Estimating Nutrient and Bacteria Concentrations in Kansas Streams with Real-Time Water-Quality Monitoring

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What Is a Surrogate?

- A surrogate is a sensor measurement that can be used in place of a constituent of greater interest.
  - In real time
  - Continuous
  - More sensor measures available

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Objectives of Real-Time Water-Quality Monitoring

- Continuously measure constituents of concern
- More accurately estimate constituent concentrations and loads
- Provide regulatory agencies & water suppliers information
- Optimize timing of sample collection

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Approach

- Upgrade USGS stream gaging stations with water-quality monitors
- Collect manual samples over the range in hydrologic conditions
- Develop regression equations using collected samples and sensor values
- Estimate concentrations and loads from continuous data and equations

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Real-time, Continuous Water-Quality Monitor

- **pH**
- **Water Temperature**
- **Dissolved Oxygen**
- **Specific Conductance**
- **Turbidity**
- **Fluorescence**

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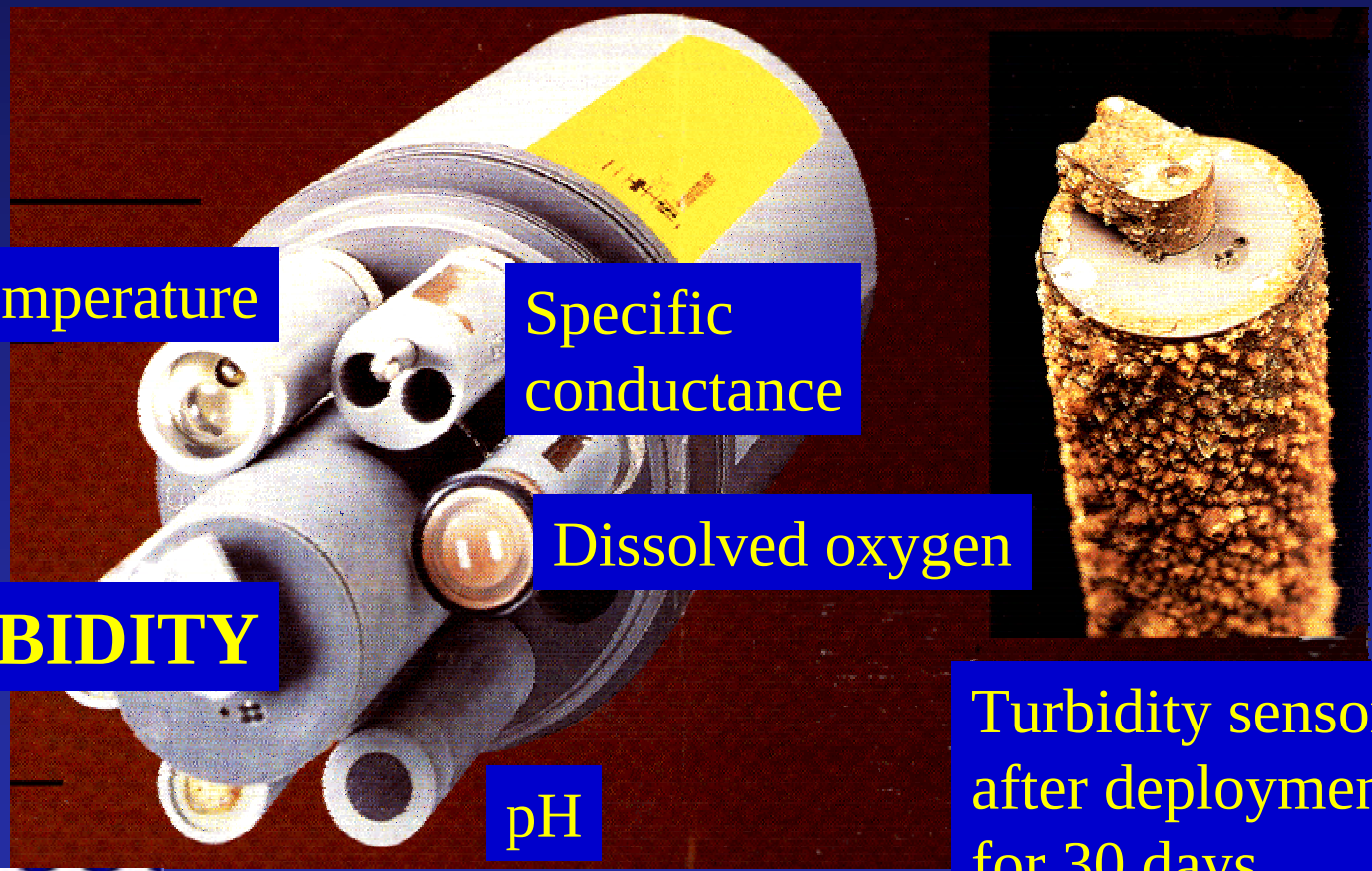
YSI Sonde



