Long-Term Water-Quality Constituent Concentrations, Loads, & Trends in the Little Arkansas River, South-Central Kansas, 1995–2021

Prepared in cooperation with the city of Wichita

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

M.L. Stone & B.J. Klager
Governor's Conference on the Future of Water in Kansas
November 17, 2022

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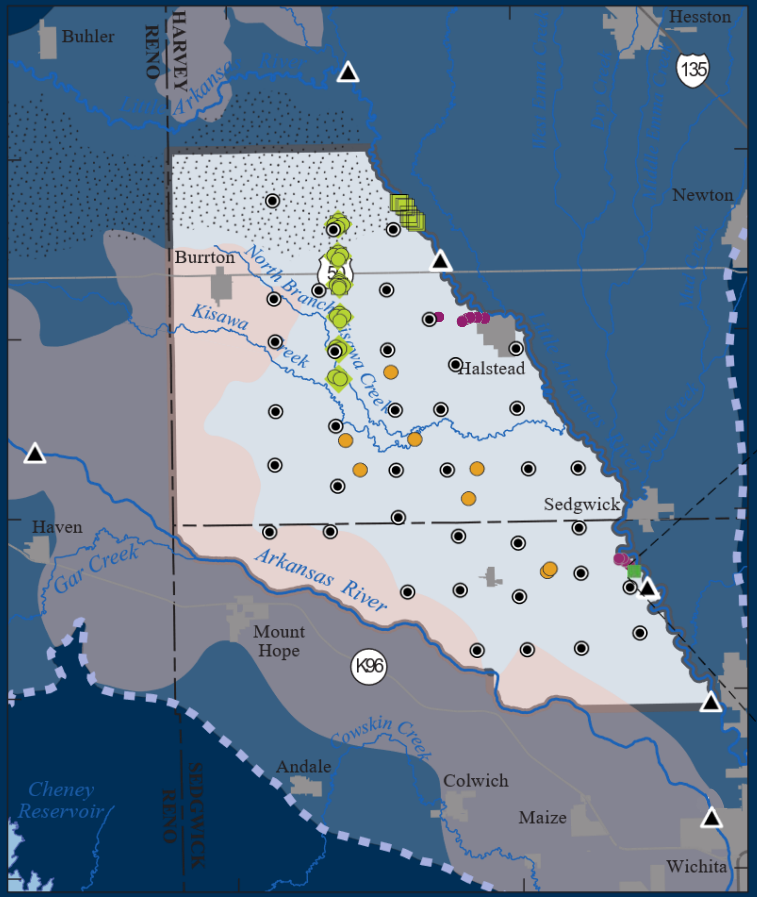
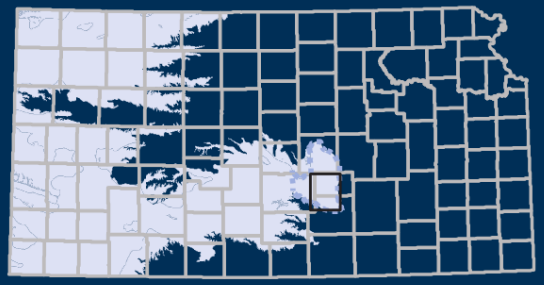
Study Area & Project Background: *Equus* Beds Aquifer ASR





Equus Beds aquifer ASR project history & sites.

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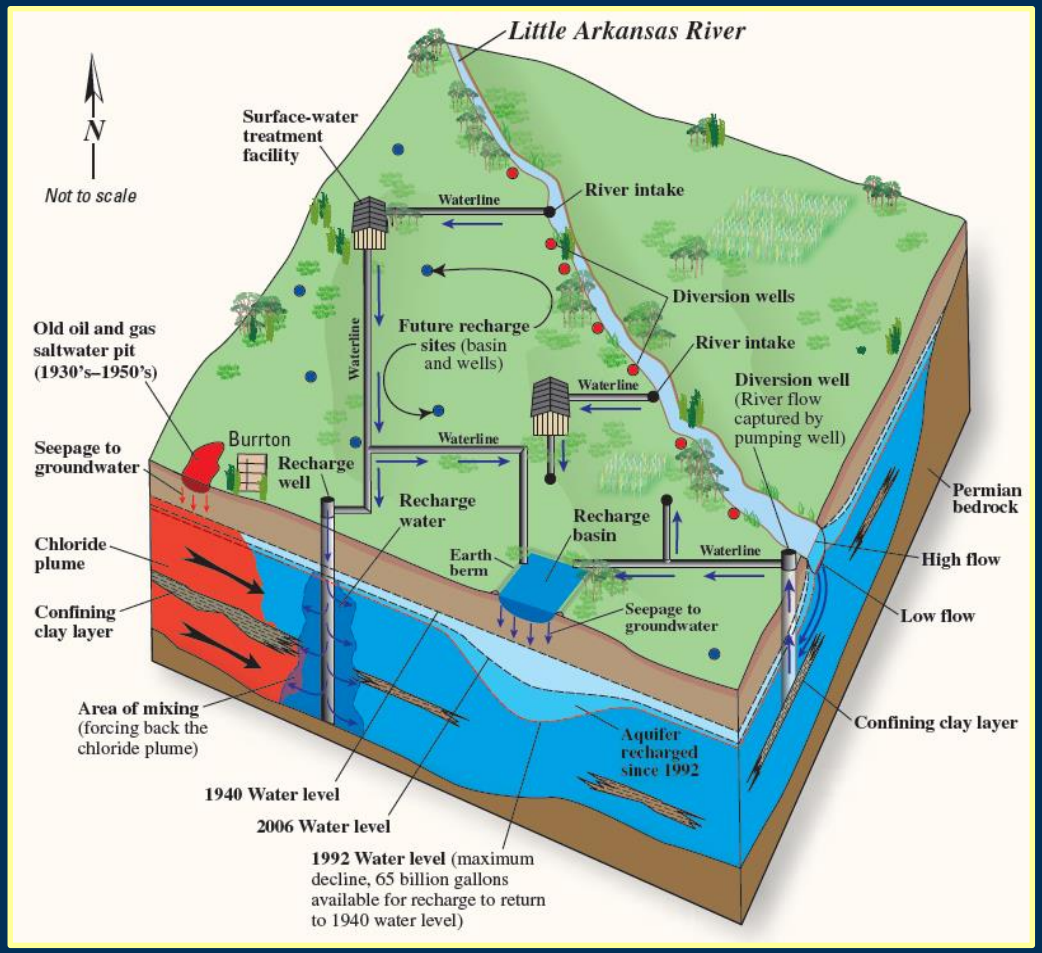
Study Area & Project Background: Previous Study Highlights



Equus Beds aquifer ASR schematic (Ziegler and others, 2010).

- Aquifer chloride plume moving about 1 ft/d
  - Klager & others (2014)
- Aquifer nitrate, chloride, & arsenic concentrations commonly exceed criteria
  - Ziegler & others (2010)
  - Tappa & others (2015)
  - Stone & others (2019)
- ASR Phase II activity study showed that changes in aquifer & river water quality largely governed by hydrology & were not persistent
  - Stone & others (2016)
- Long-term continuous water-quality dataset
  - Surface- & groundwater monitoring
  - 1998-present (2022)
- Surrogate relations for water-quality constituents of interest
  - Stone and Klager (2022)
  - Available at the National Real-Time Water Quality Network: nrtwq.usgs.gov

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Current Study Efforts: Purpose & Objectives

Little Arkansas River & ASR Phase II intake structure near Upstream ASR site.

