# Aquifers of Arkansas

## Protection, Management, and Hydrologic and Water-Quality Characteristics of Arkansas' Groundwater

**U.S. Geological Survey, Arkansas Water Science Center**

**Arkansas Natural Resources Commission**

**FTN Associates**

U.S. Department of the Interior
U.S. Geological Survey

# Overview of Groundwater Quality

- Sixteen identified aquifers organized by Coastal Plain and Interior Highlands
- Compiled over 8,000 sites with QW from USGS NWIS and ADEQ water-quality databases
- Selected major inorganic constituents (Ca, Mg, K, Na, Cl, $SO_4$, $HCO_4$), trace metals (Fe, Mn, As), $NO_3$, dissolved solids, field parameters (pH, specific conductance), and well depth
- Compiled descriptive statistics for all aquifers
- Looked at spatial distribution in ArcGIS and for temporal relations where data available

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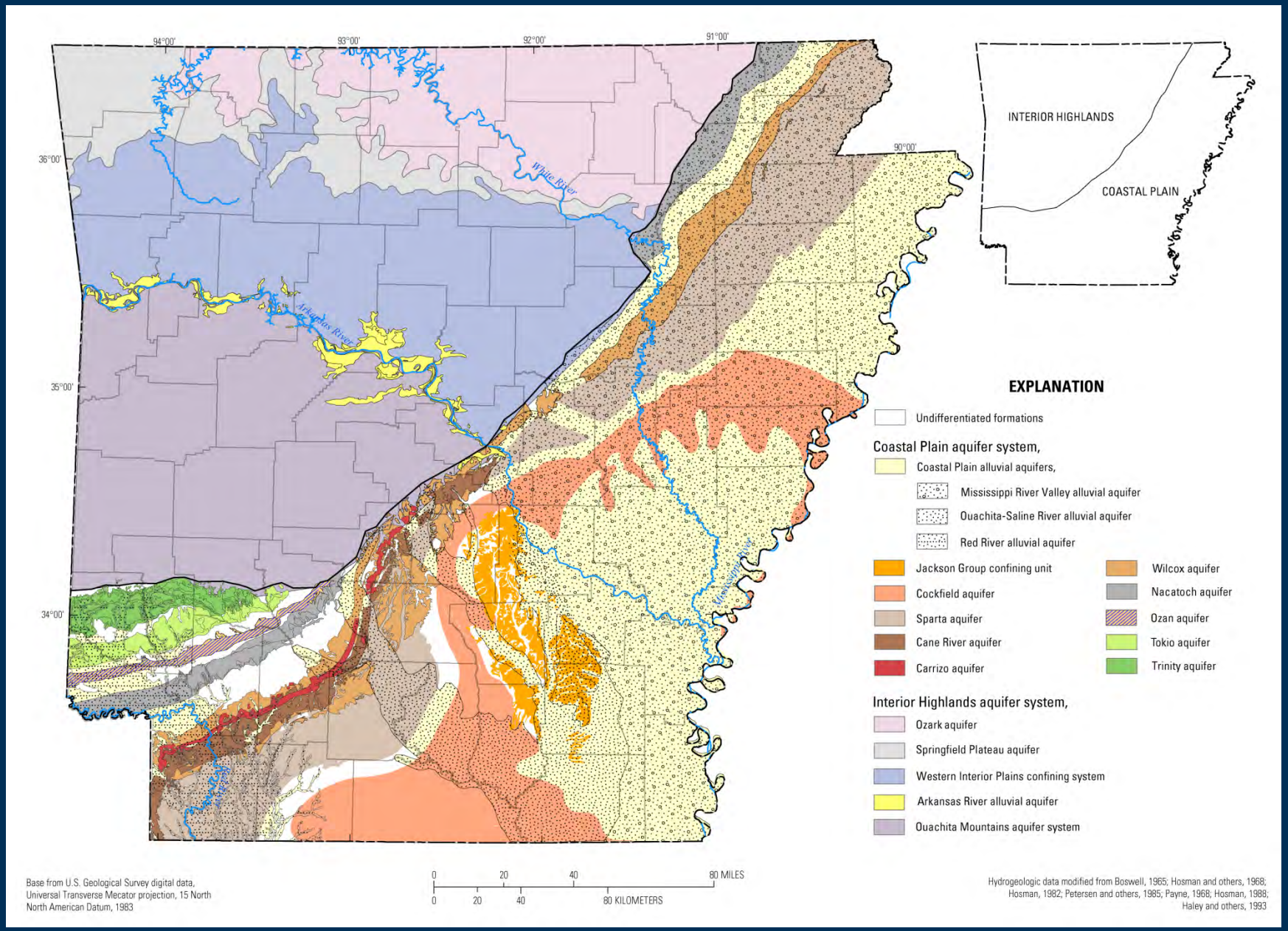
# The Sixteen Aquifers of Arkansas



# Location, Age, Use, Aquifer Codes, and Number of Water-Quality Sites

| Major Division | Province | Section | Formation or Group of Formations | Geologic Age | Hydrogeologic Unit Name | Aquifer Code | Aquifer Use[1] | Water-Quality Sites |
|---|---|---|---|---|---|---|---|---|
| Atlantic Plain | Coastal Plain | Mississippi Alluvial Plain and West Gulf Coastal Plain | Coastal Plain Alluvium | Quaternary | Mississippi River Valley, Ouachita-Saline, and Red River alluvial aquifers | 110ALVM, 112ALVM 112VLTR, 112TRRC | IR, ps, in | 4,061 |
| | | | Jackson Group | Tertiary | Vicksburg-Jackson confining unit | 124JCKS | D | 68 |
| | | | Cockfield Formation | Tertiary | Cockfield aquifer | 124CCKF | IN, IR, ps | 257 |
| | | | Sparta Sand | Tertiary | Sparta aquifer | 12405MP, 124SPRT, 124MMPS | IR, PS, IN | 1,626 |
| | | | Cane River Formation | Tertiary | Cane River aquifer | 124CRVR, 124CANR | PS, d | 45 |
| | | | Carrizo Sand | Tertiary | Carrizo aquifer | 124CRRZ | D | 12 |
| | | | Wilcox Group | Tertiary | Wilcox aquifer | 124WLCX, 124WLCXG | PS, ir, in | 170 |
| | | | Nacatoch Sand | Cretaceous | Nacatoch aquifer | 211NCTC | PS | 143 |
| | | West Gulf Coastal Plain | Ozan Formation | Cretaceous | Ozan aquifer | 212OZAN | D | 14 |
| | | | Tokio Formation | Cretaceous | Tokio aquifer | 212TOKO | PS, in | 165 |
| | | | Trinity Group | Cretaceous | Trinity aquifer | 218TRNT | PS, in | 38 |
| Interior Highlands | Ouachita Province | Arkansas Valley | Arkansas River Valley Alluvium | Quaternary | Arkansas River Valley alluvial aquifer | 110ALVM, 110TRRC 112TRRC | PS, IR, d | 680 |
| | | Ouachita Mountains | Collier Shale through Boggy Formation[4] | Cambrian through Pennsylvanian | Ouachita Mountains aquifer | 325HRSR, 325MCAL 326ATOK, 328JKFK 330ARKS, 330HSPG 330STNL, 350MSRM 361PKCK, 364BGFK | D | 162 |
| | Ozark Plateaus | Boston Mountains | Moorefield Formation through McAlester Formation[2] | Mississippian and Pennsylvanian | Western Interior Plains Confining System | 325HRSR, 325MCAL 326ATKN, 326ATOK 328BLYD, 328CNHL 328JKFK, 3331BSVL 331MFLD, 331PTKN | D | 287 |
| | | Springfield-Salem Plateaus | Boone Formation | Mississippian | Springfield Plateau aquifer | 330BOON | D, ps | 95 |
| | | | Van Buren Formation through Clifty Limestone[3] | Ordovician through Devonian | Ozark aquifer | 361FRVL, 364EVRN 364JCHM, 364STPR 367CTJF, 367CTTR 368PWLL, 371POTS 367RBDX, 367GNTR | PS, d | 131 |

# Aquifers of the Coastal Plain

- Long regional flow paths (generally southeast) from outcrop and subcrop areas to major river systems
- Generally high yields related to increased storage and permeability of coarse-grained sediments
- Predominant rock-water interaction is mineral dissolution and cation exchange
- Abundant organics in aquifers lead to microbial-mediated processes resulting in well-defined redox zonation along flow path
- Areas of high salinity predominantly related to upwelling from poor-quality underlying formations, incomplete flushing of residual salinity, and evapotranspiration

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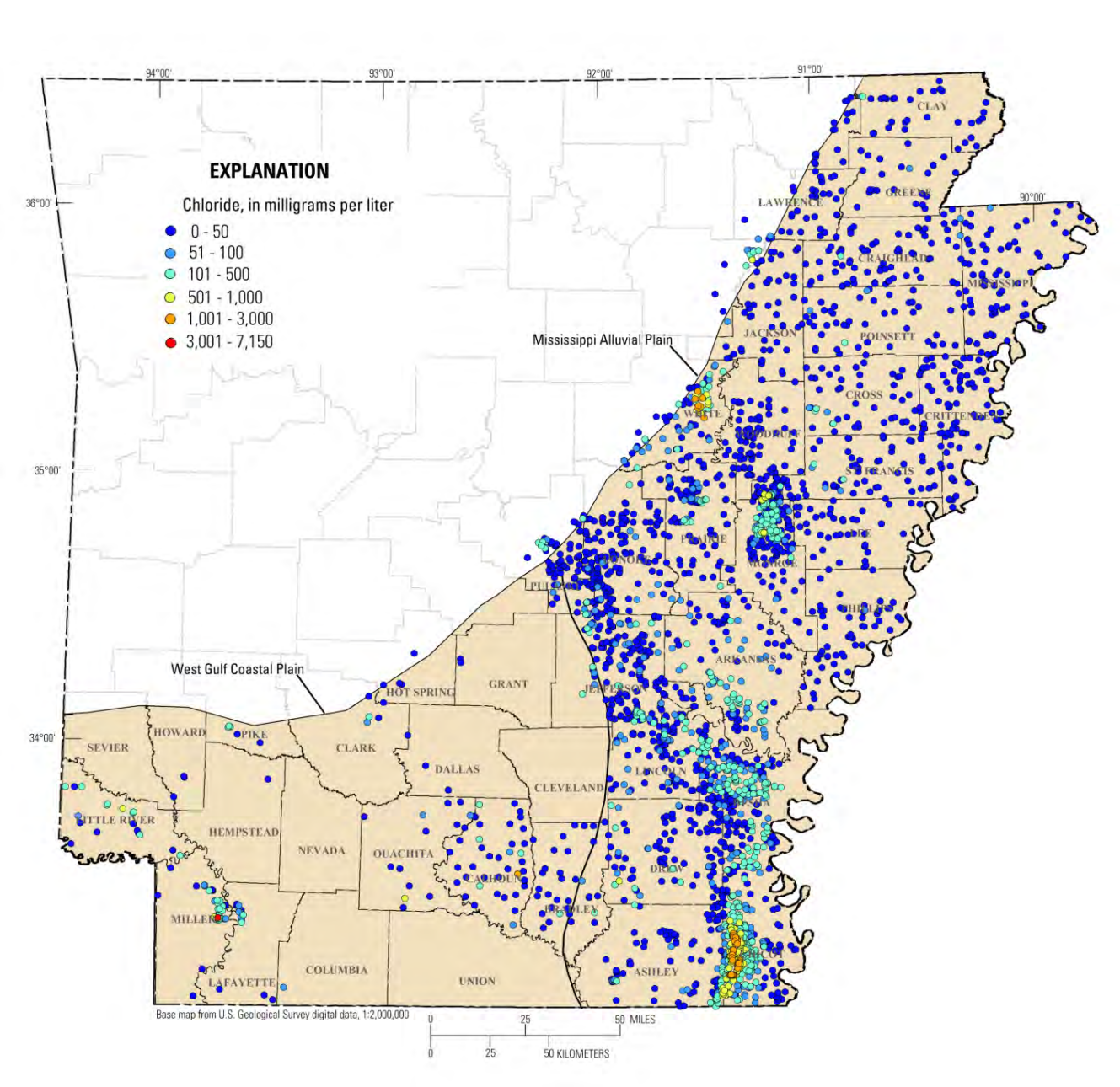
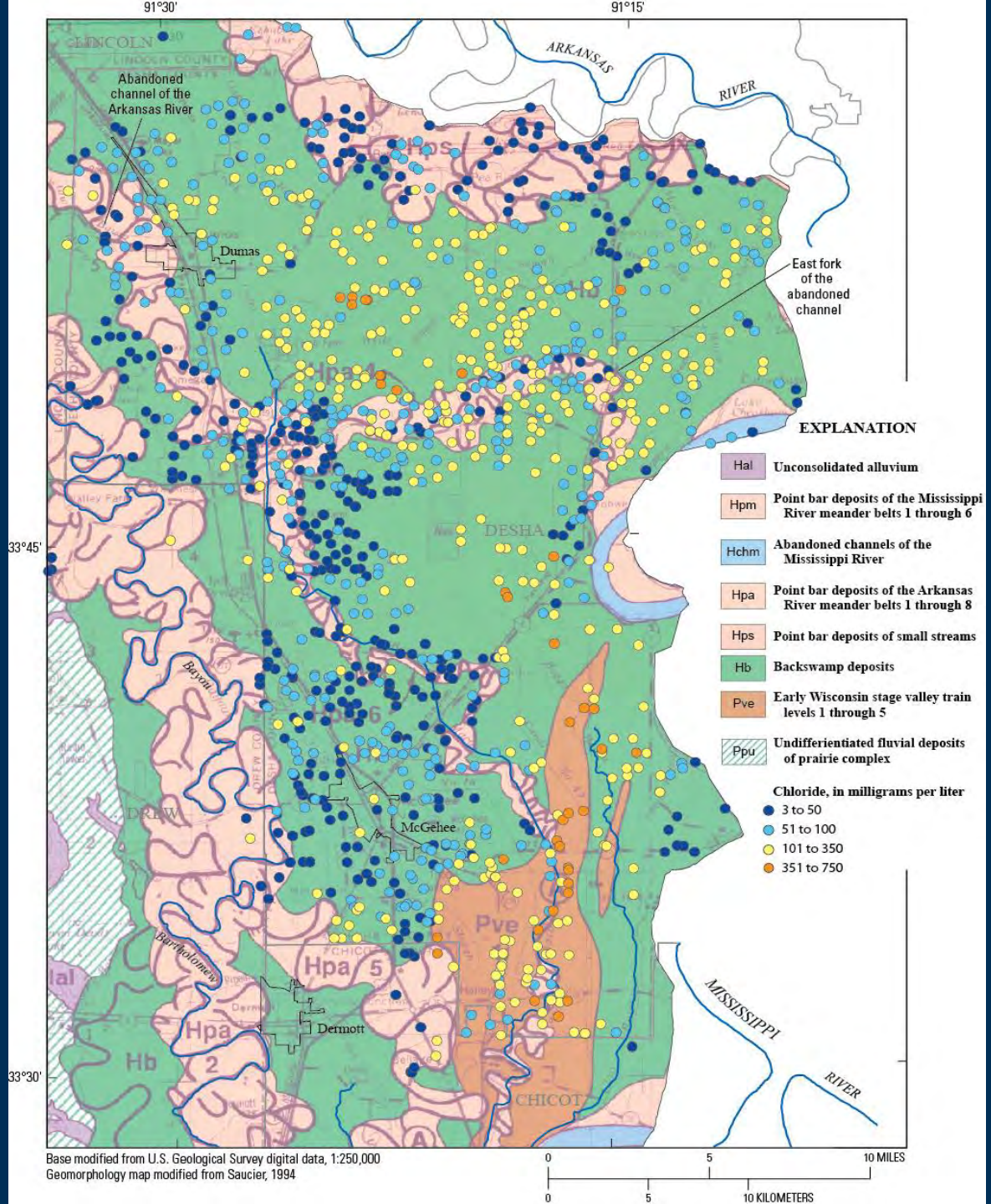
# Coastal Plain Alluvial Aquifer System