Turbidity sensor after deployment for 30 days

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Surrogate used to Predict

Specific Conductance	**Chloride, alkalinity, dissolved solids, sulfate, triazine**
Turbidity	**Total suspended solids, suspended sediment, fecal coliform, *E. coli*, total nitrogen, total phosphorus**
Fluorescence	**Chlorophyll-a,Taste and odor (Geosmin and MIB)**

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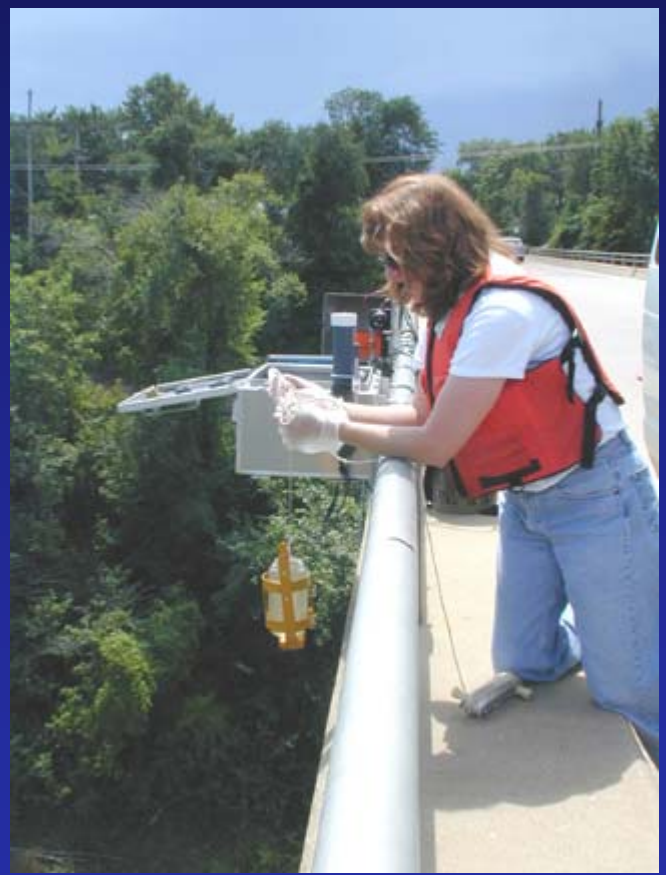
Collection of manual samples

- Collected throughout the range of expected hydrologic conditions
- Analyzed for chloride, sediment, bacteria, and other constituents
- Historical data may be used



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Problems with Conventional Water-Quality Monitoring

- Limited number of samples are collected annually
- Annual load estimates are based on a small finite number of samples
- Seasonal, diurnal, and event driven fluctuations are nearly always missed
- Costs of manual sampling and analysis