- Quantify and characterize Little Arkansas River water quality
- Develop additional surrogate relations for water-quality constituents of interest
- Compute continuous concentrations & loads for water-quality constituents of interest
- Compare computed water-quality concentrations to relevant criteria
- Evaluate long-term water-quality trends

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Study Area & Sites: Little Arkansas River Watershed

- **Agricultural land use**
- **TMDLs**
  - nutrients
  - sediment
  - fecal coliform bacteria
  - total suspended solids
  - total phosphorus
  - atrazine
- **Little Ark R. study sites**
  - Nr Halstead "Hwy 50" (07143672)
  - "Upstream ASR" Fac (375350097262800)
  - Nr "Sedgwick" (07144100)

Location of study sites, watersheds, and land use.

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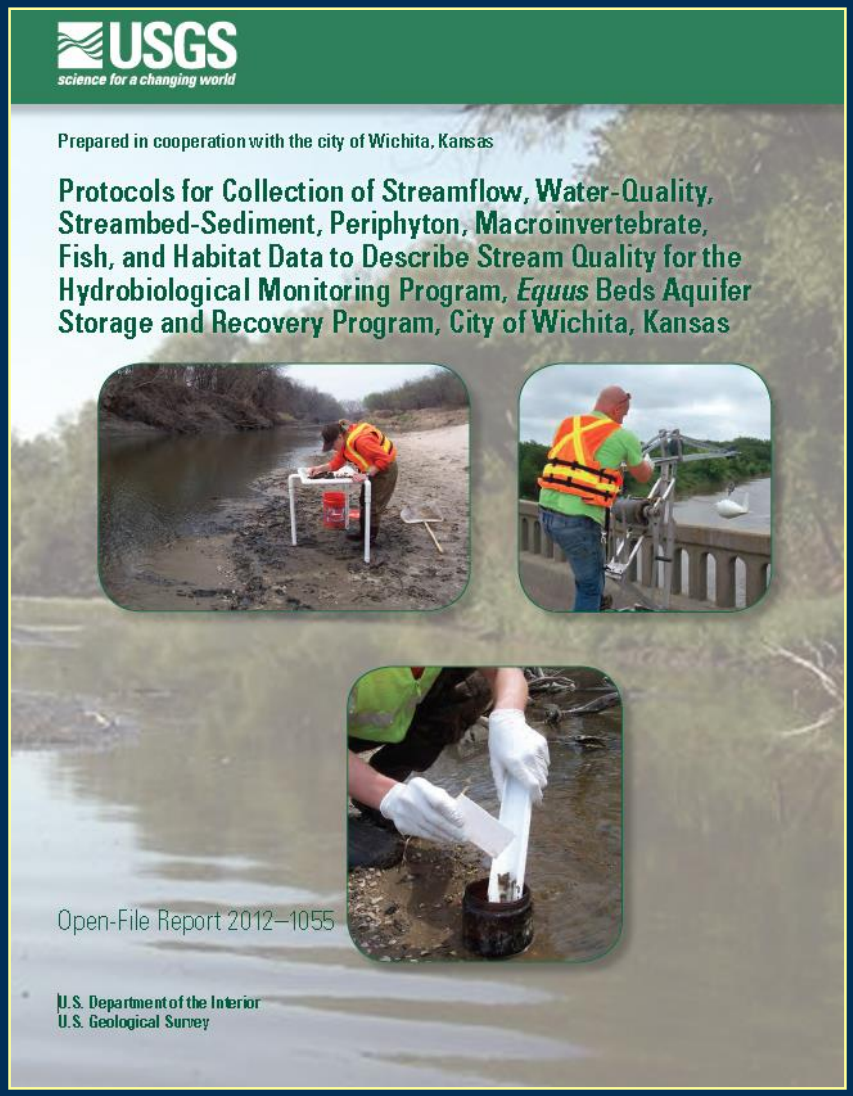
Data Collection: Little Arkansas River, 1995-2021

- Continuous streamflow (since 1993)
- Continuous water quality (since 1998)
  - Water temperature
  - pH
  - Specific conductance
  - Dissolved oxygen
  - Turbidity
  - fDOM
  - Nitrate plus nitrite
- Discrete water quality (since 1995)
  - Primary ions
  - Nutrient & carbon species
  - Sediment
  - Pesticides
- Data available at the USGS National Water Information System (NWIS) database: *waterdata.usgs.gov/nwis*



Stone & others (2012)

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In-situ water quality monitor & sampling.

Data Analysis: Little Arkansas River Surrogate Models

- Relation between continuous & discrete data
- Data available at National Real-Time Water Quality

  https://nrtwq.usgs.gov/ks/
- Stone & Klager (2022)
  - Ions
  - Nutrients & carbon
  - Sediment
  - Bacteria
- New & updated models
  - Bromide
  - Atrazine
- Long-term computed concentrations & loads

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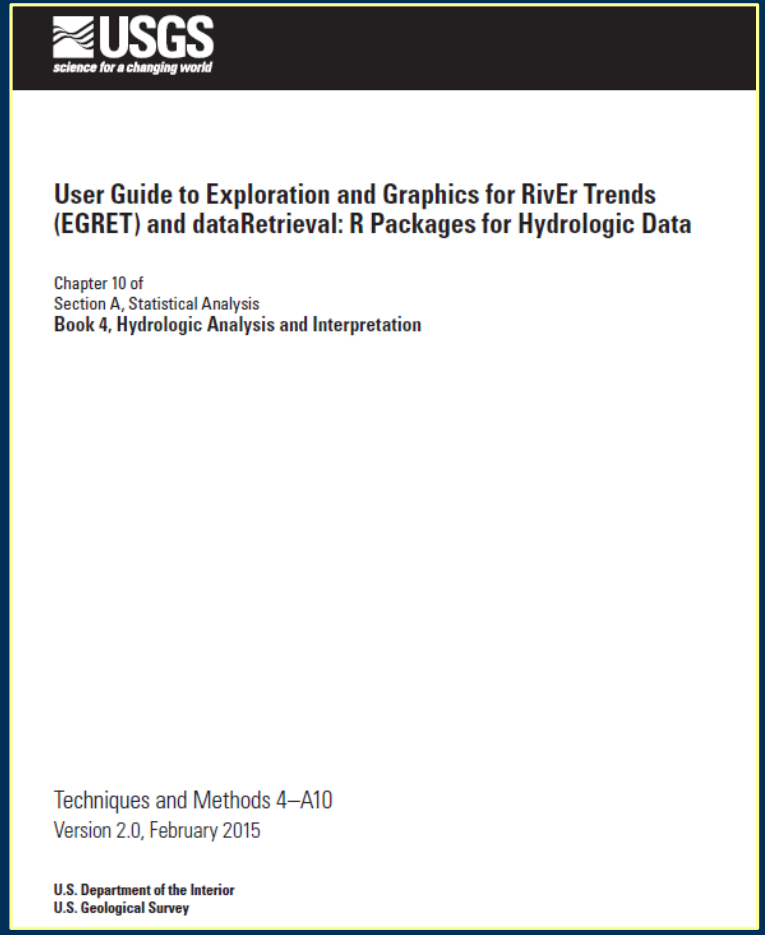
Data Analysis: Little Arkansas River Trends, 1995-2021

- EGRET (Exploration & Graphics of RivEr Trends)
- WRTDS (Weighted Regressions on Time, Discharge, & Season)
- WBT (WRTDS Bootstrap Test; Hirsch and others, 2015)

  Assigns trend likelihood & descriptors:

Trend probability	Upward trend descriptors	Downward trend descriptors
≥ 0.95 and ≤1.0	Highly likely	Highly unlikely
≥0.90 and <0.95	Very likely	Very unlikely
≥0.66 and <0.90	Likely	Unlikely
>0.33 and <0.66	About as likely as not	About as likely as not
>0.1 and ≤0.33	Unlikely	Likely
>0.05 and ≤0.1	Very unlikely	Very likely
≥0 and ≤0.05	Highly unlikely	Highly likely

Hirsch & others (2015)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User Guide to Exploration and Graphics for RivEr Trends (EGRET) and dataRetrieval: R Packages for Hydrologic Data