# MRV alluvial aquifer – Desha County

Chloride concentrations highest in backswamp areas versus channel deposits

Iron and arsenic highest in channel deposits – low in backswamp areas

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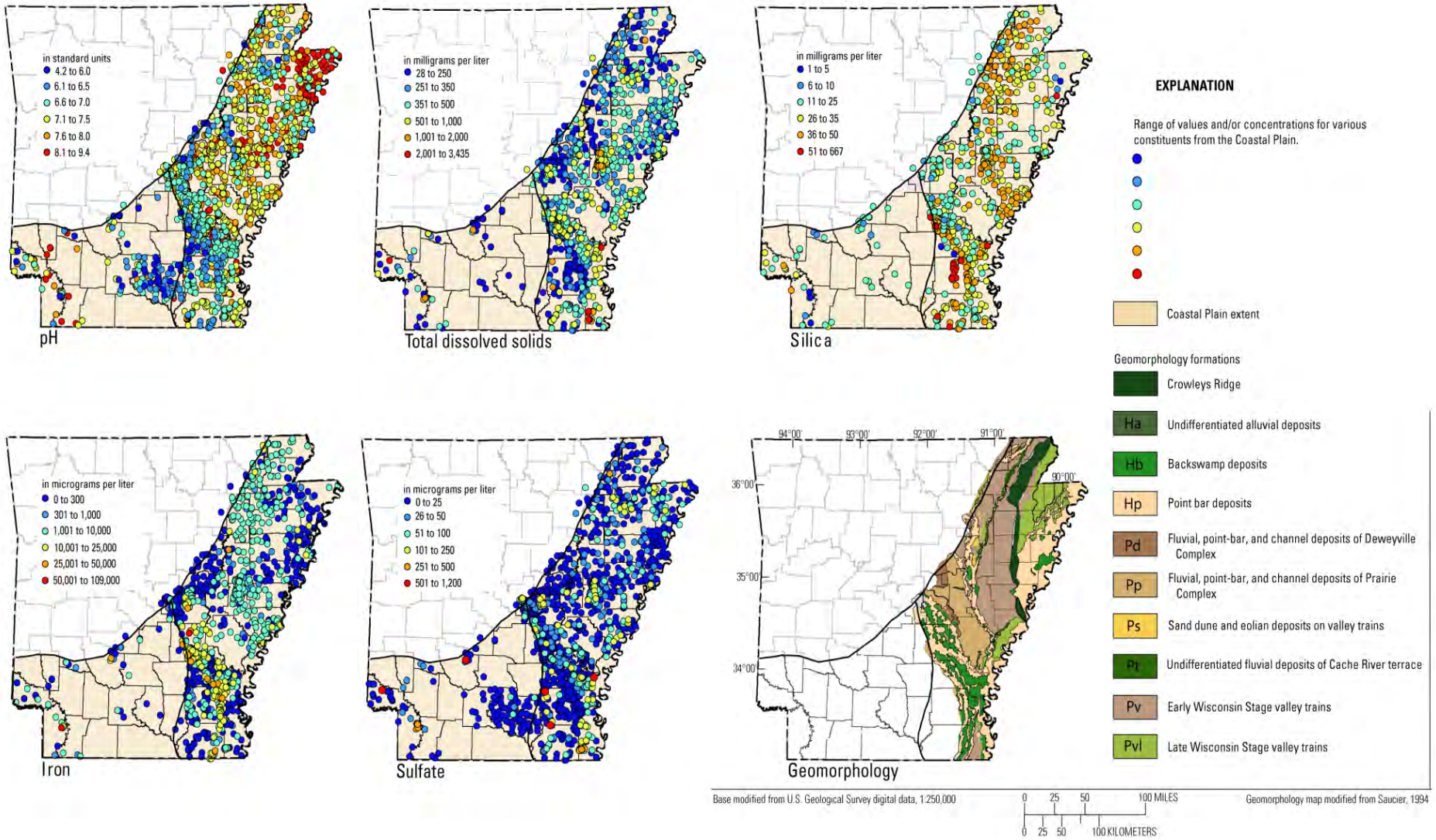
# Spatial distribution of other constituents

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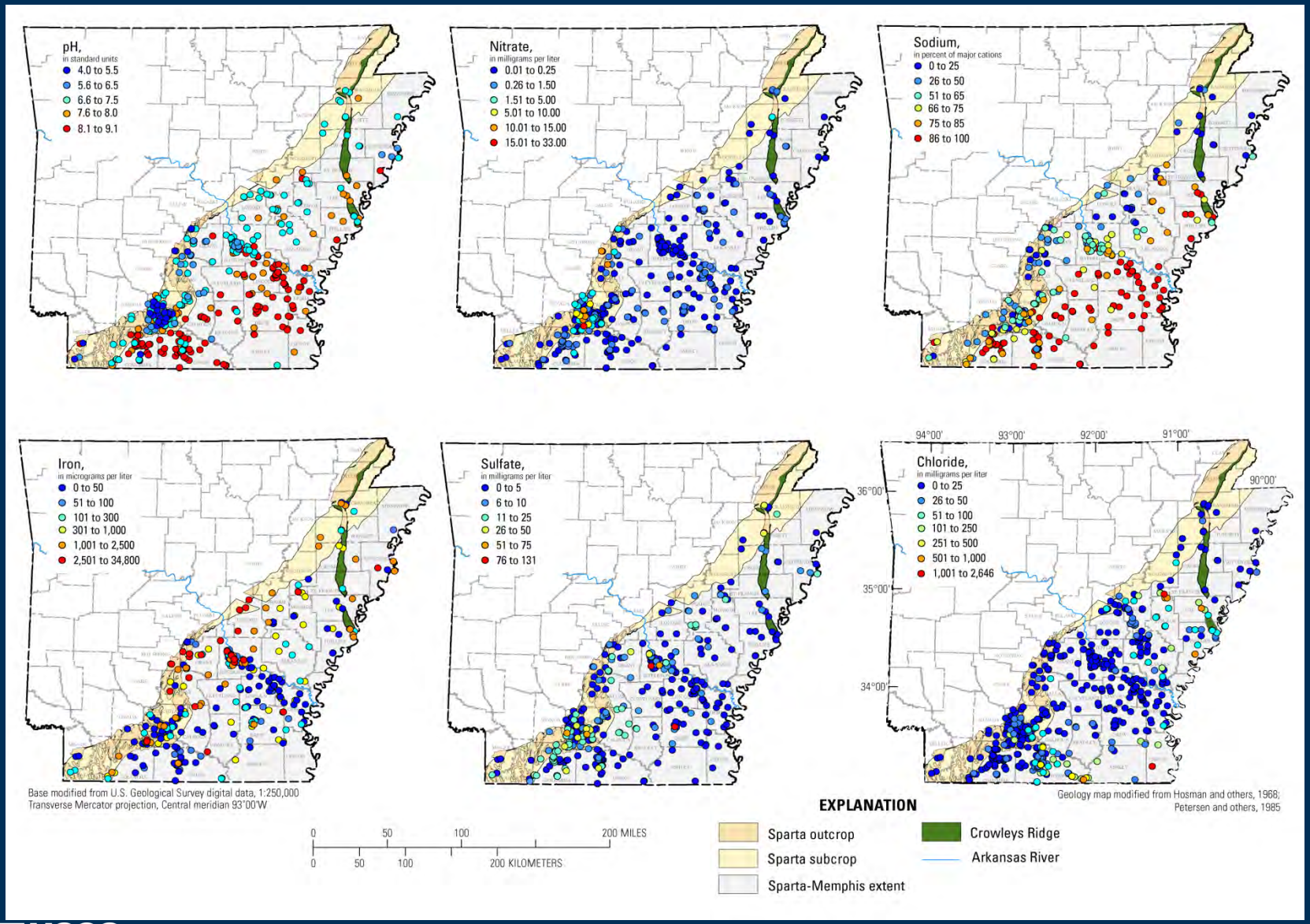
# Sparta Aquifer

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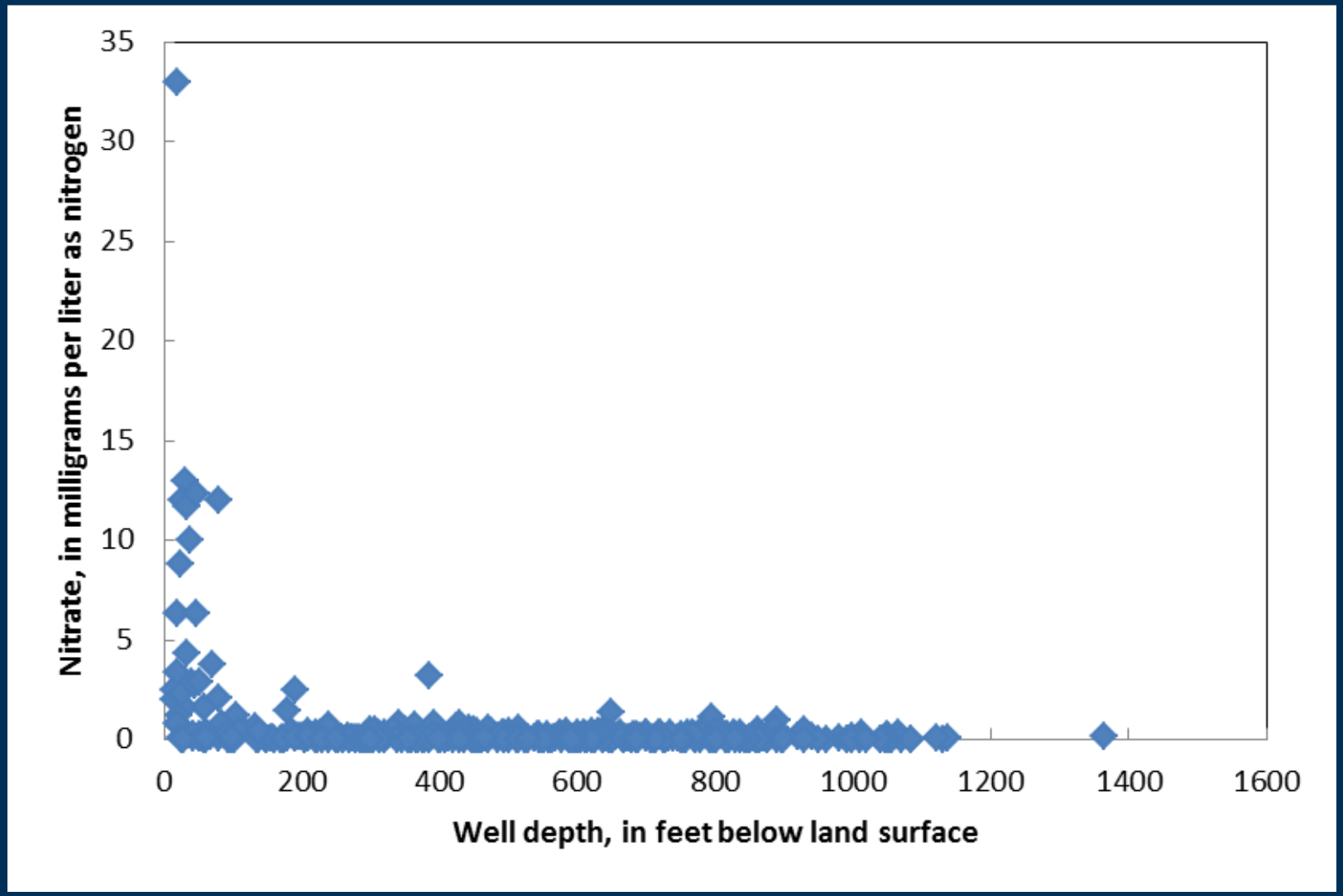
# Sparta Aquifer – Nitrate vs Well Depth

