from Instrumental Mean

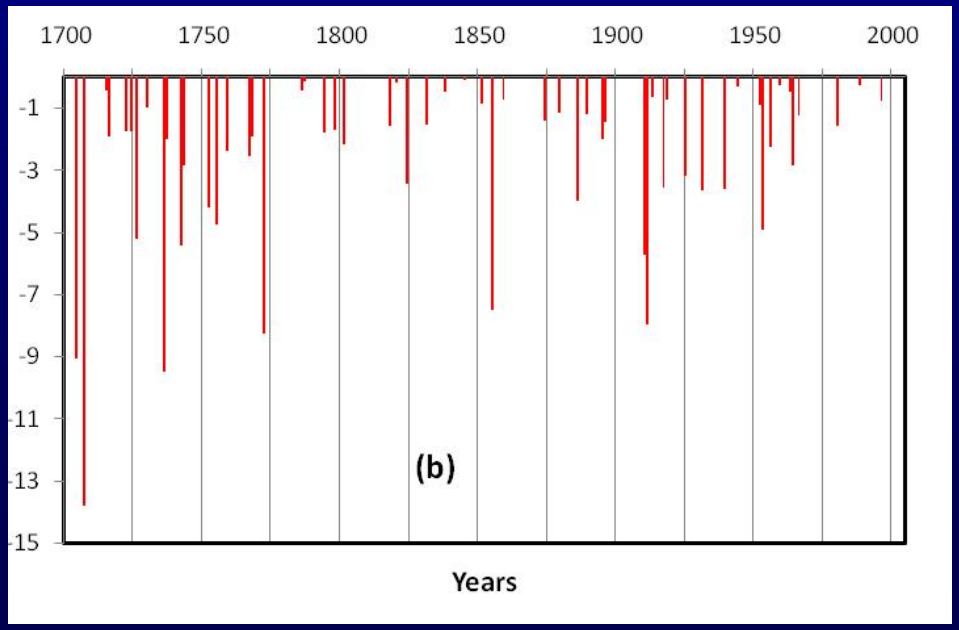


Threshold

The drought that occurs on average once every 5 years.

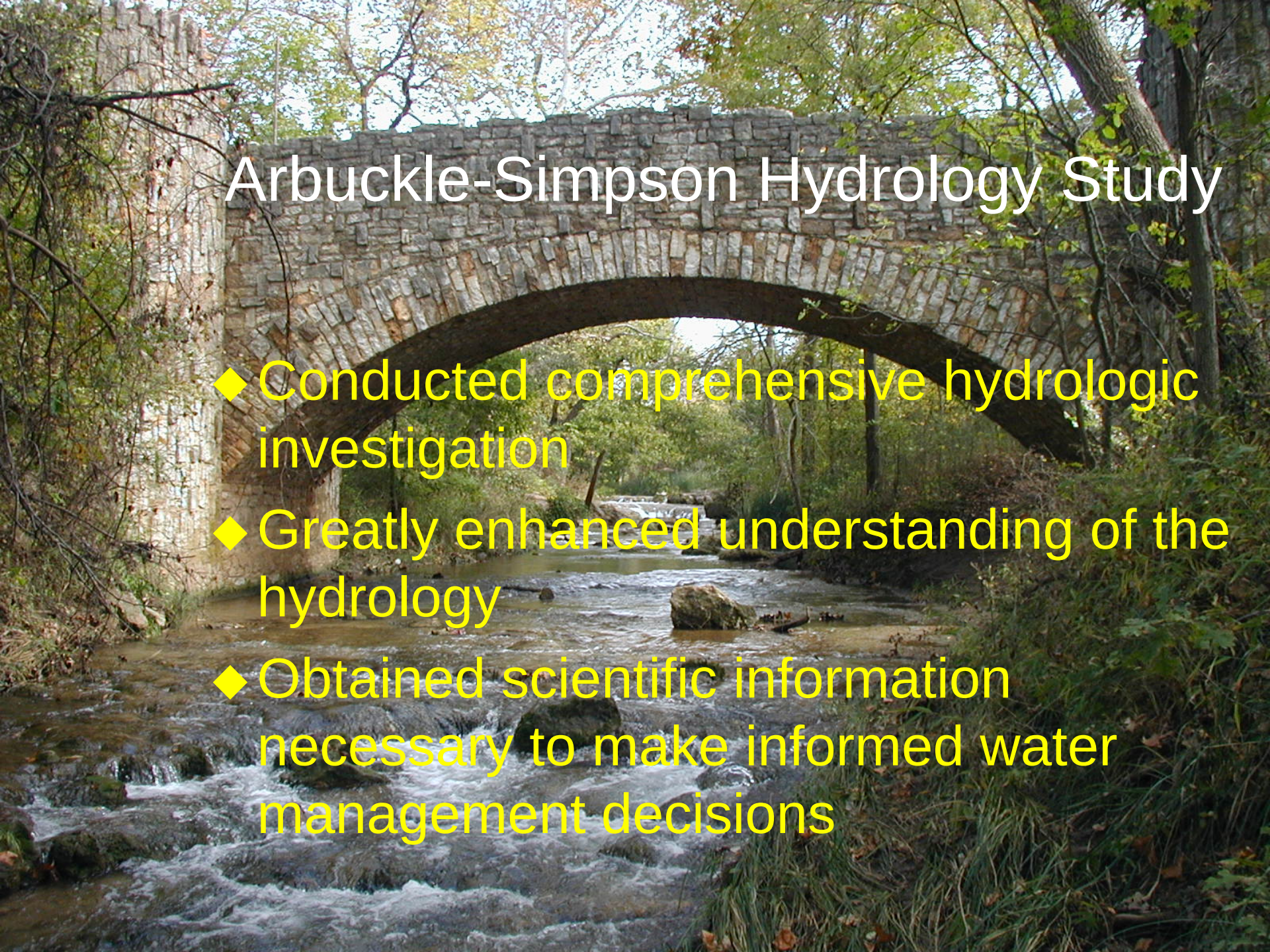
Precipitation Departure from 5-year Threshold

- Droughts most common 1700-1770 and 1900-1960.
- Worst drought in instrumental record 1910-11 (1.6% recurrence).
- Droughts of 1950s rank high (3.3% recurrence).



Hydroclimatic Reconstruction Conclusions

- Multi-decadal droughts are rare.
- Droughts lasting 2 or more years occur about once every 20 years.
- Droughts lasting 1 year are most common.
- Recurrence intervals of severe droughts are relatively low.
- Period of study is representative of the last 300 years.



Arbuckle-Simpson Hydrology Study

- Conducted comprehensive hydrologic investigation
- Greatly enhanced understanding of the hydrology
- Obtained scientific information necessary to make informed water management decisions