Chapter 10 of
Section A, Statistical Analysis
Book 4, Hydrologic Analysis and Interpretation

Techniques and Methods 4–A10
Version 2.0, February 2015

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

Hirsch & De Cicco (2015)

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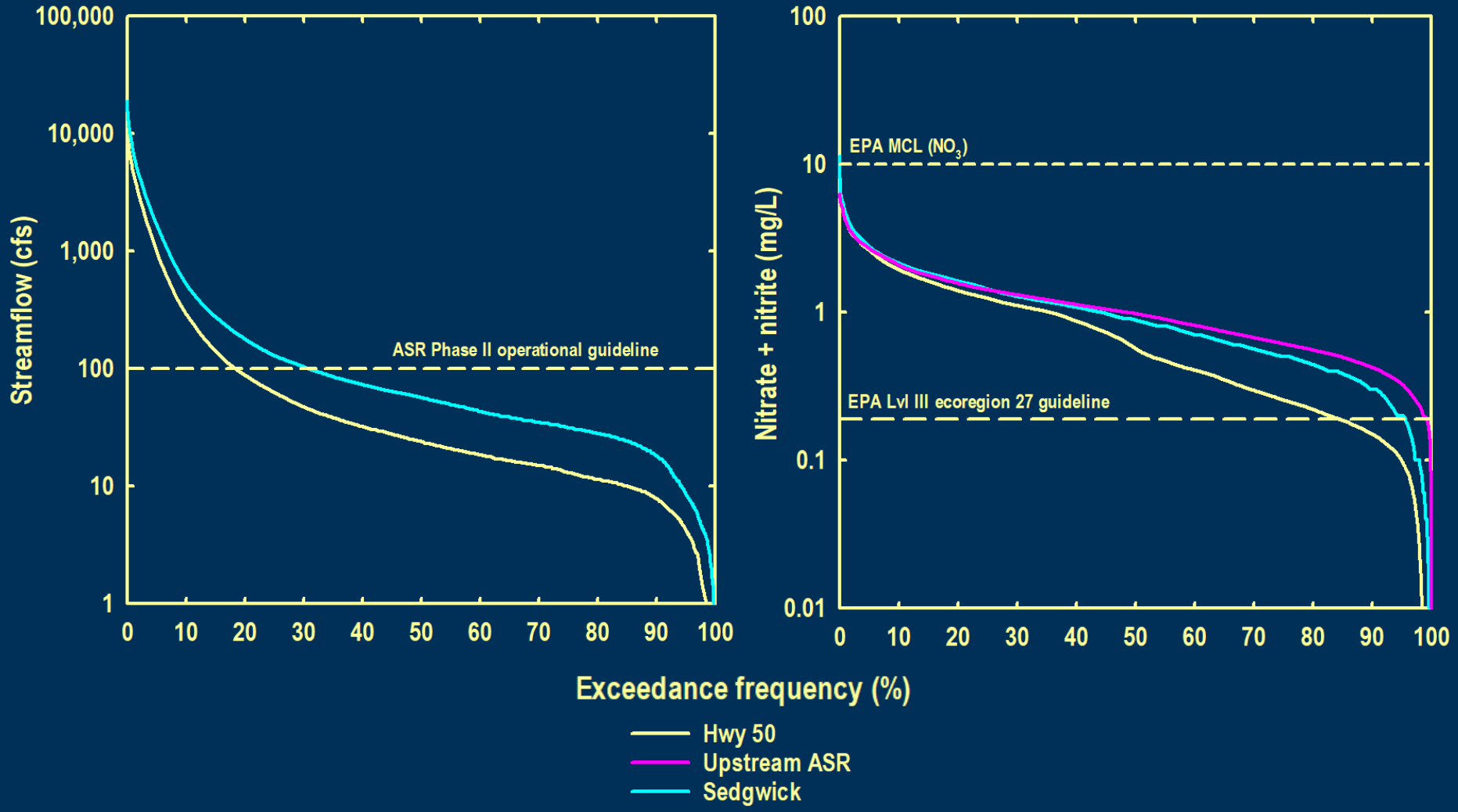
Results: Little Arkansas River Continuous Streamflow (1995-2021) & Nitrate (2012-2021)



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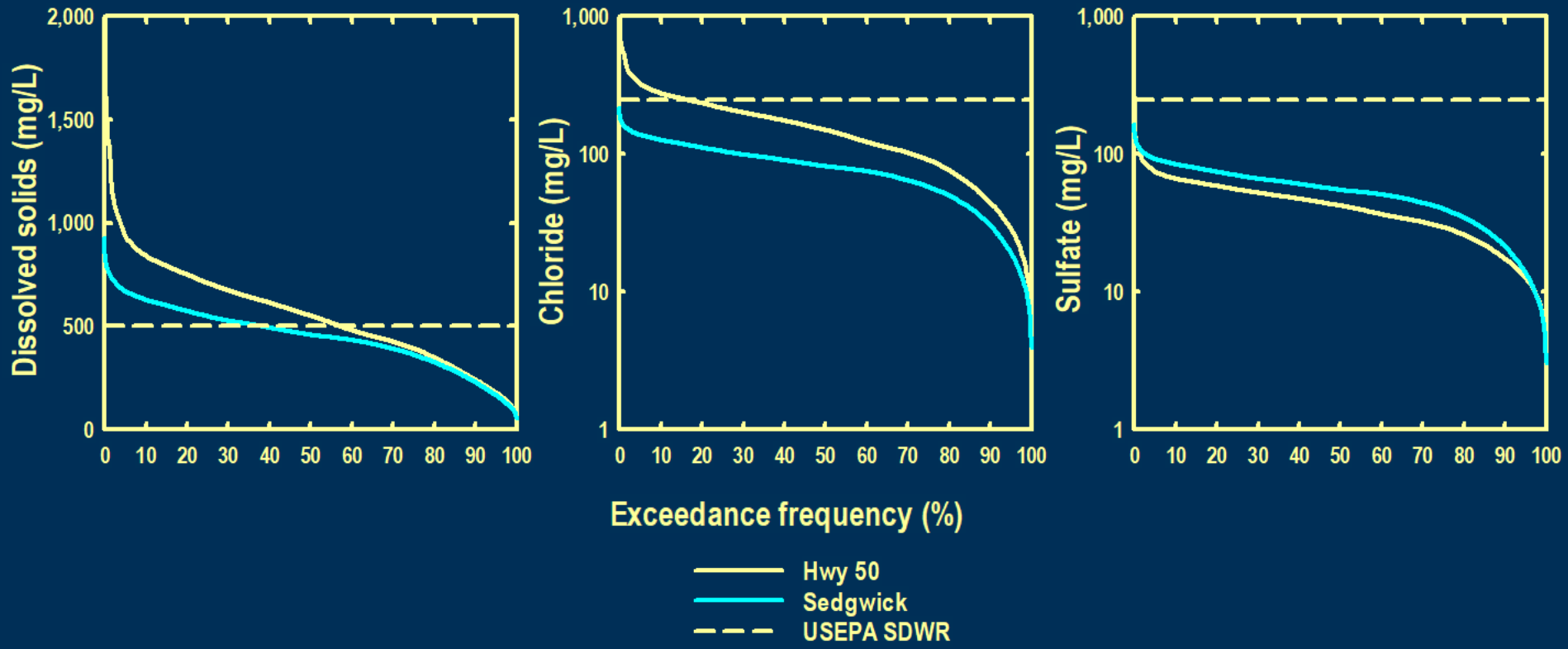
Results: Little Arkansas River
Continuously Computed Ions 1998-2021