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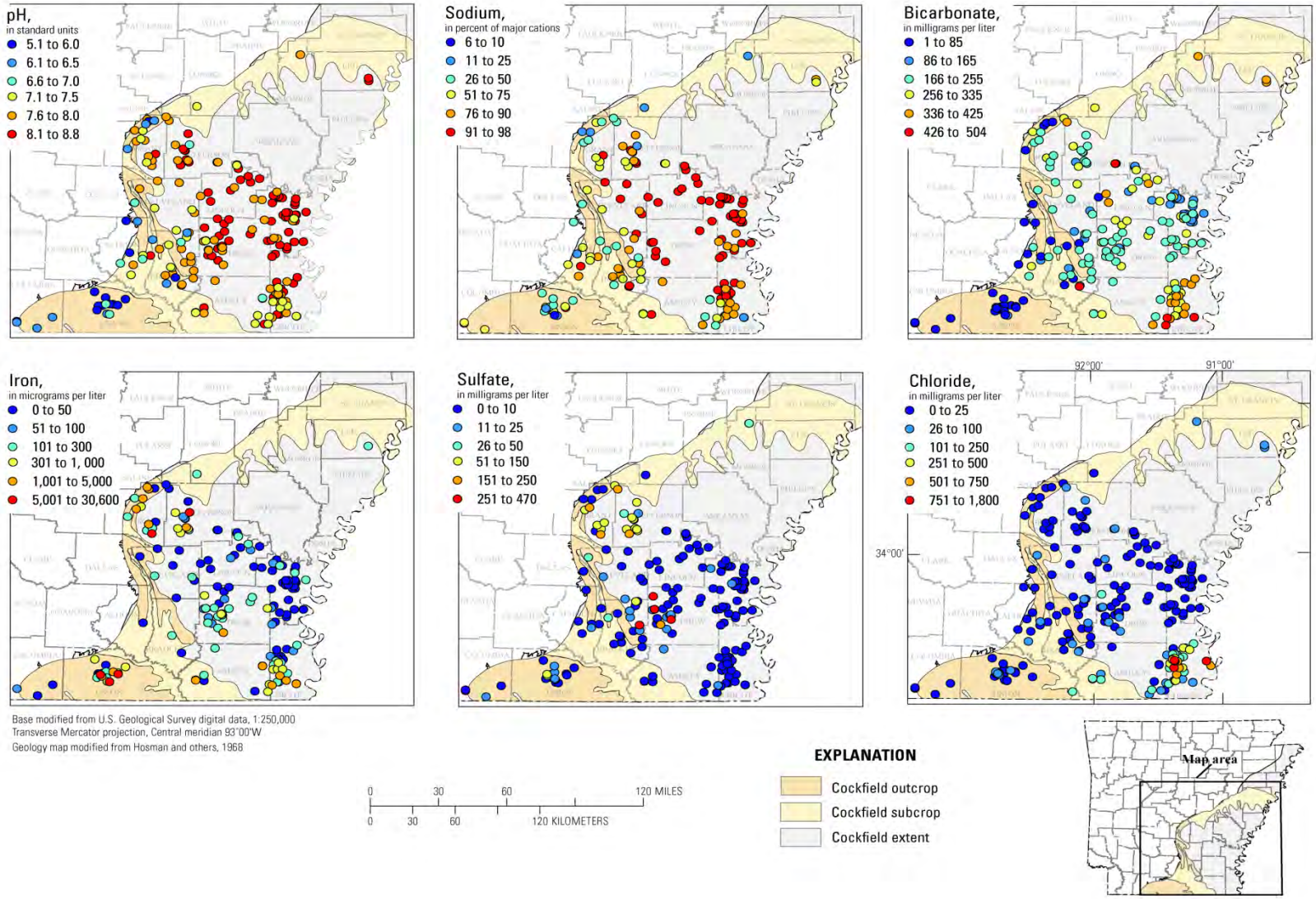
# Cockfield Aquifer

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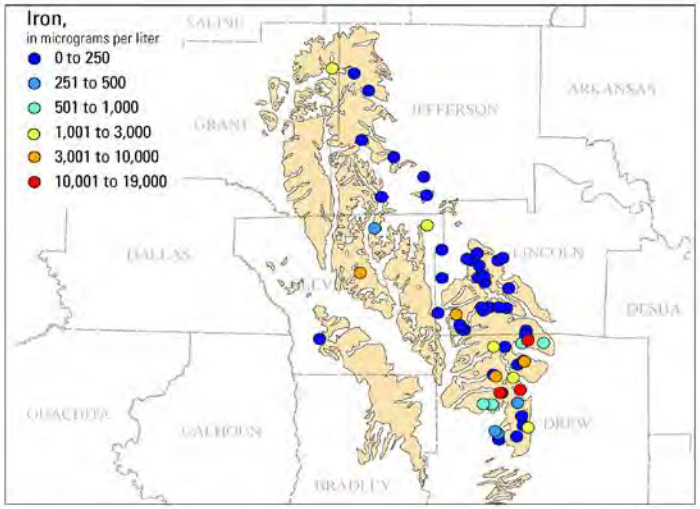
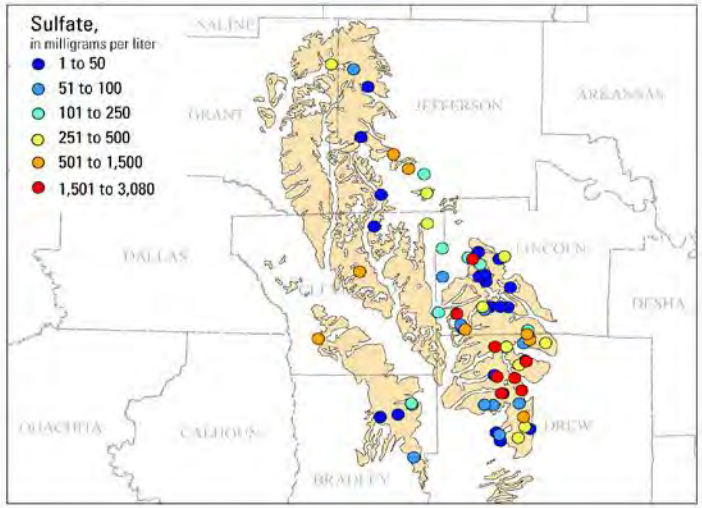
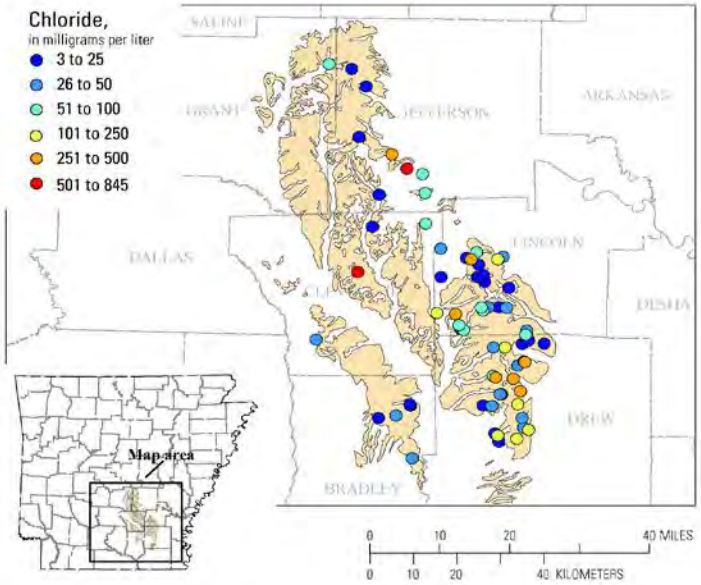
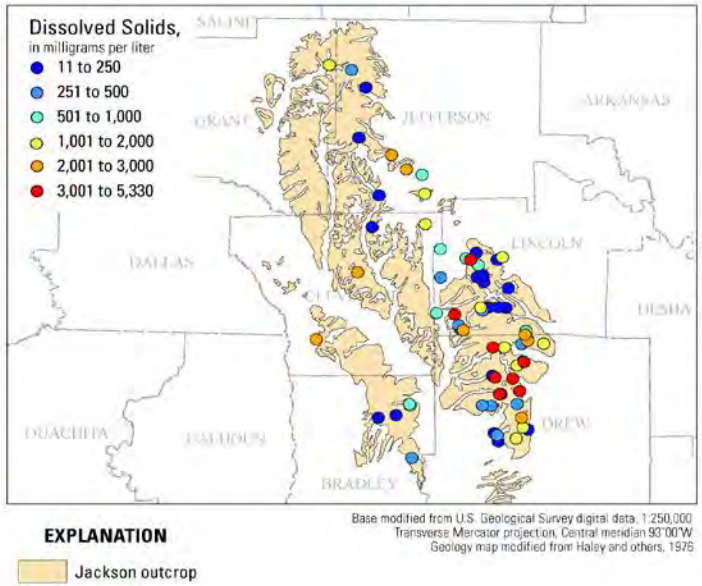
# Jackson Group Aquifer

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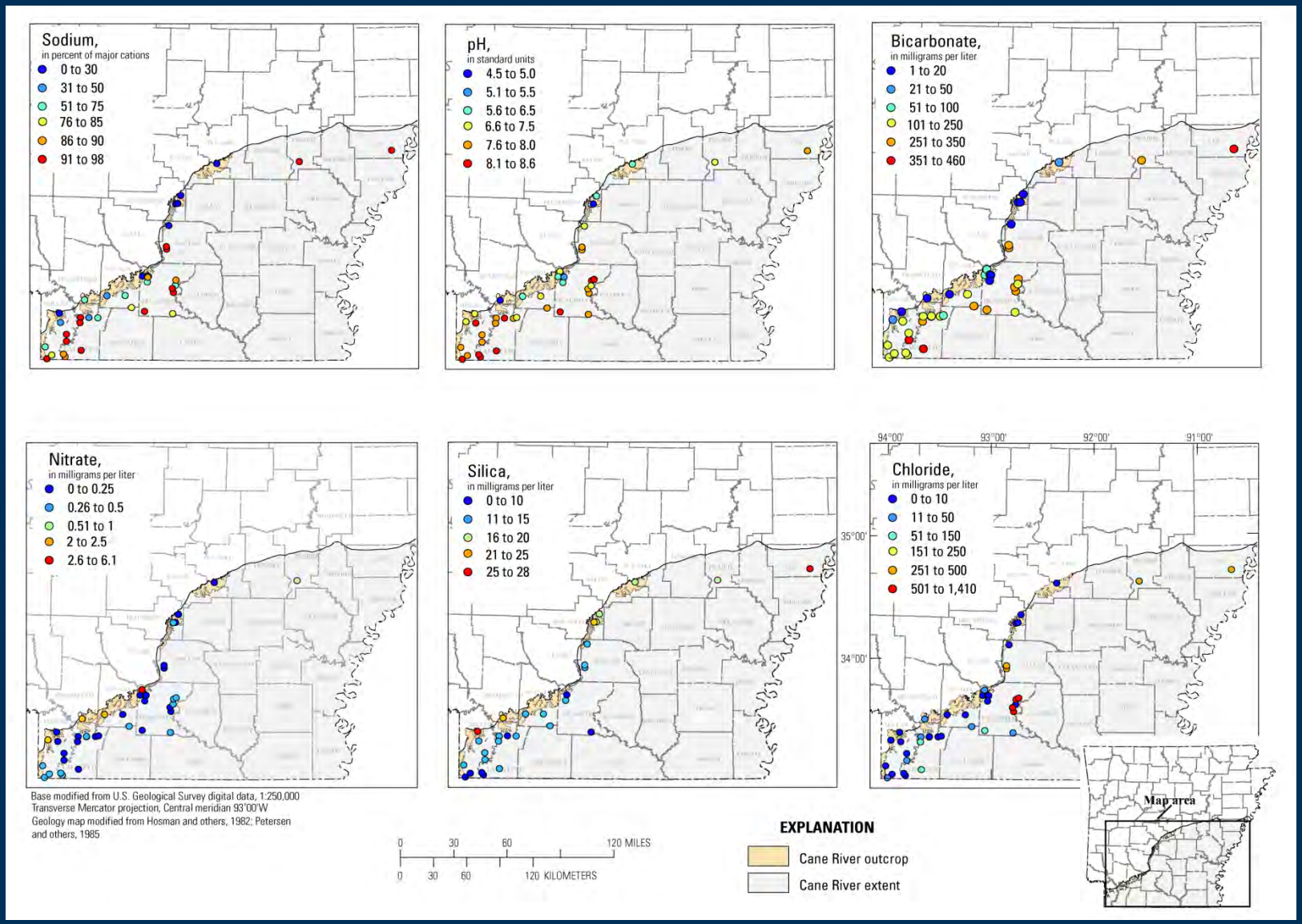
# Cane River Aquifer

