The Arbuckle-Simpson Hydrology Study
Noel Osborn
Arbuckle-Simpson Hydrology Study

- Study area
- Study overview
- Describe hydrologic concepts and define terms
- Hydrogeologic setting of the Arbuckle-Simpson aquifer
- Examples
Population Density
Average Annual Withdrawal
2004-2008
Eastern Arbuckle-Simpson Aquifer
Average Annual Withdrawal 2004-2008
Avg. 5,400 (acre-feet)/year
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
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.
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)
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
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
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.
Putting the pieces together

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

**Climate:**
- Fittstown Mesonet station
- Hydrologic budget
- Tree-ring analysis

**Surface Water:**
- 3 USGS gages
- Baseflow monitoring
- Rainfall-runoff modeling
- Instream flow study

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

Cross Section Through the Arbuckle Anticline
Showing Geological Structure Along I-35

These rocks were originally deposited as horizontal layers of sediment in a marine sea. The sedimentary layers overlay igneous rocks (purple) of a volcanic origin. About 265 million years ago, the strata were folded by tectonic compression to create the high mountain range. Over eons of time, wind & water have worn away the mountains, leaving only the small hills that now adorn the surrounding countryside.

Geological signs were sponsored by the Geological Society and erected with the aid of the State Highway Department.

State of Oklahoma
Water Resources Board
The water agency
# Hydrostratigraphic Units

<table>
<thead>
<tr>
<th>Time-Stratigraphic Unit</th>
<th>Rock-Stratigraphic Unit</th>
<th>Hydrogeologic Unit</th>
<th>Model Hydrostratigraphic Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvanian to Late Ordovician</td>
<td>Post-Simpson Geologic Units, Undifferentiated</td>
<td>Upper Confining Unit</td>
<td>Post-Simpson</td>
</tr>
<tr>
<td>Middle Ordovician</td>
<td>Simpson Group</td>
<td></td>
<td>Simpson</td>
</tr>
<tr>
<td>Arbuckle Group</td>
<td>Bromide Formation</td>
<td>Arbuckle-Simpson Aquifer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tulip Creek Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>McLish Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil Creek Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Joins Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Ordovician</td>
<td>Arbuckle Group</td>
<td></td>
<td>Arbuckle-Timbered Hills</td>
</tr>
<tr>
<td></td>
<td>West Spring Creek Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kindblade Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cool Creek Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>McKenzie Hill Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late Cambrian</td>
<td>Timbered Hills Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Signal Mountain Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Butterfly Dolomite</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fort Sill Limestone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Royer Dolomite</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Honey Creek Limestone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reagan Sandstone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle Cambrian</td>
<td>Colbert Rhyolite</td>
<td>Basement Confining Layer</td>
<td>Basement</td>
</tr>
<tr>
<td>Precambrian</td>
<td>Tishomingo Granite, Troy Granite, granodiorite, and granitic gneiss</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Deep Test Hole

Helicopter Electromagnetic

Ground Penetrating Radar

Gravity
Seismic Survey
3D Geologic Model
Stream Monitoring

Explanation
- ● OWRB Monitoring Site
- △ OWRB Periodic Gage
- ♠ USGS Stream Gage

Arbuckle - Simpson Outcrop Area
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).
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