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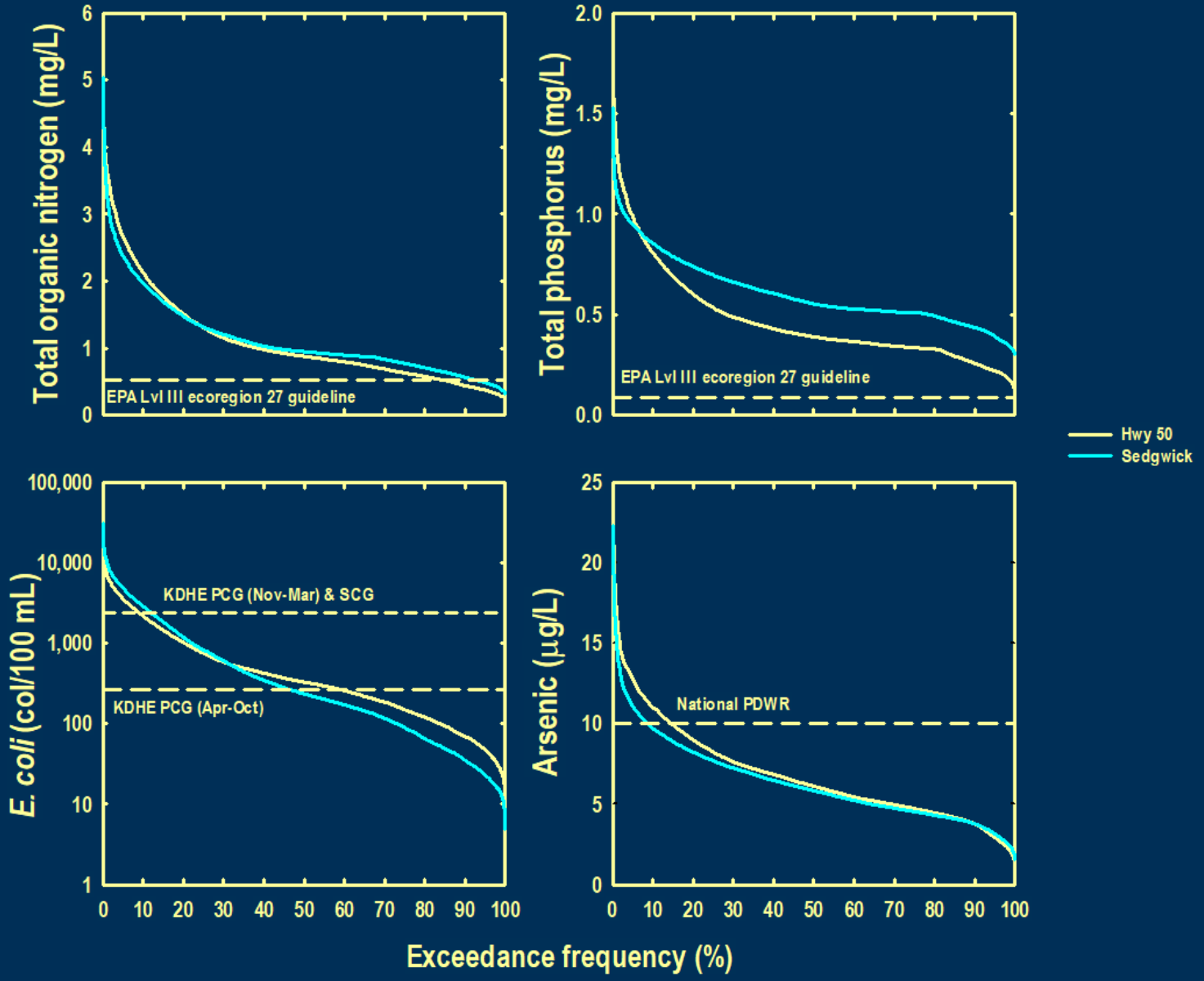
Results: Little Arkansas River Continuously Computed Nutrients, Bacteria, & Arsenic 1998-2021



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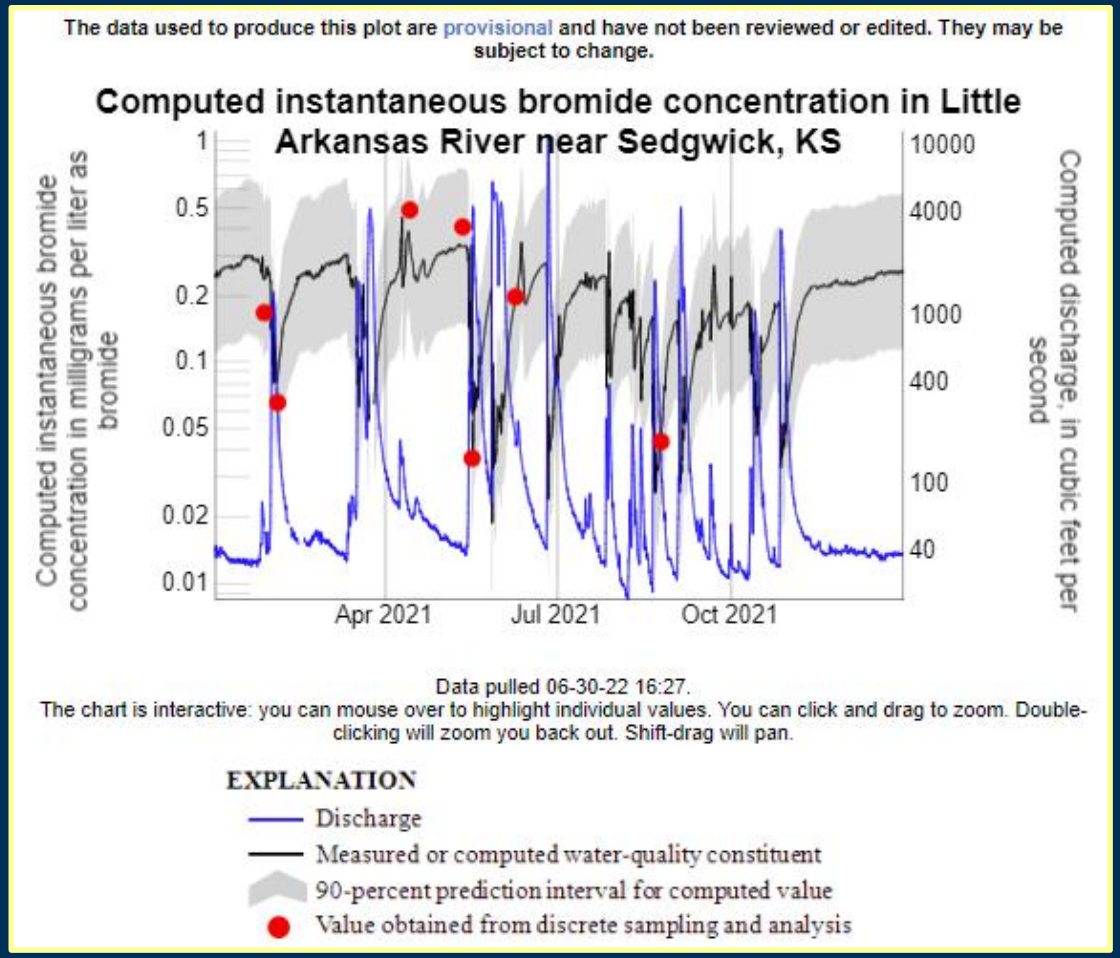
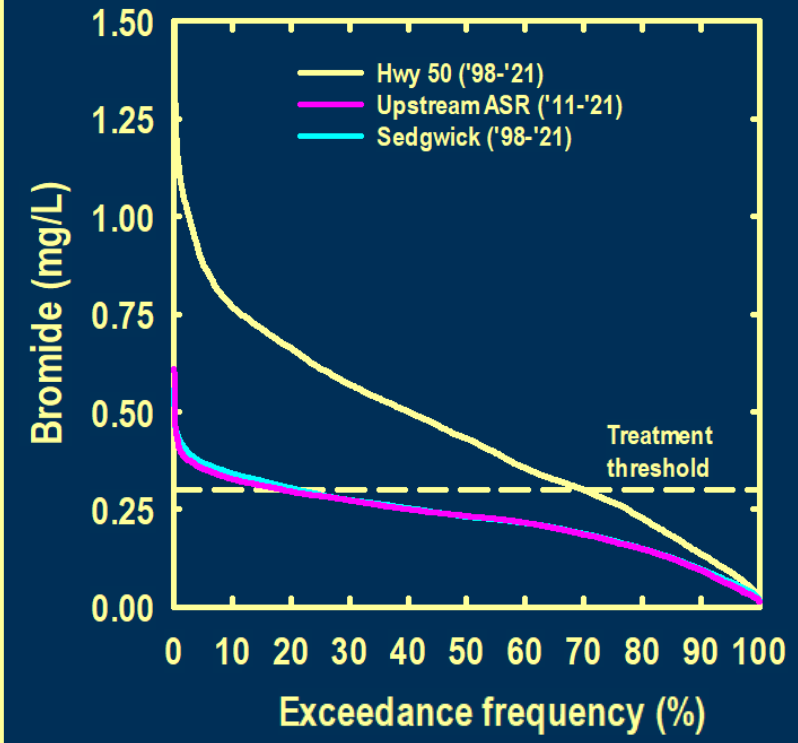
Results: Little Arkansas River Continuously Computed Bromide