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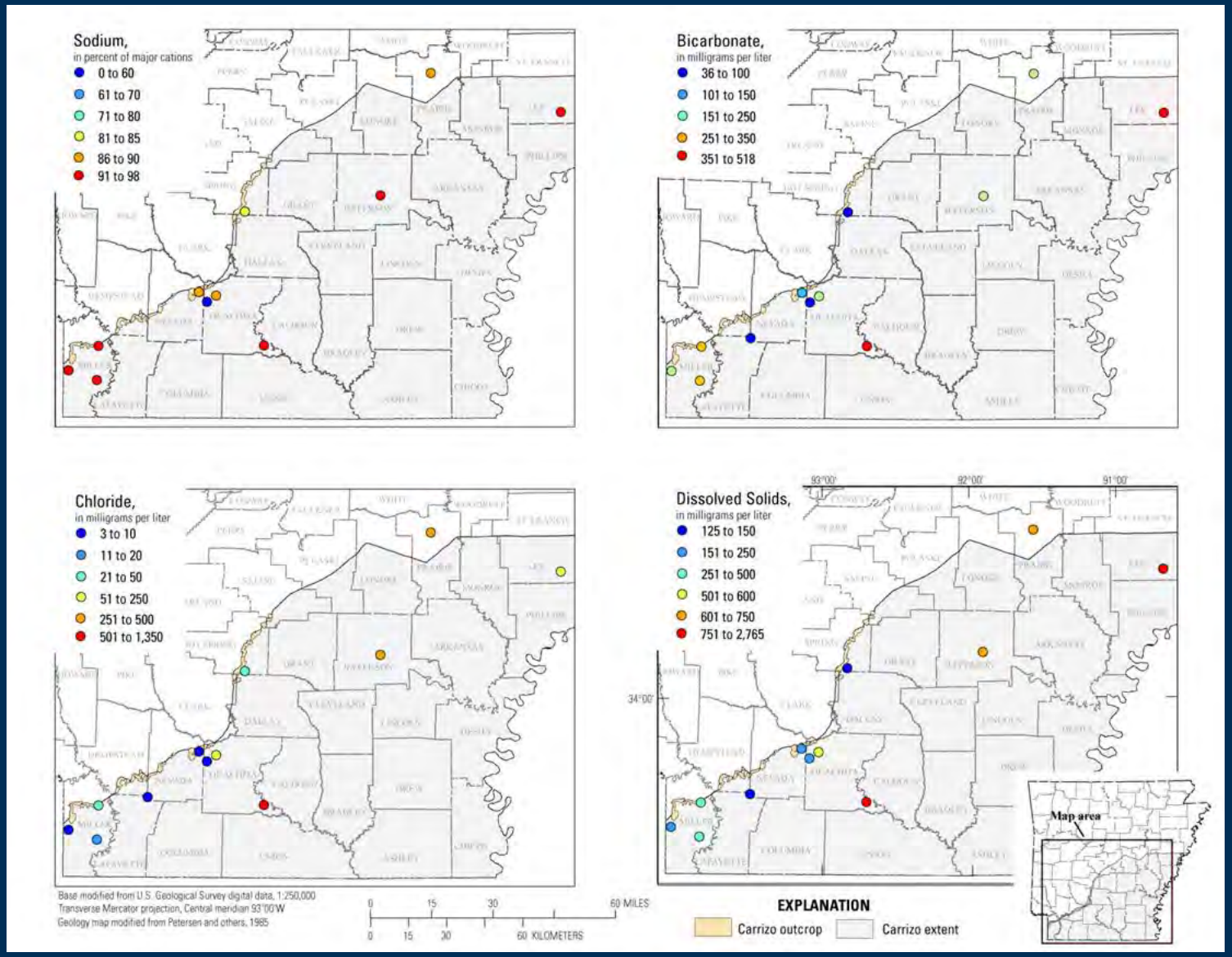
# Carrizo Aquifer

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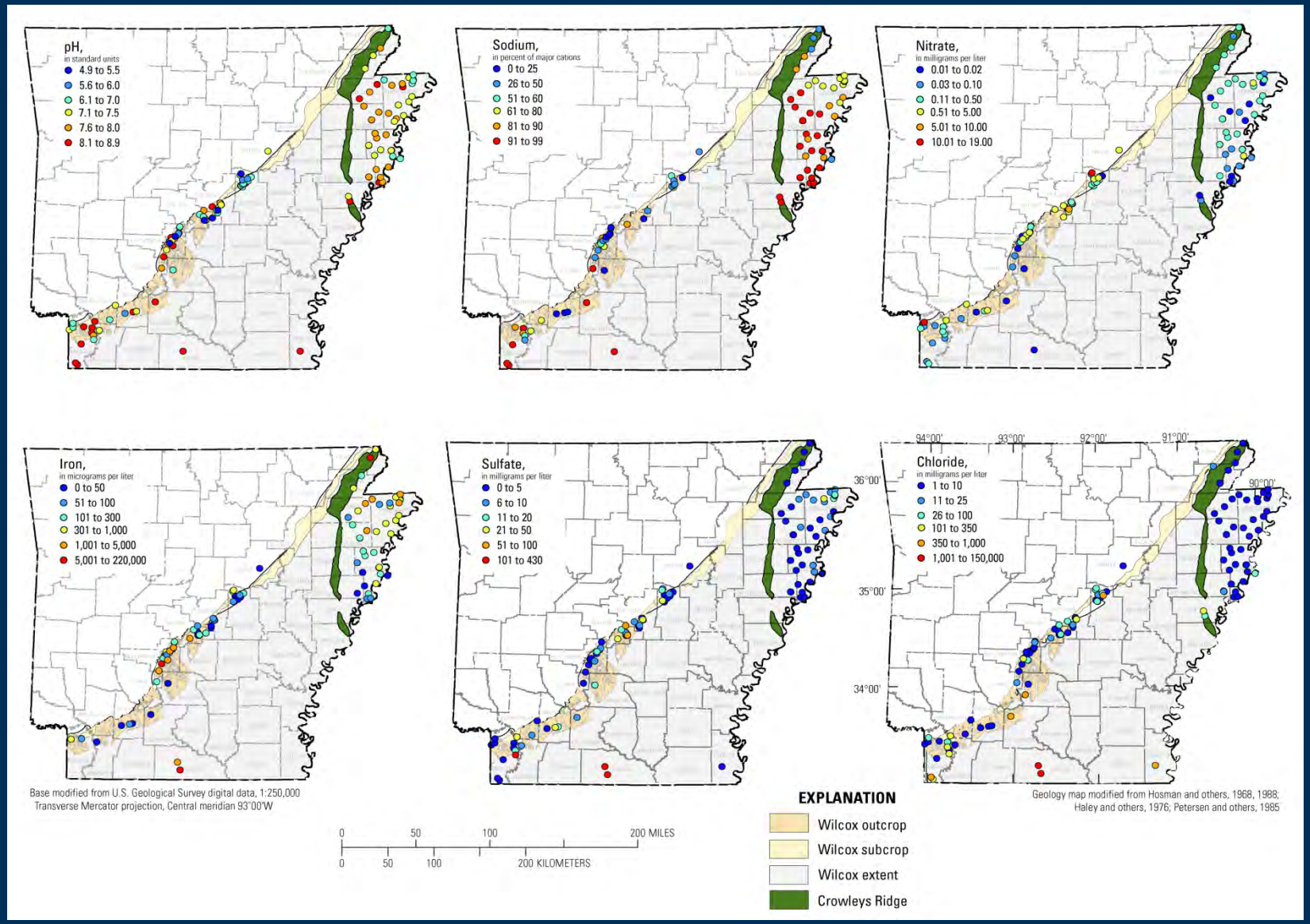
# Wilcox Aquifer

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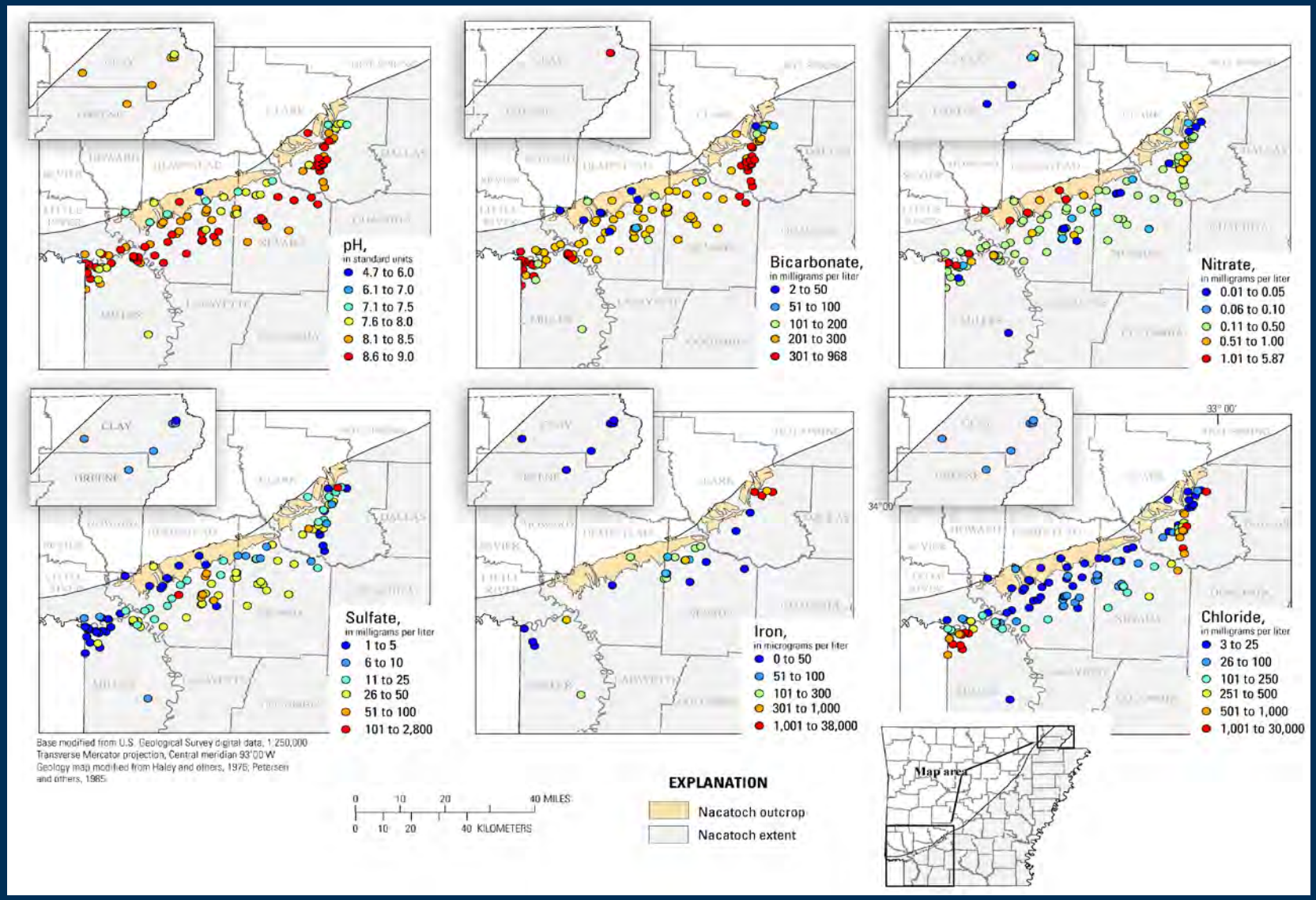
# Nacatoch Aquifer

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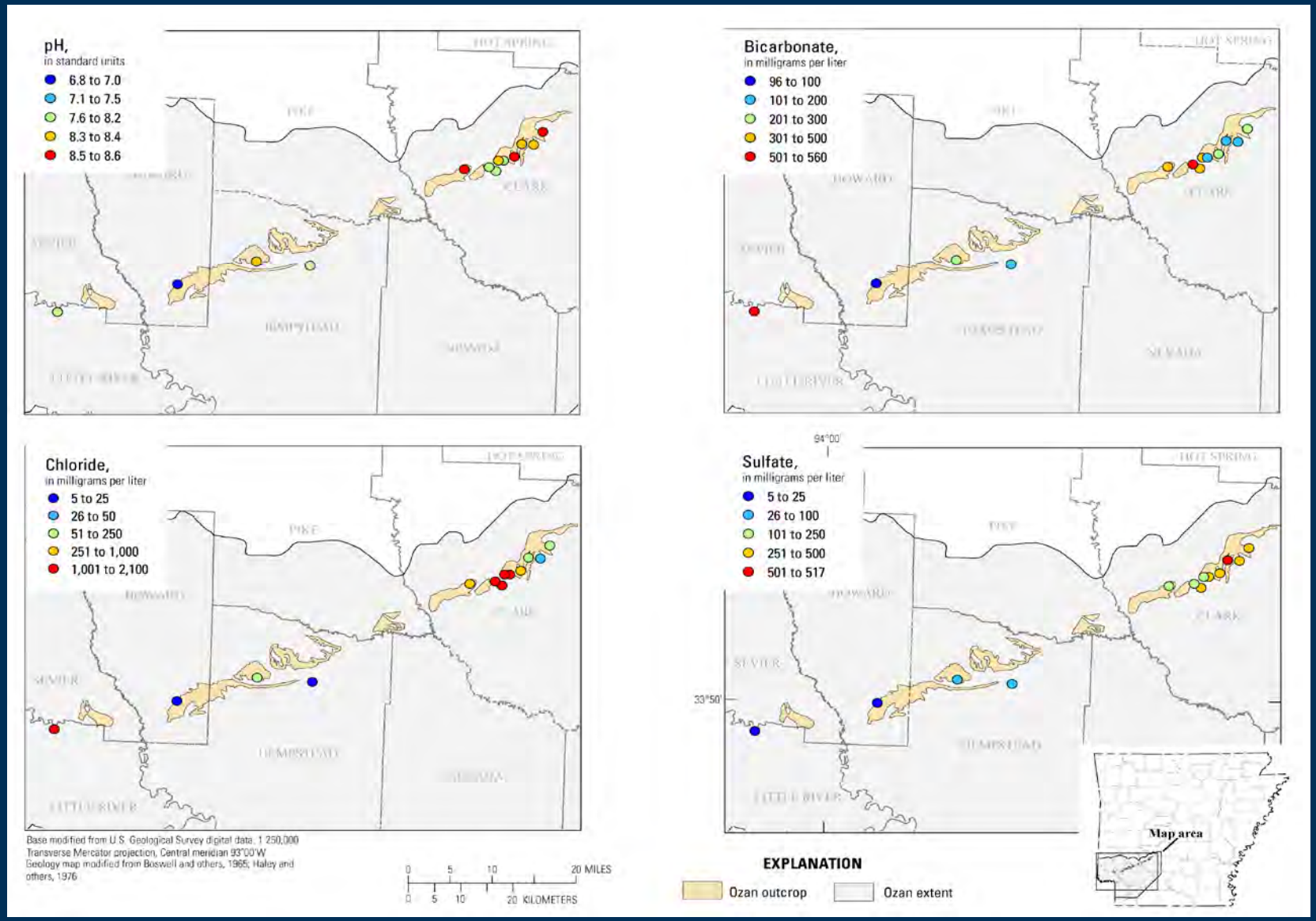
# Ozan Aquifer