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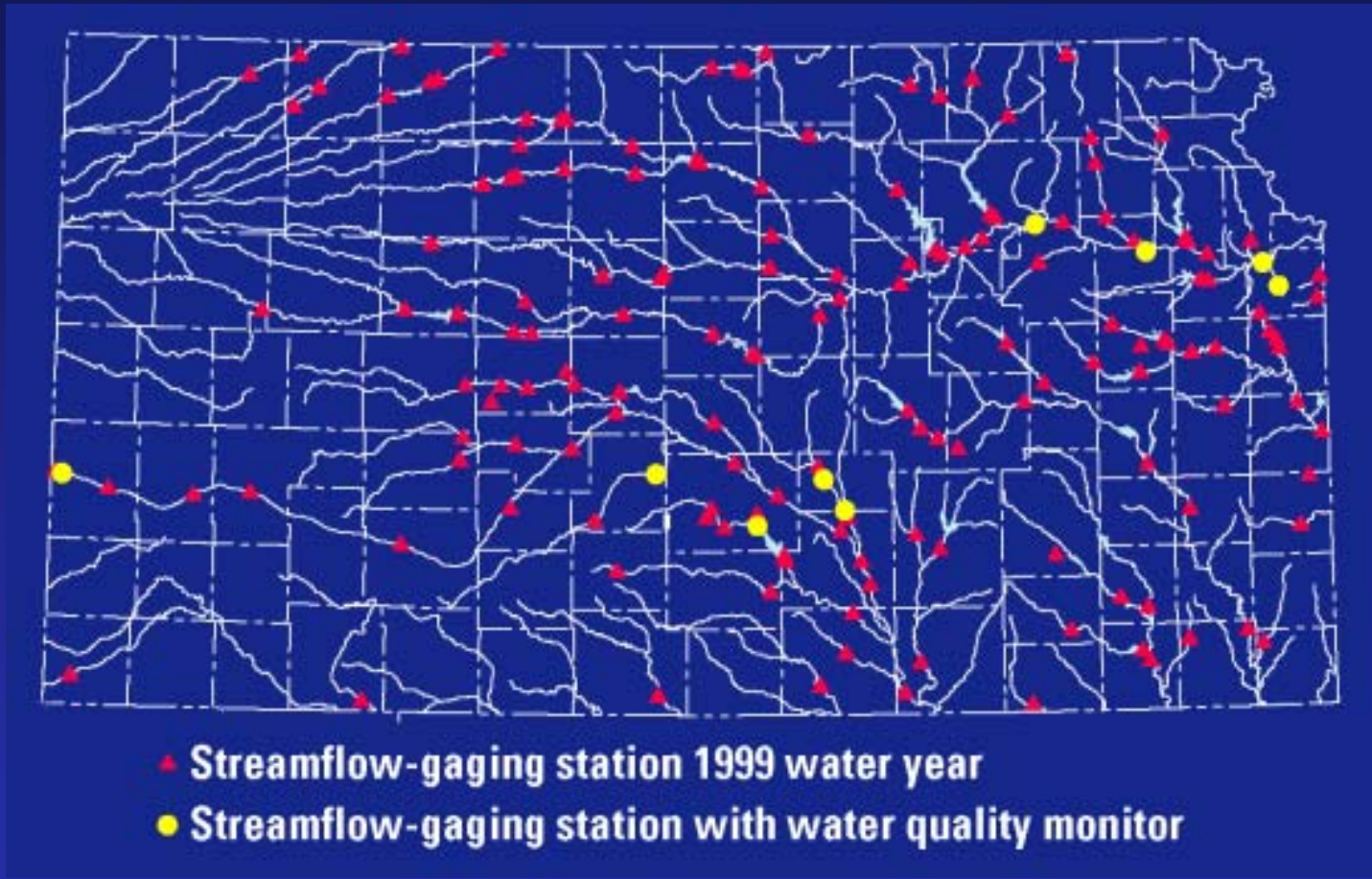
Streamflow-Gaging and Real-Time Water-Quality Stations in Kansas



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Real-Time Water-Quality Studies in Kansas

- **Quivira National Wildlife Refuge**
- **Kansas River Real-Time TMDL Network**
- **New Lake Olathe**
- **Equus Beds Ground-Water Recharge Project**

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Quivira National Wildlife Refuge

- U.S. Fish and Wildlife Service / GMD 5
- Alert USFWS to high constituent concentrations entering refuge
- Possibly divert when T&E species are present
- Establish TMDLs
- Establish baseline concentrations before hog CAFOs move into basin

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Kansas River Real-time Network

- In cooperation with Kansas Dept of Health and Environment (KDHE)
- Monitor TMDLs
- Alert downstream water suppliers
- Optimize sample collection frequency
- Fecal Coliform vs. E. Coli

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New Lake Olathe

- City of Olathe
- Determine nutrient loads to urban reservoir
- Taste and odor problems
- Chlorophyll sensors

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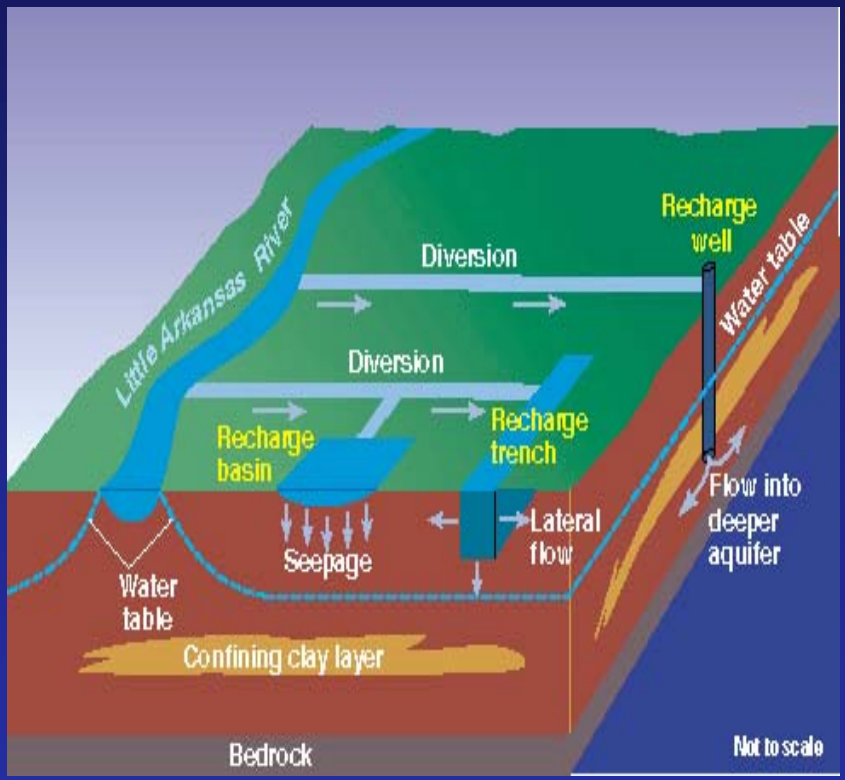
Equus Beds Ground Water Recharge Project – Little Arkansas River