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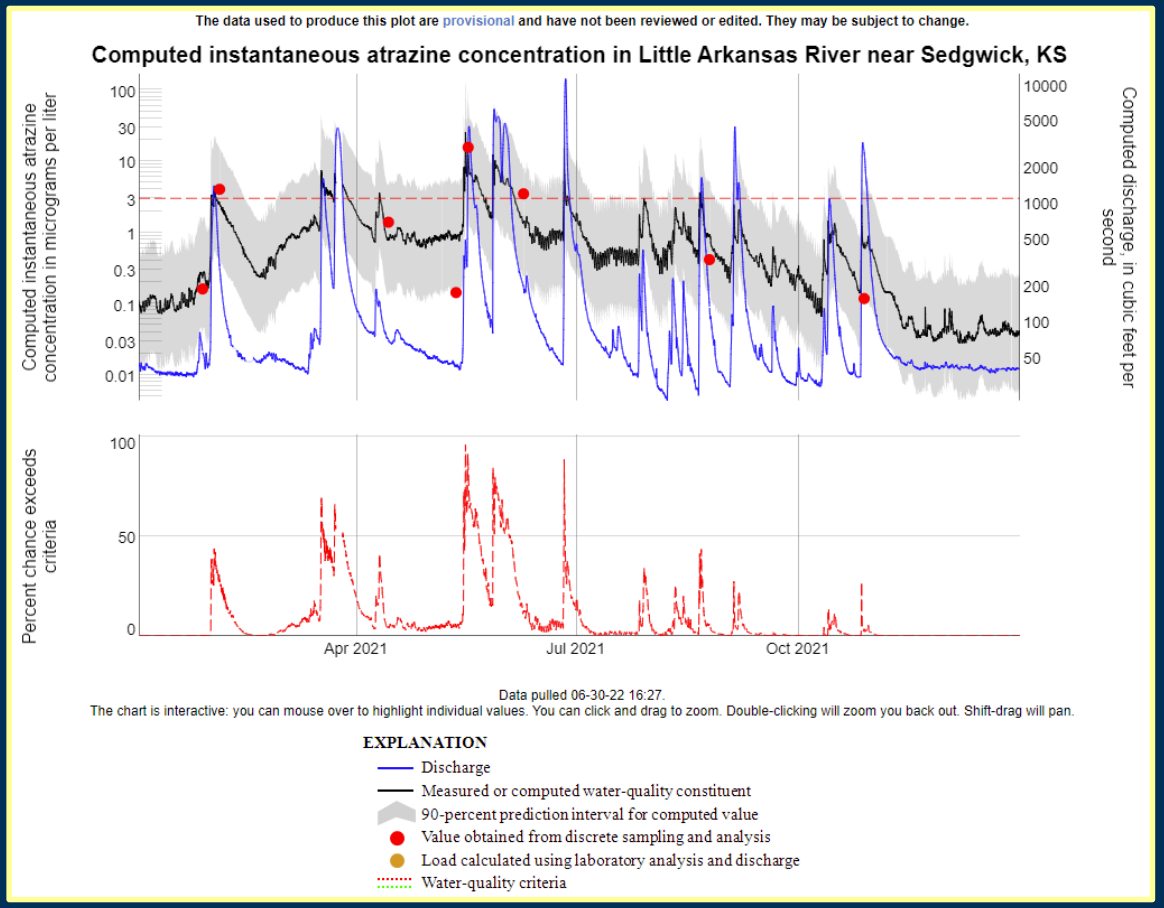
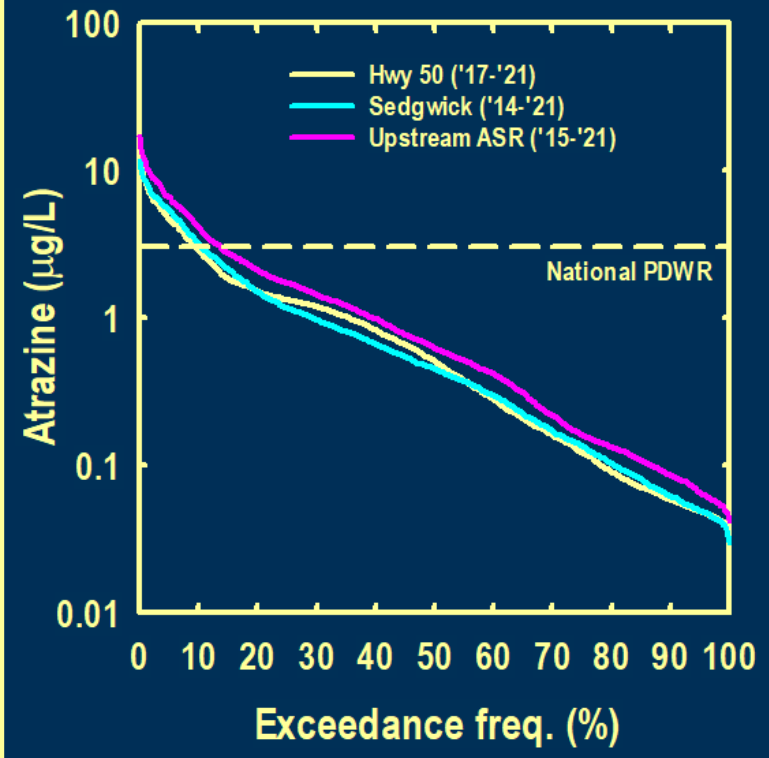
Results: Little Arkansas River Continuously Computed Atrazine