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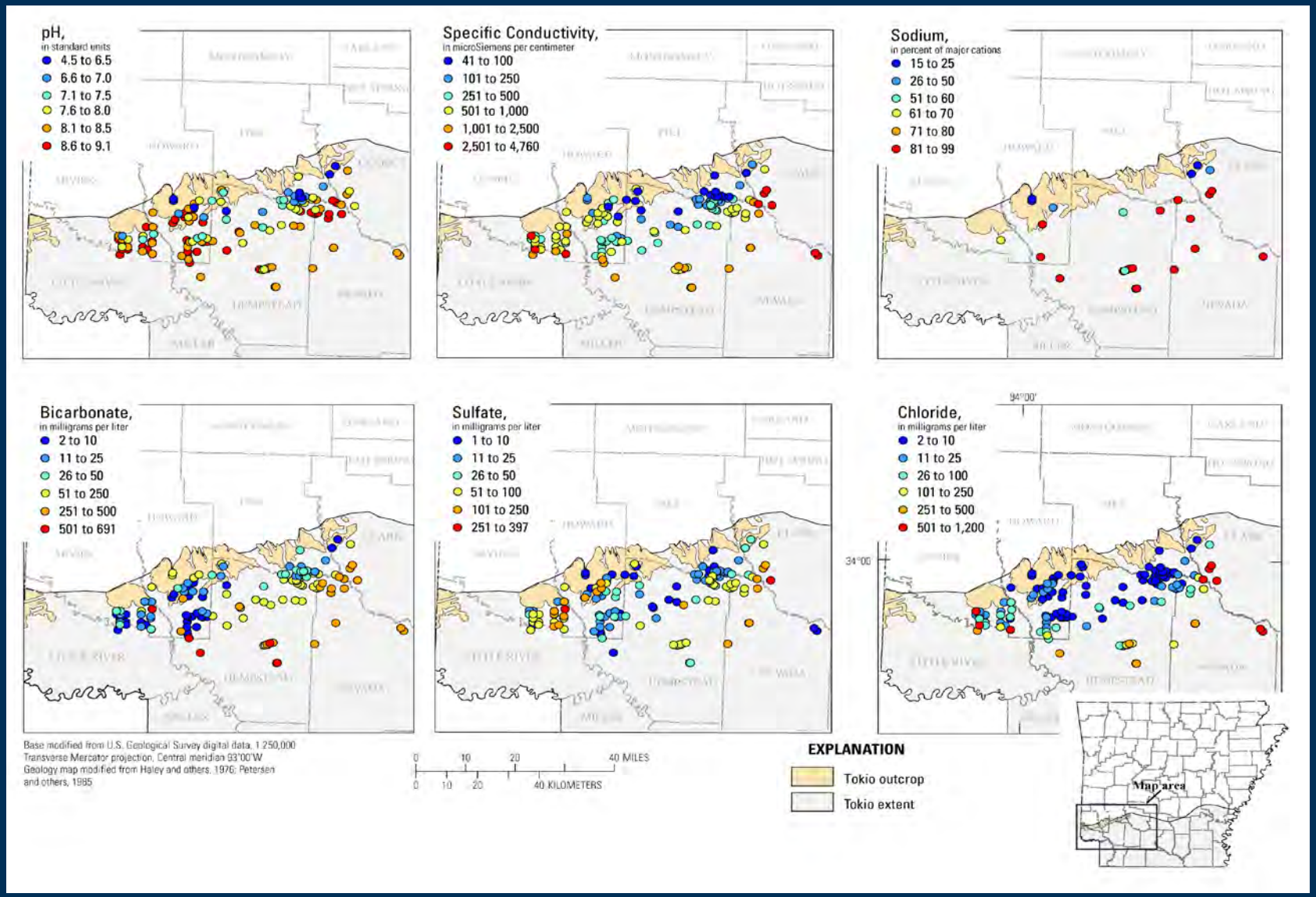
# Tokio Aquifer

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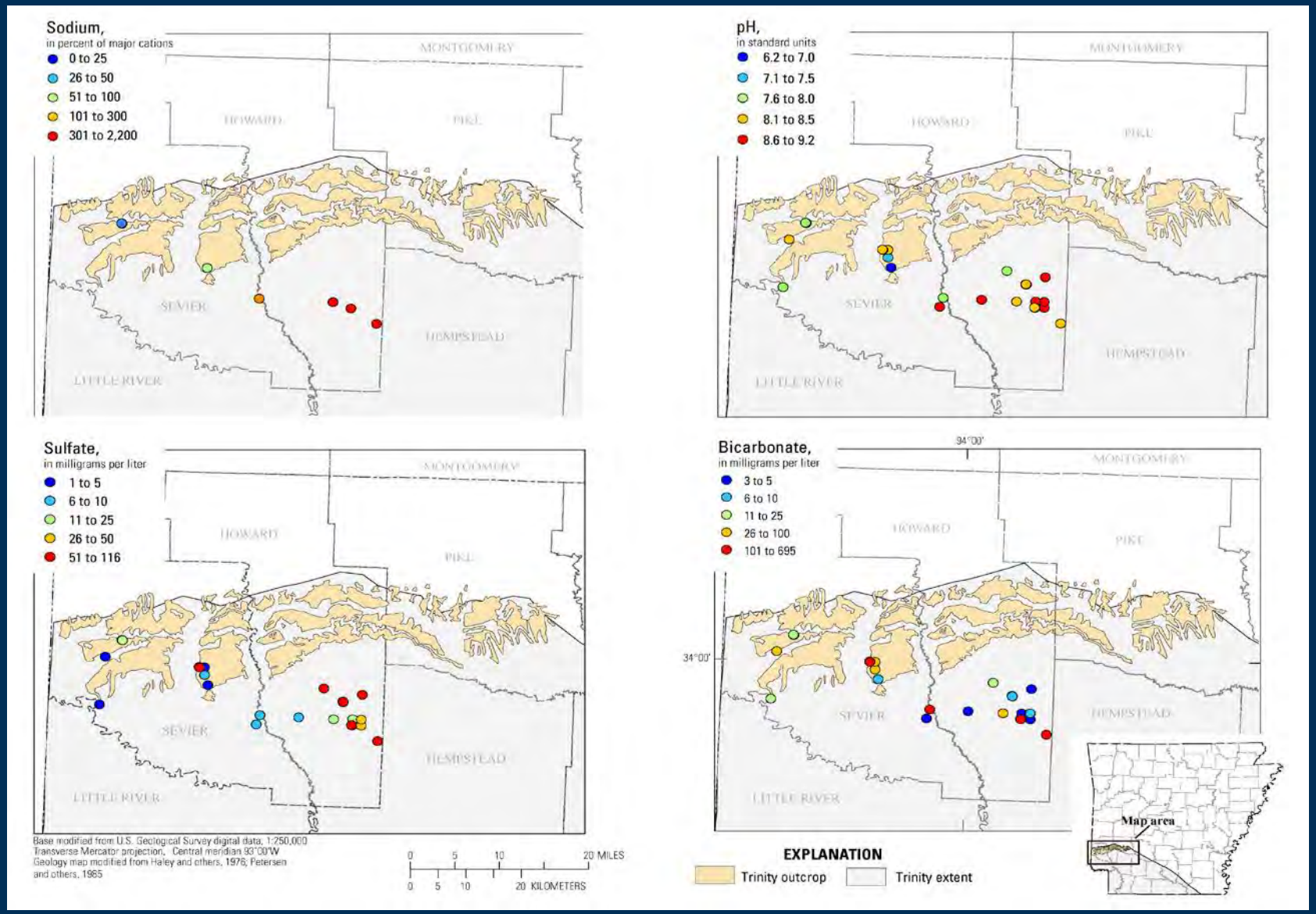
# Trinity Aquifer

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# Summary of Alluvial Aquifer Water Quality

- Constituent concentrations related to geomorphology – large areas with low iron available for multiple uses. Protection strategies have increased importance in high recharge (low clay content) areas
- Along major streams, iron, arsenic, and other metals high in channel deposits and lower in clay-rich backswamp deposits
- Areas of elevated salinity exist in several locations and related to upwelling of high salinity water from underlying formations or evapotranspiration in clay-rich, low-recharge areas

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# Summary of Tertiary/Cretaceous Water Quality

- Constituent concentrations related to outcrop and subcrop areas: in outcrop area (recharge zone) pH and major ions are lower in concentrations, whereas iron, sulfate, and nitrate are higher in concentration. Planning and management strategies are vitally important in area of recharge
- Groundwater transitions from a calcium- to a sodium-bicarbonate water type downgradient of outcrop (subcrop) areas
- Areas of high salinity for Sparta and Cockfield aquifers related to upwelling of high salinity water from underlying formations in localized areas; otherwise, overall quality is good
- Cane River, Carrizo, Wilcox, Nacatoch, Ozan, Tokio, and Trinity most important and best water quality in and near outcrop areas in southwest Arkansas; although Wilcox and Nacatoch used in northeast Arkansas
- Higher salinity for these aquifers is located downgradient (at various distances) from outcrop area (in southeast Arkansas) from incomplete flushing of original salinity associated with deposition in shallow seas or upwelling of higher salinity waters at depth

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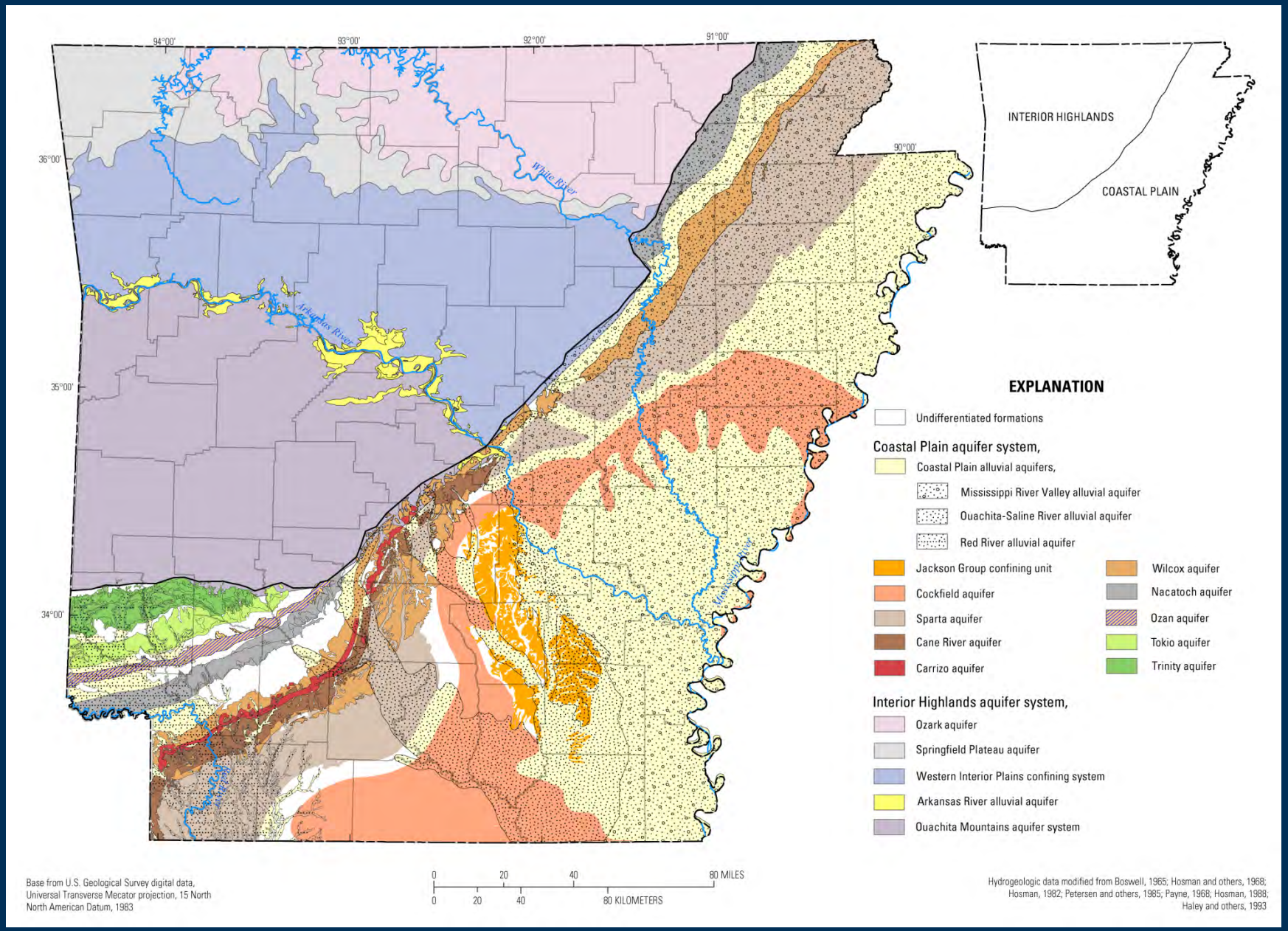
# Aquifers of the Interior Highlands