- City of Wichita
- Increase drinking water supply
- Prevent salt-water intrusion into aquifer
- Development of TMDLs
- Real-time warning of high constituent concentrations

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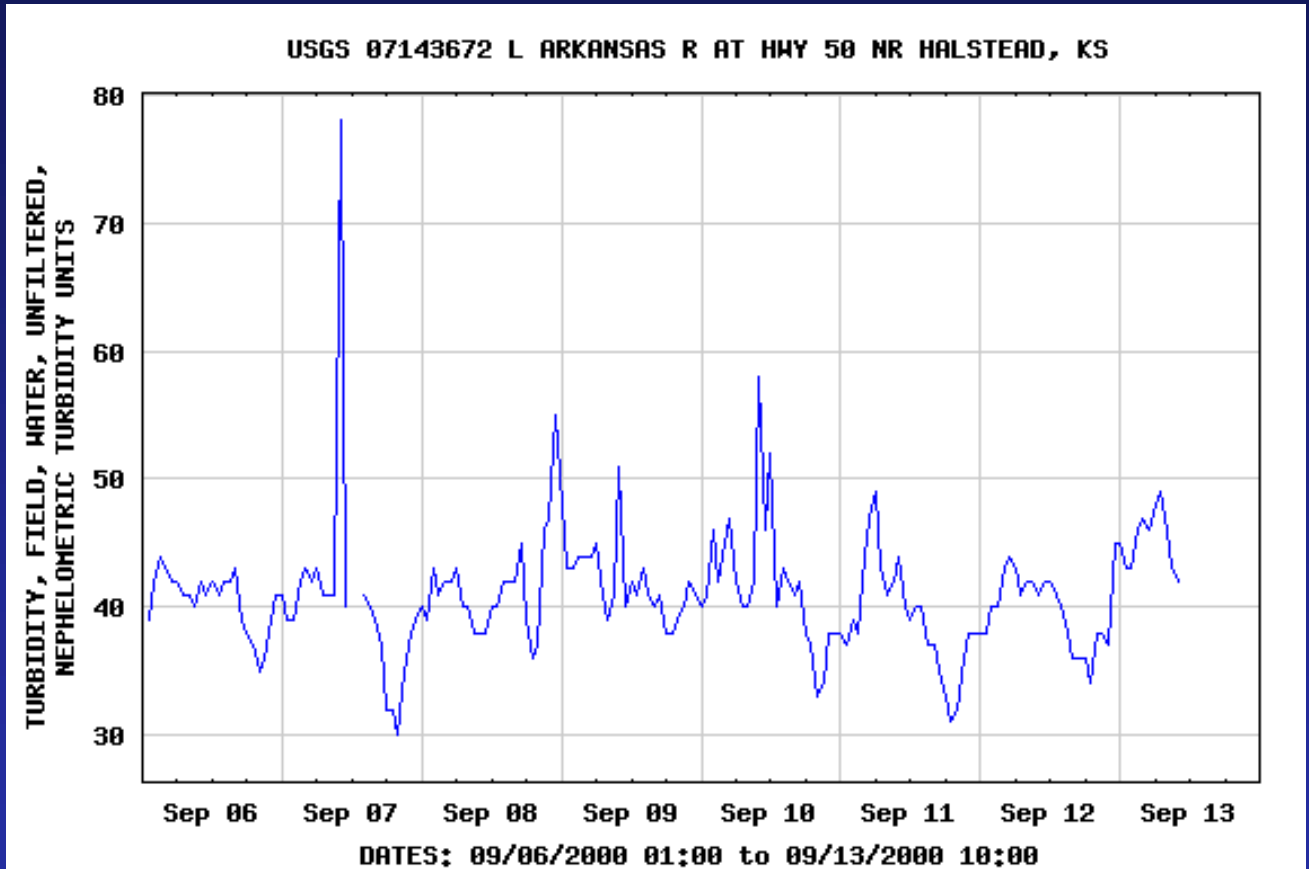
Real-time turbidity