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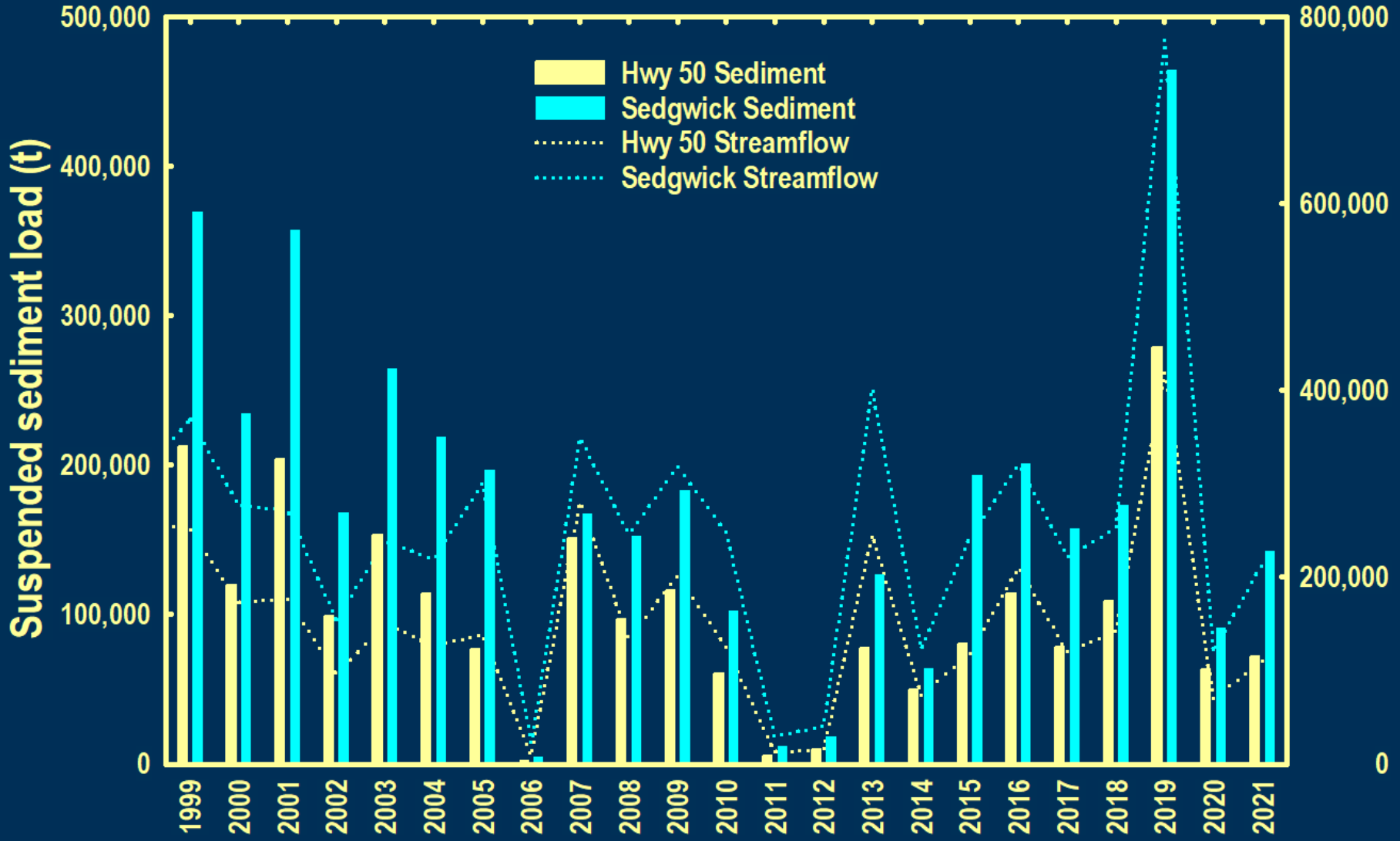
Results: Little Arkansas River Suspended Sediment Concentration Load



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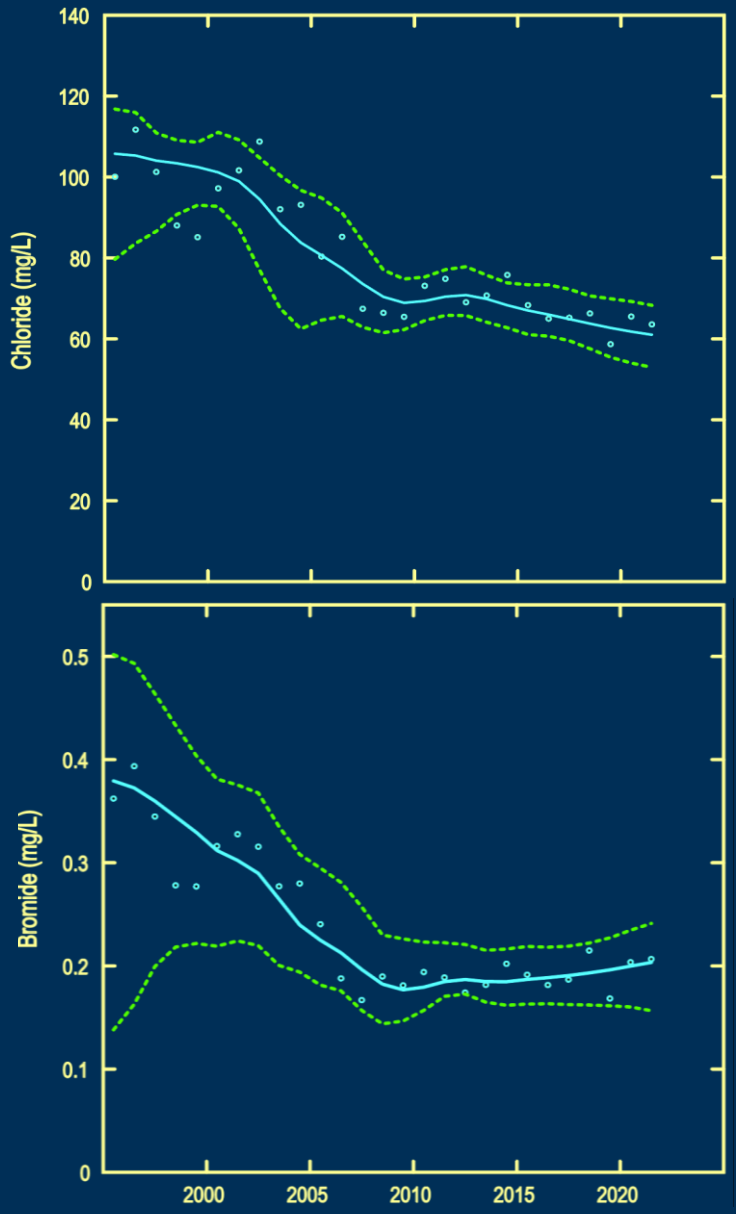
Results: Little Arkansas River (Sedgwick) Long-Term Trends



Chloride:

Frequency that flow-normalized concentration is trending down in bootstrap replicates: 0.98

downward trend highly likely

1995 flow-normalized: 106 mg/L

2021 flow-normalized: 61 mg/L

Trend magnitude: 43% decrease

Bromide:

Frequency that flow-normalized concentration is trending down in bootstrap replicates: 0.77