# Aquifers of the Interior Highlands

- Short, local flow paths from upland areas to local streams in small watersheds
- Characterized by fractured bedrock with limited secondary porosity, leading to limited yields from shallow wells (generally less than 5 gpm)
- Geochemistry strongly controlled by major rock type and mineralogy (quartz, shale, limestone formations)
- Redox processes strong control on water quality – particularly in shale formations
- High vulnerability in Ozark and Springfield Plateau resulting from karst landscape and Ag land use

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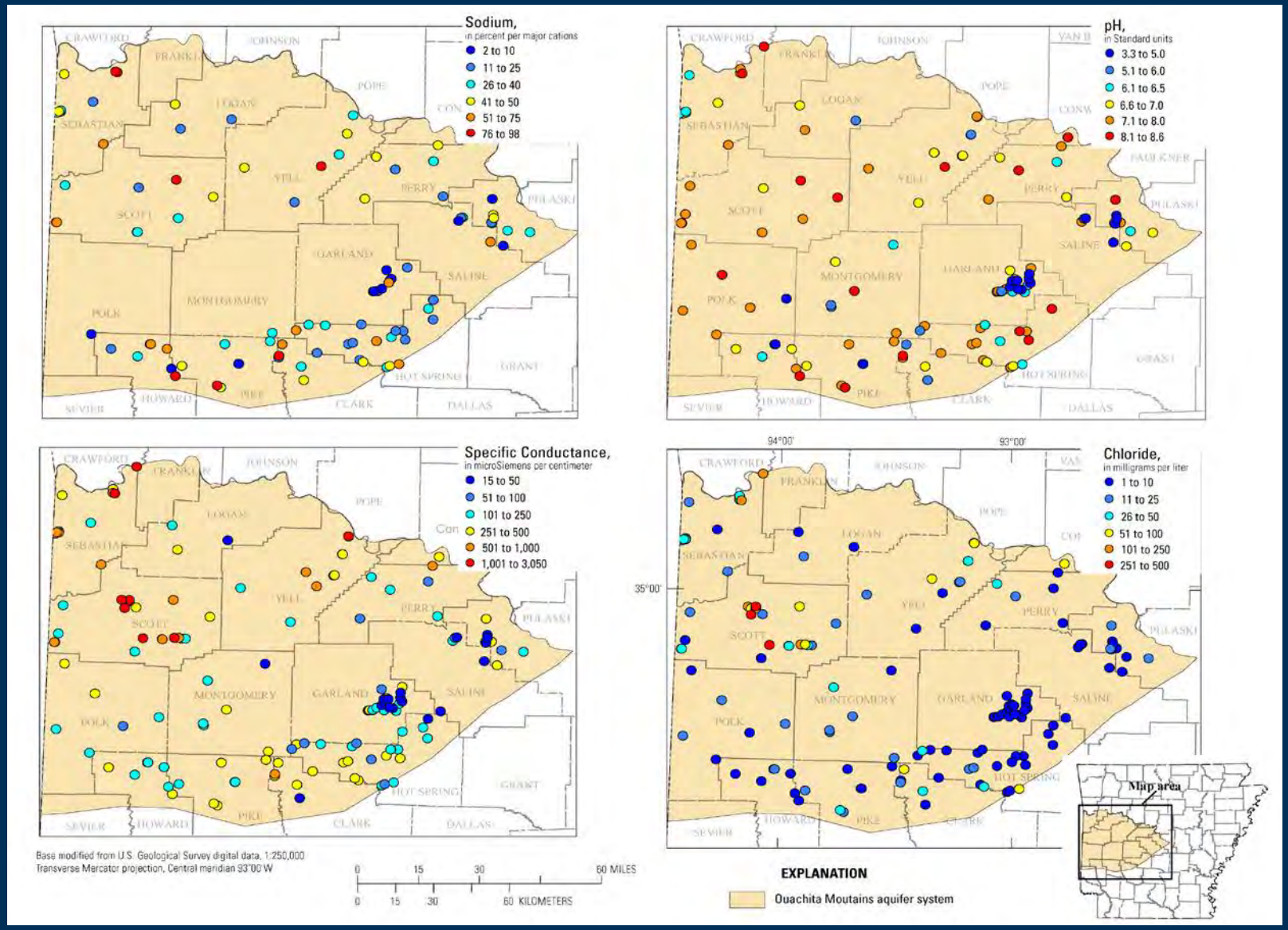
# Ouachita Mountains Aquifer

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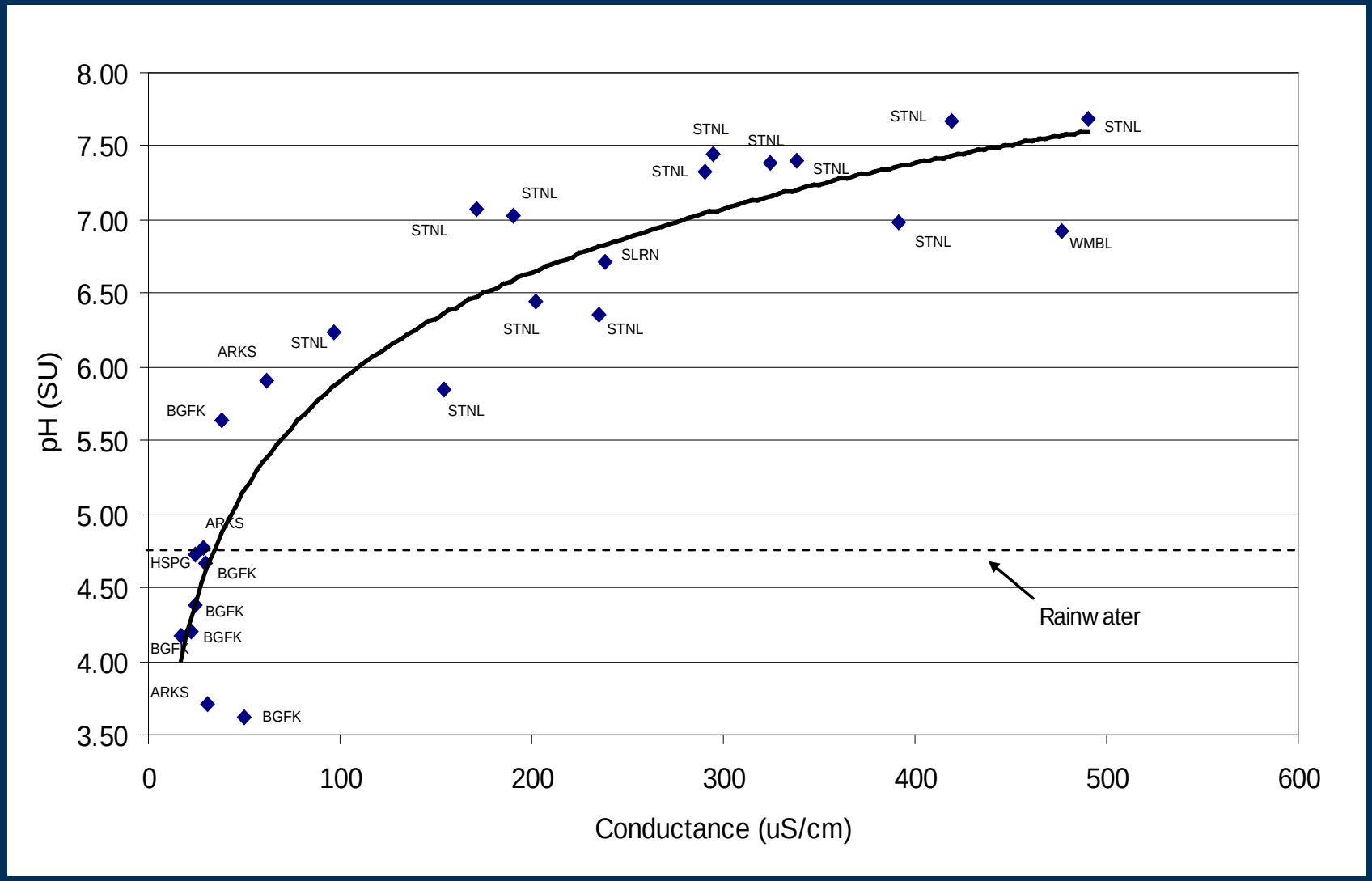
# Ouachita Mountains Aquifer – pH vs Spec. Conductance

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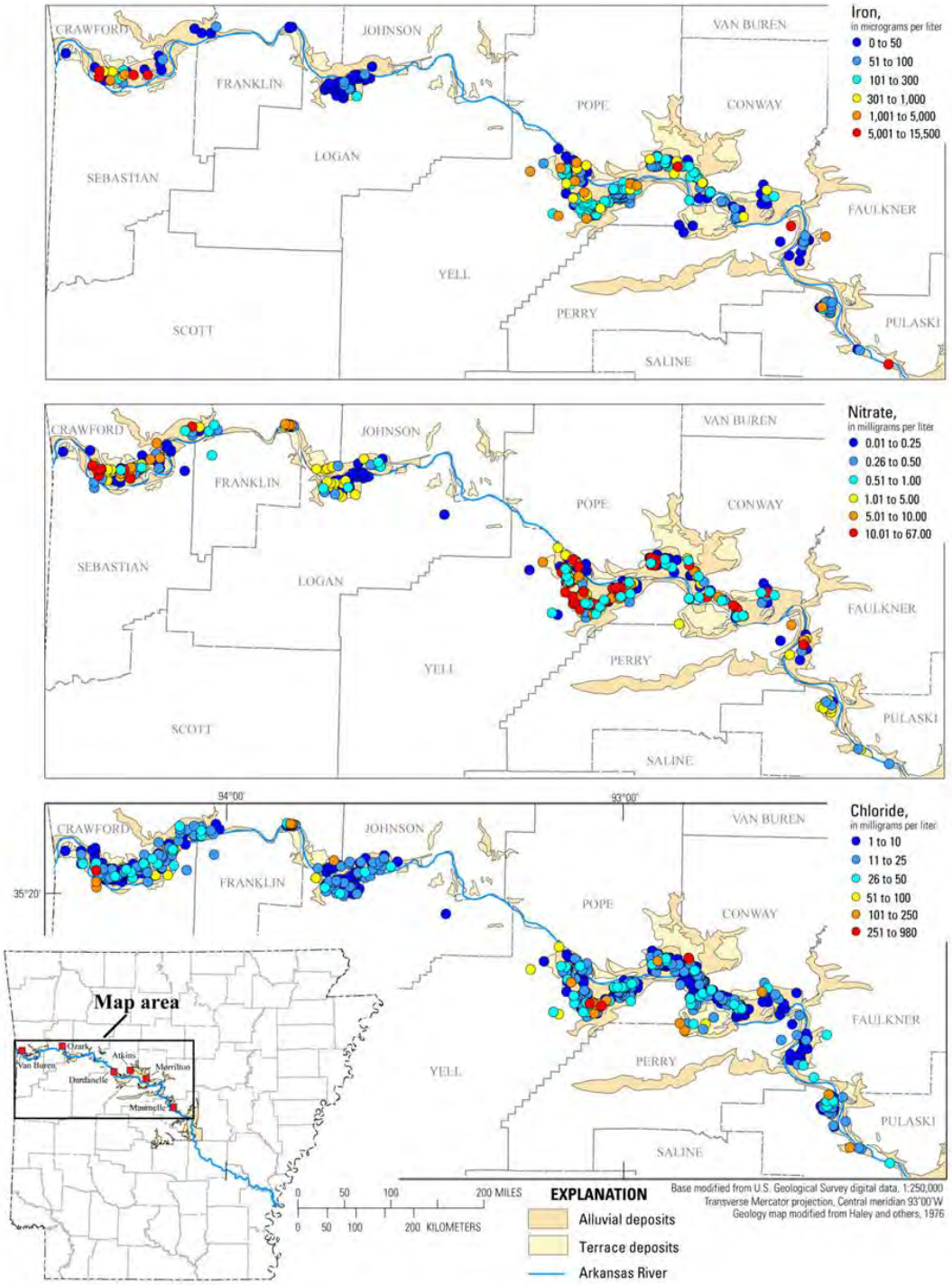
# Arkansas River Valley Alluvial Aquifer