downward trend likely

1995 flow-normalized: 0.38 mg/L

2021 flow-normalized: 0.20 mg/L

Trend magnitude: 45% decrease

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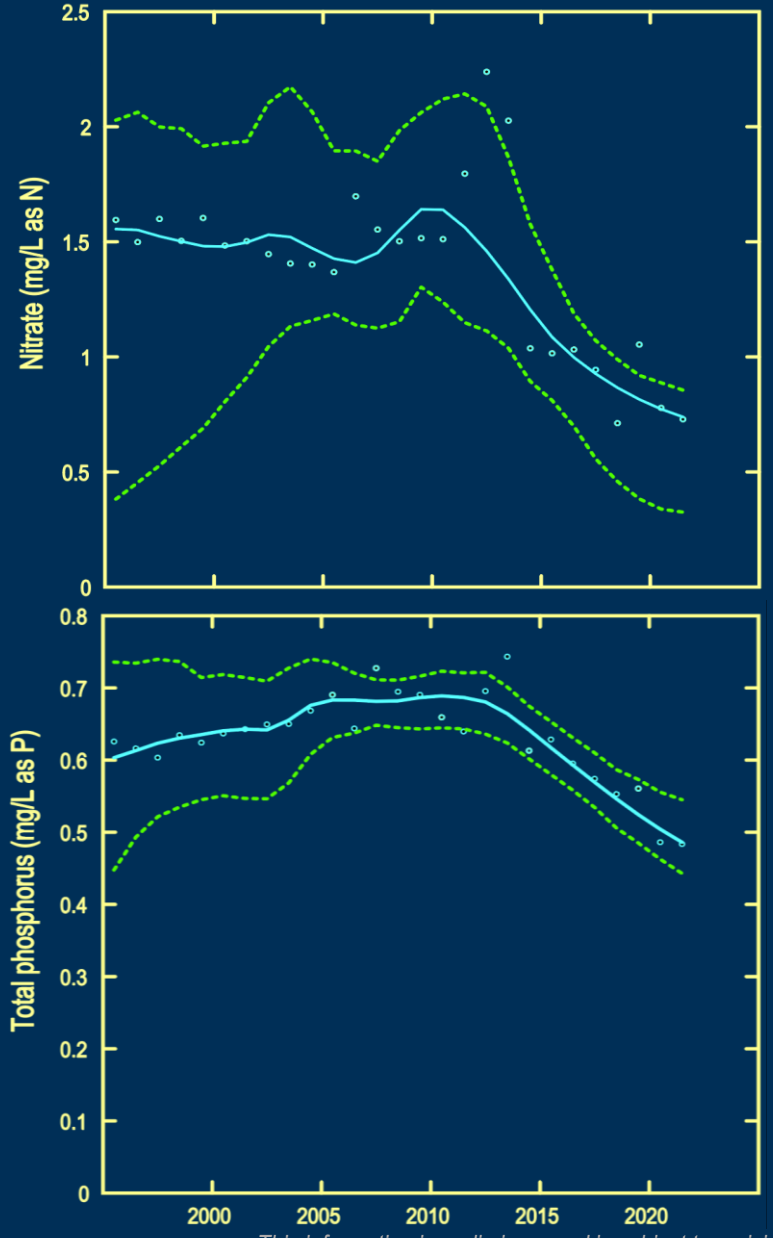
Results: Little Arkansas River (Sedgwick) Long-Term Trends



Nitrate:

Frequency that flow-normalized concentration is trending down in bootstrap replicates: 0.82

downward trend likely

1995 flow-normalized: 1.6 mg/L

2021 flow-normalized: 0.74 mg/L

Trend magnitude: 52% decrease

Total Phosphorus:

Frequency that flow-normalized concentration is trending down in bootstrap replicates: 0.81

downward trend likely

1995 flow-normalized: 0.38 mg/L

2021 flow-normalized: 0.20 mg/L

Trend magnitude: 20% decrease

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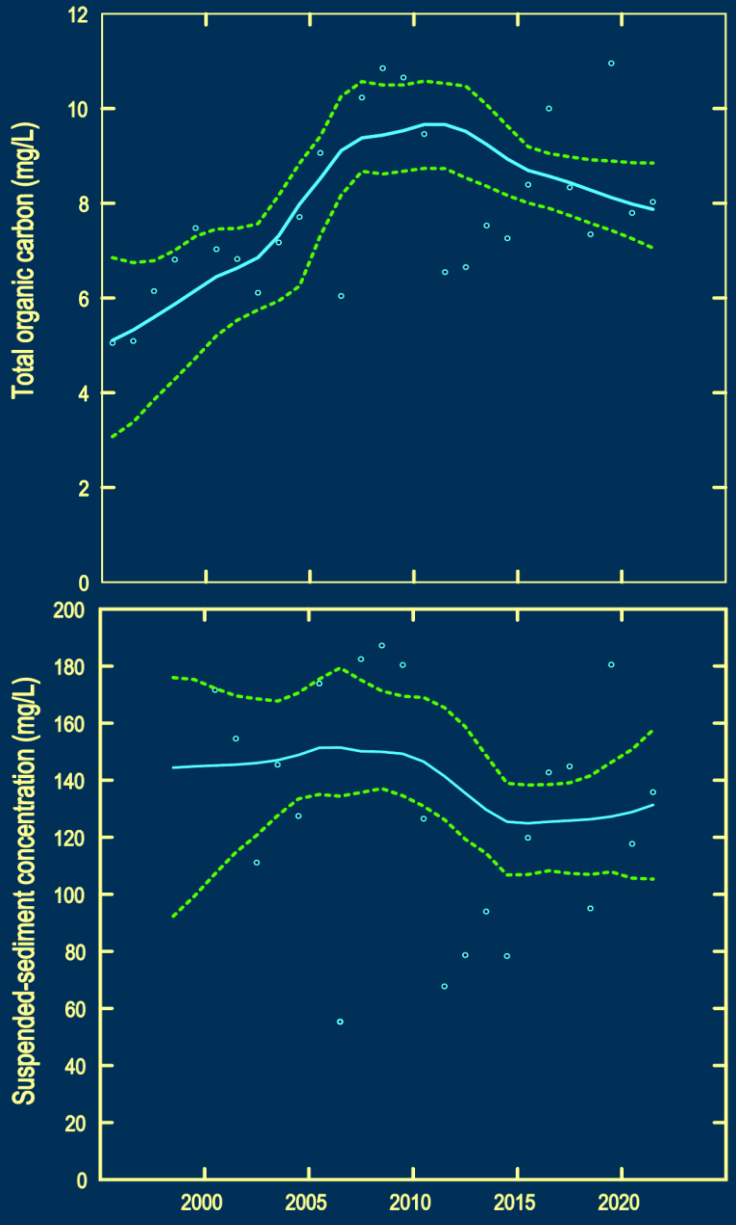
Results: Little Arkansas River (Sedgwick) Long-Term Trends



Total organic carbon:

Frequency that flow-normalized concentration is trending up in bootstrap replicates: 0.99

- ***upward trend is highly likely***
- **1995 flow-normalized: 5.1 mg/L**
- **2021 flow-normalized: 7.9 mg/L**
- **Trend magnitude: 52% increase**

Suspended sediment:

Frequency that flow-normalized concentration is trending down in bootstrap replicates: 0.53

- ***downward trend is about as likely as not***
- **1998 flow-normalized: 144 mg/L**
- **2021 flow-normalized: 131 mg/L**
- **Trend magnitude: 7% decrease**

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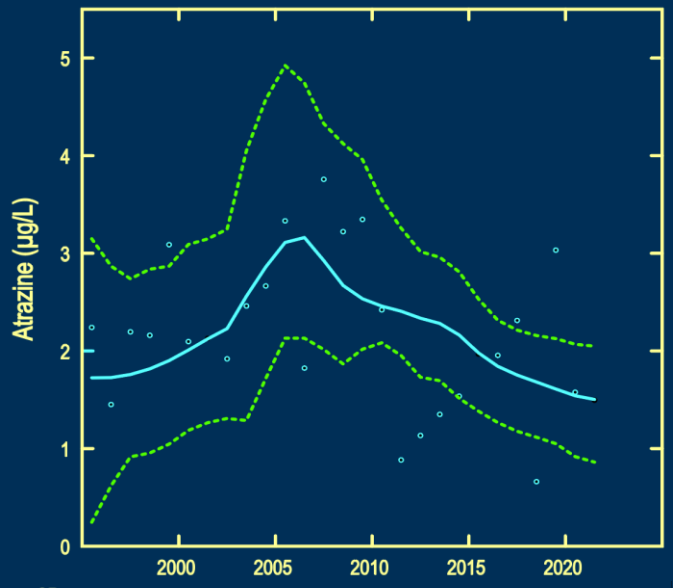
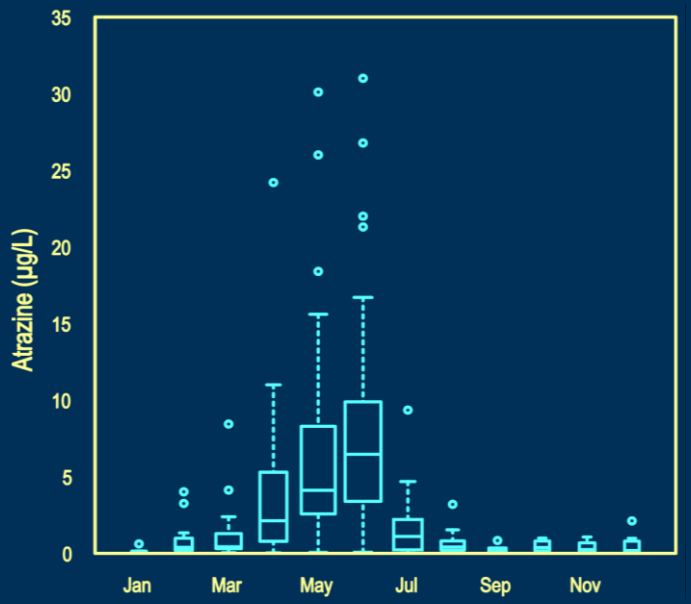
Results: Little Arkansas River (Sedgwick) Long-Term Trends



Atrazine:

Frequency that flow-normalized concentration is trending down in bootstrap replicates: 0.72

- *downward trend is likely*
- **1995 flow-normalized: 1.7 mg/L**
- **2021 flow-normalized: 1.5 mg/L**
- **Trend magnitude: 13% decrease**



Seasonality

Trend exploration with seawaveQ

- **Ryberg and York (2020)**

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National Water Quality Program

seawaveQ—An R Package Providing a Model and Utilities for Analyzing Trends in Chemical Concentrations in Streams with a Seasonal Wave (seawave) and Adjustment for Streamflow (Q) and Other Ancillary Variables, Version 2.0.0

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USGS National Water Quality Network: *nrtwq.usgs.gov/nwqn*

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Tracking Water Quality in U.S. Streams and Rivers

USGS National Water Quality Network Data, Water-Quality Loads, and Trends

The USGS National Water Quality Network (NWQN) consists of 110 stream and river sites with long-term, consistent information on streamflow and water-quality conditions. Data are collected to assess the status and trends of water-quality conditions at large inland and coastal river sites, as well as in small streams indicative of urban, agricultural, and reference conditions. These data can be useful to local, regional, or national-scale studies related to multiple topics, including drinking water-quality, chemical fate and transport, and harmful algal blooms. In addition to site-specific information provided through the map below or the NWQN site list, additional pages are provided that display maps of water-quality trends at a national scale, quantify water-quality loading to the Gulf of Mexico in support of goals of the Mississippi River/Gulf of Mexico Hypoxia Task Force, and display trends in water-quality in the Delaware River Basin. This website provides details on NWQN operations, access to data collected at NWQN sites, and graphs that display how water-quality conditions are changing through time. In addition to the 110 sites funded through the NWQN, this webpage also hosts information on water-quality conditions at 36 sites with sufficient data operated by USGS Water Science Centers through Cooperative Matching Funds. More information on network objectives, data collection and reporting methods, and sites can be accessed via links below. Input on NWQN site, data, and on how data are presented on this Web site helps us improve NWQN operations and data presentation. Please take a few minutes to provide information on how you are using NWQN data and suggestions for improving the network and Web site.

Network information

- NWQN site list
- National maps of water-quality trends
- Network objectives and scope
- Methods and glossary
- Previous network information
- Stakeholder feedback form

Water-quality loading to the Gulf of Mexico

- Trends in annual water-quality loads to the Gulf of Mexico through 2021
- Monthly nutrient loads used to estimate the size of the Gulf Hypoxic Zone (Preliminary Estimates)

Water-quality trends in the Delaware River Basin

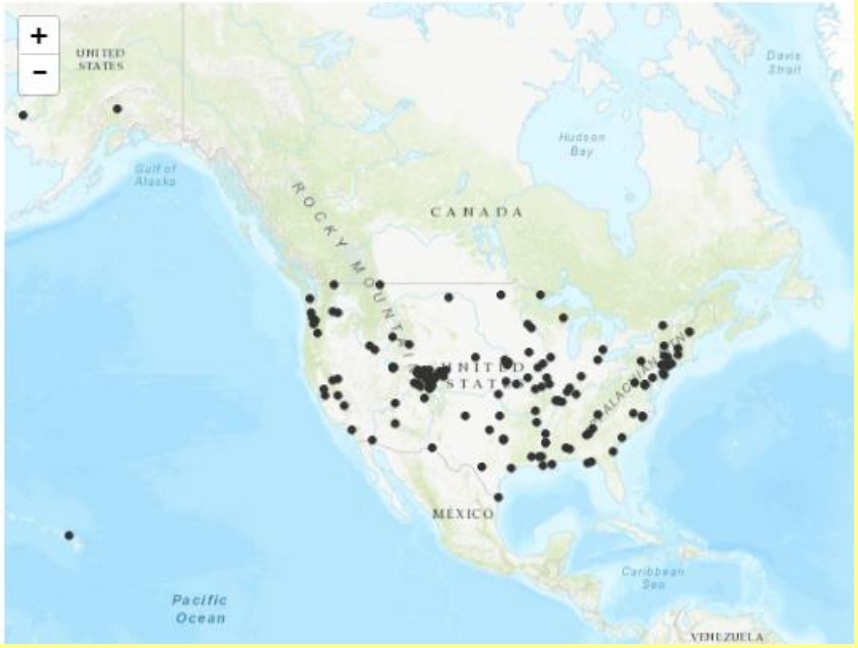
Download data

- All published NWQN data
- Data from sites in the Mississipppi/Atchafalaya River Basin

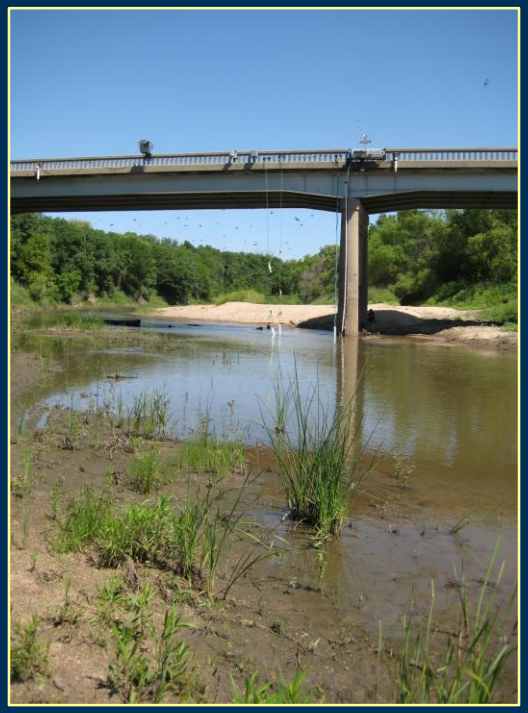
Related USGS Links

- Tracking Progress: Long-term Trends in Stream and River Quality
- Nutrient Sources and Transport in the Mississippi River Basin--SPARROW Nutrient Mapper
- Water Quality Watch - Real-time water-quality data
- USGS National Water Information System

Hover on a circle and click on the site name to get site-specific information



Preliminary Conclusions: Little Arkansas River Long-Term Data Collection, 1995-2021



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https://www.usgs.gov/centers/kswsc/science

- Specific conductance best predicted primary ions, including chloride & bromide
- Turbidity best predicted unfiltered nutrients, carbon, sediment, & pesticides
- Chloride, bromide, nitrate, total phosphorus, & atrazine concentrations had downward trends
- Total organic carbon concentrations had an upward trend
- Sediment concentrations exhibited no trend
- Continuous monitoring measures changing conditions over time & provides critical information
- Future research efforts include analysis for pesticide trends & during targeted flow conditions to assess drivers

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