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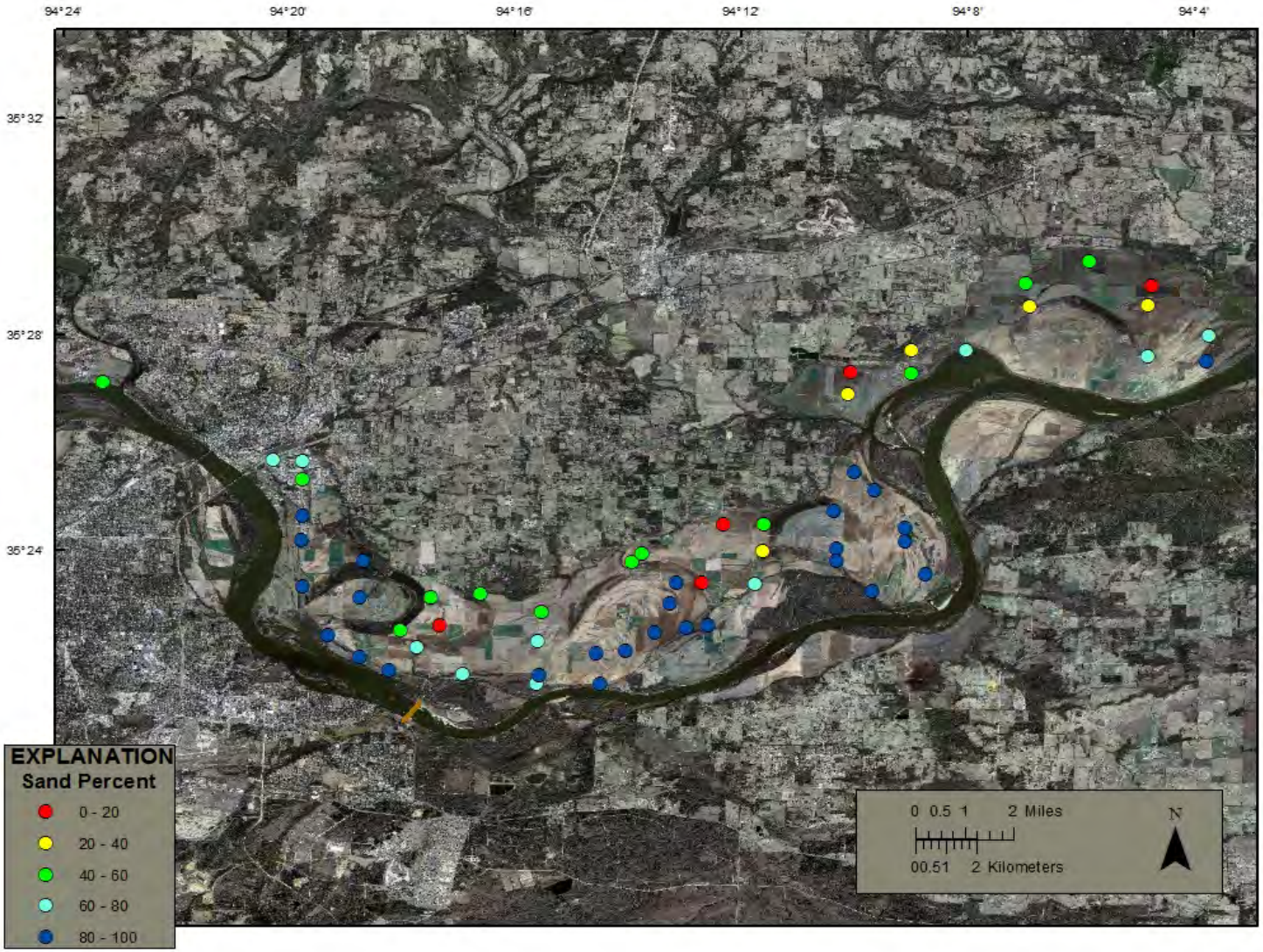
# Arkansas River Near Van Buren, Arkansas

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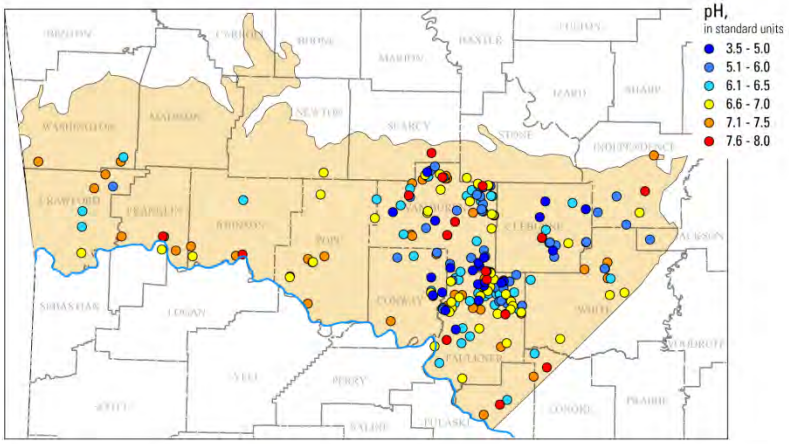
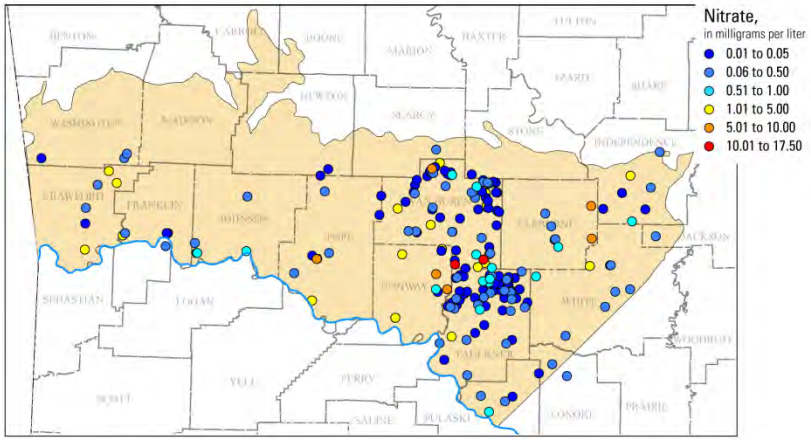
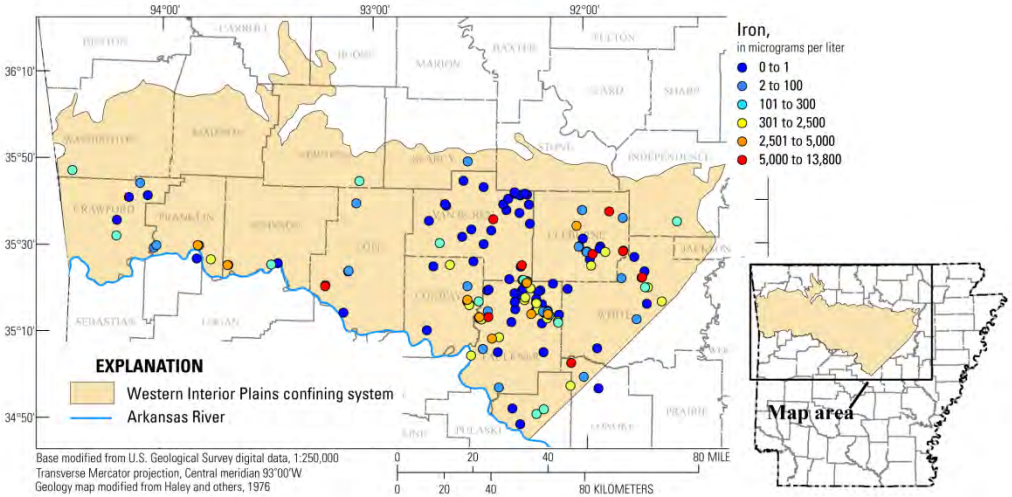
# Western Interior Plains Confining System

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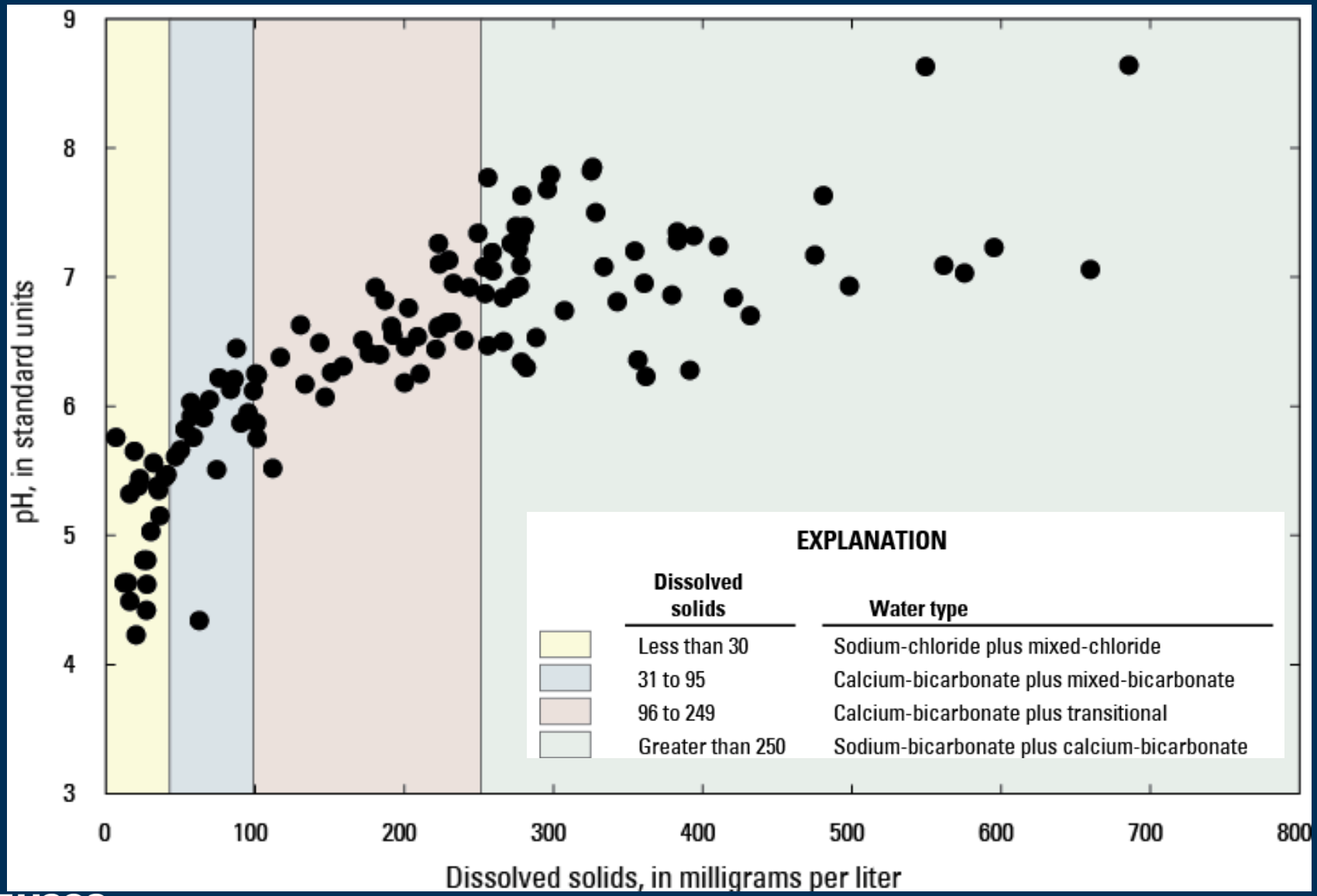
# Western Interior Plains – pH vs Dissolved Solids

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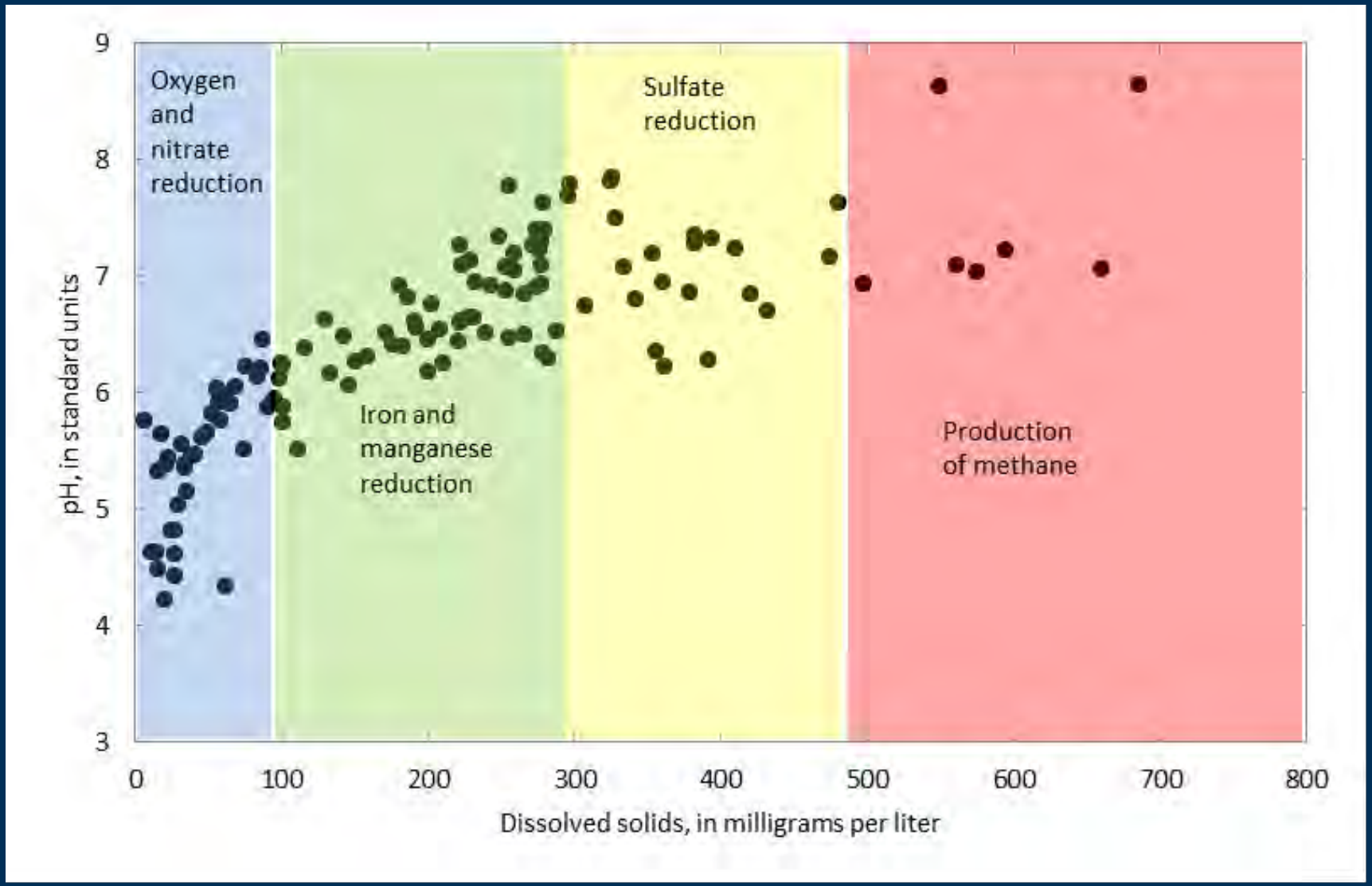
# Western Interior Plains – Redox Zonation

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# Springfield Plateau and Ozark Aquifers

- No relation of well depth to nitrate for either aquifer, which demonstrates the effects of karst features, mixing across zones, and numerous other physical attributes
- No relation of pH to dissolved solids or well depth; much carbonate dissolution within regolith zone
- Occurrence, distribution, and concentration of nitrate in groundwater directly related to percent agricultural land use
- Areas with higher density of sinkholes shown to increase vulnerability and nitrate concentrations
- Lower Ozark aquifer (Rubidoux-Gunter) high yields, but occurrence of elevated radium and fluoride prevent more extensive use

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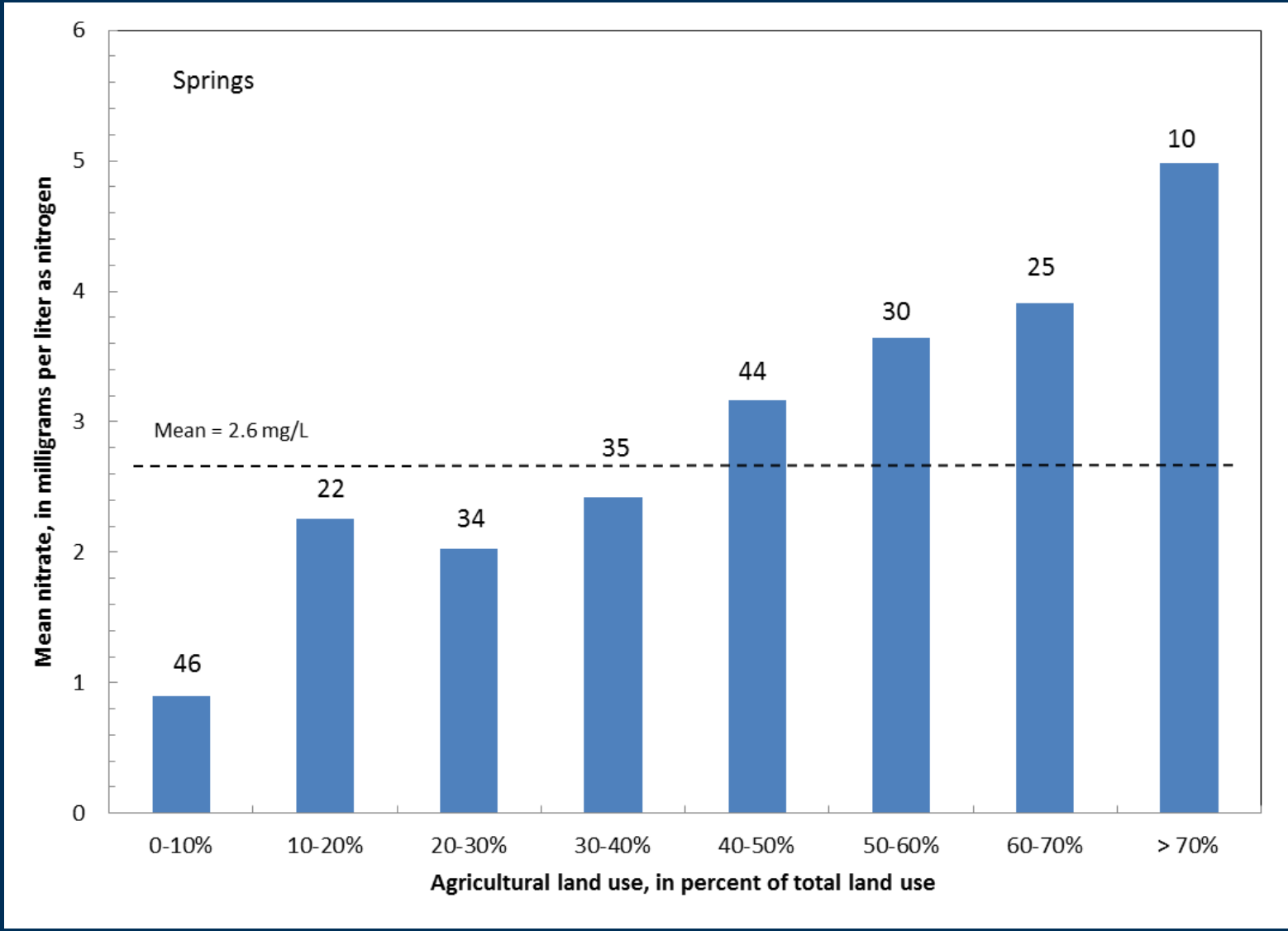
# Springfield Plateau Aquifer – $NO_3$ vs Ag Land Use

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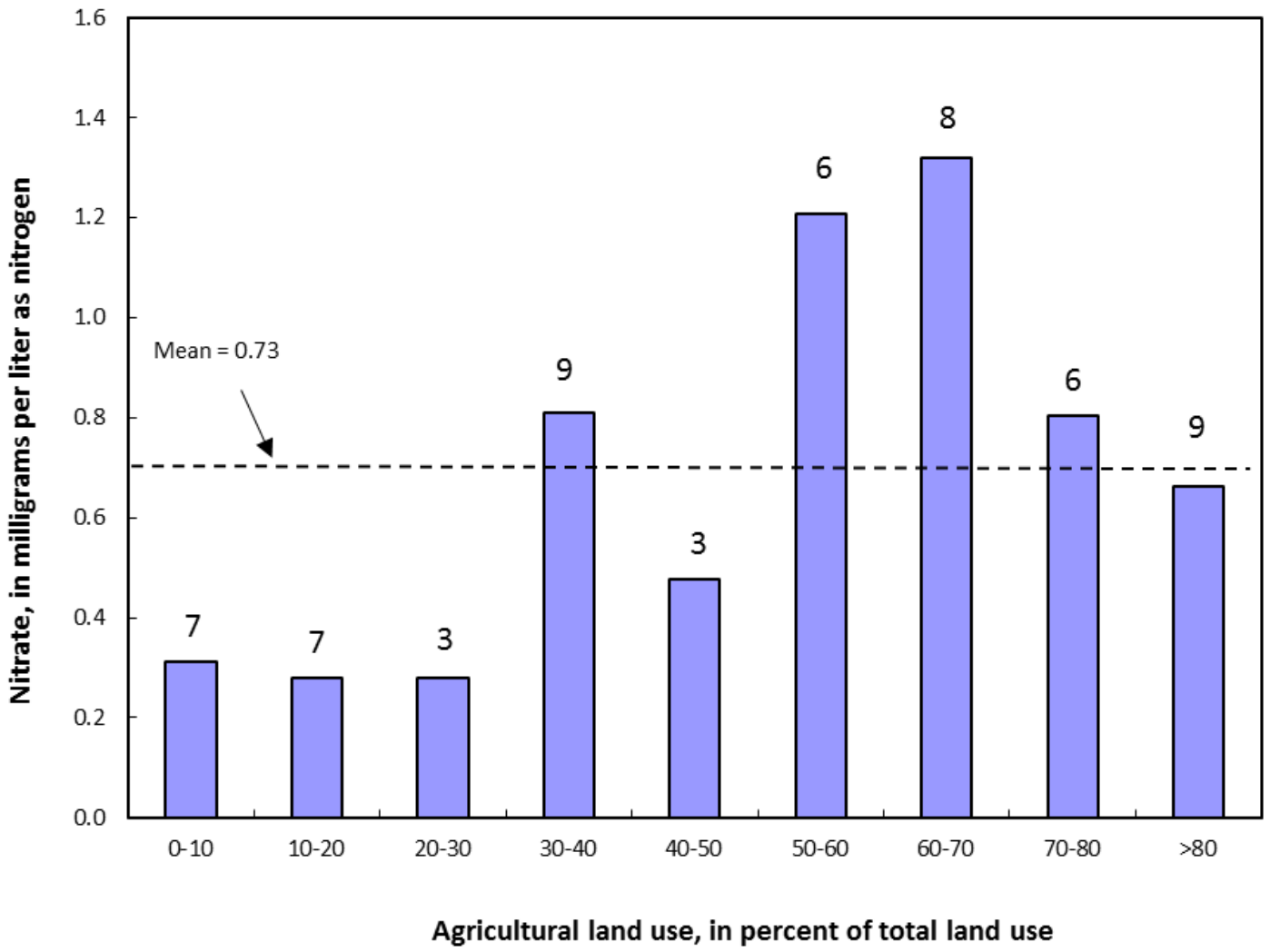
# Ozark Aquifer – $NO_3$ vs Ag Land Use

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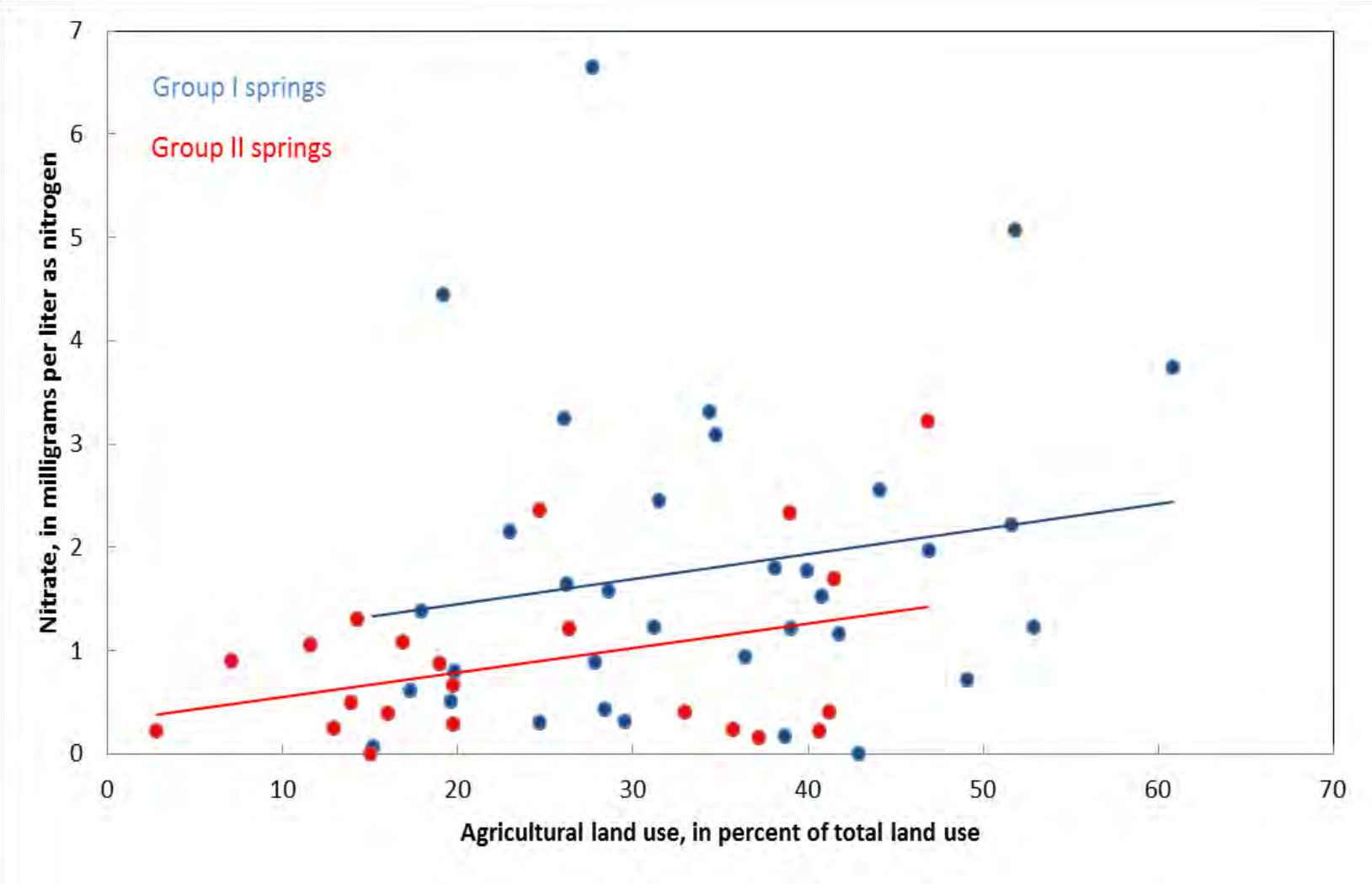
# Springfield Plateau Aquifer – Effects of Karst

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# SUMMARY

- Inventory of data reveals gaps in knowledge and gaps in database – prioritization of future needs
- Interpretive exercise provided new and important understanding of aquifer systems
  - Controls on evolution of geochemistry along flow paths
  - Differences in local and regional flow paths and resultant geochemistry between Coastal Plain and Interior Highlands
  - Relation of geochemistry to geomorphology in alluvial aquifer
  - Impact of Ag land use on distribution of elevated nitrate
  - Potential communication between Sp Plateau and Ozark aquifers
  - Effects of karst features on influx of surface contaminants
- Data from this project has shown long-term benefits from a healthy GW quality monitoring program

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