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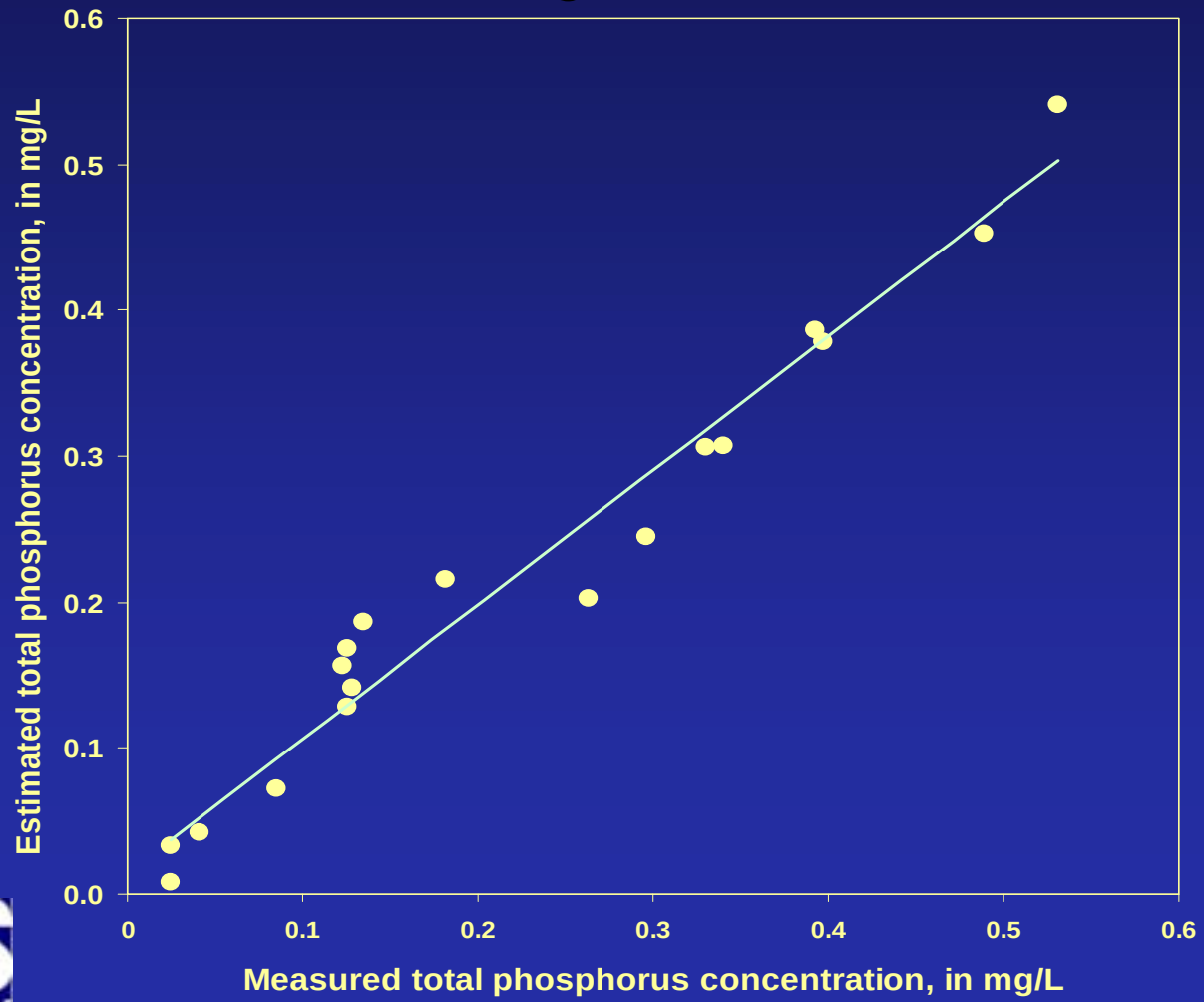
Estimated versus Measured Total Phosphorus Concentrations

$$TP = 0.00113\,NTU - 0.223\log_{10} SC + 0.00568\,WT + 0.754$$



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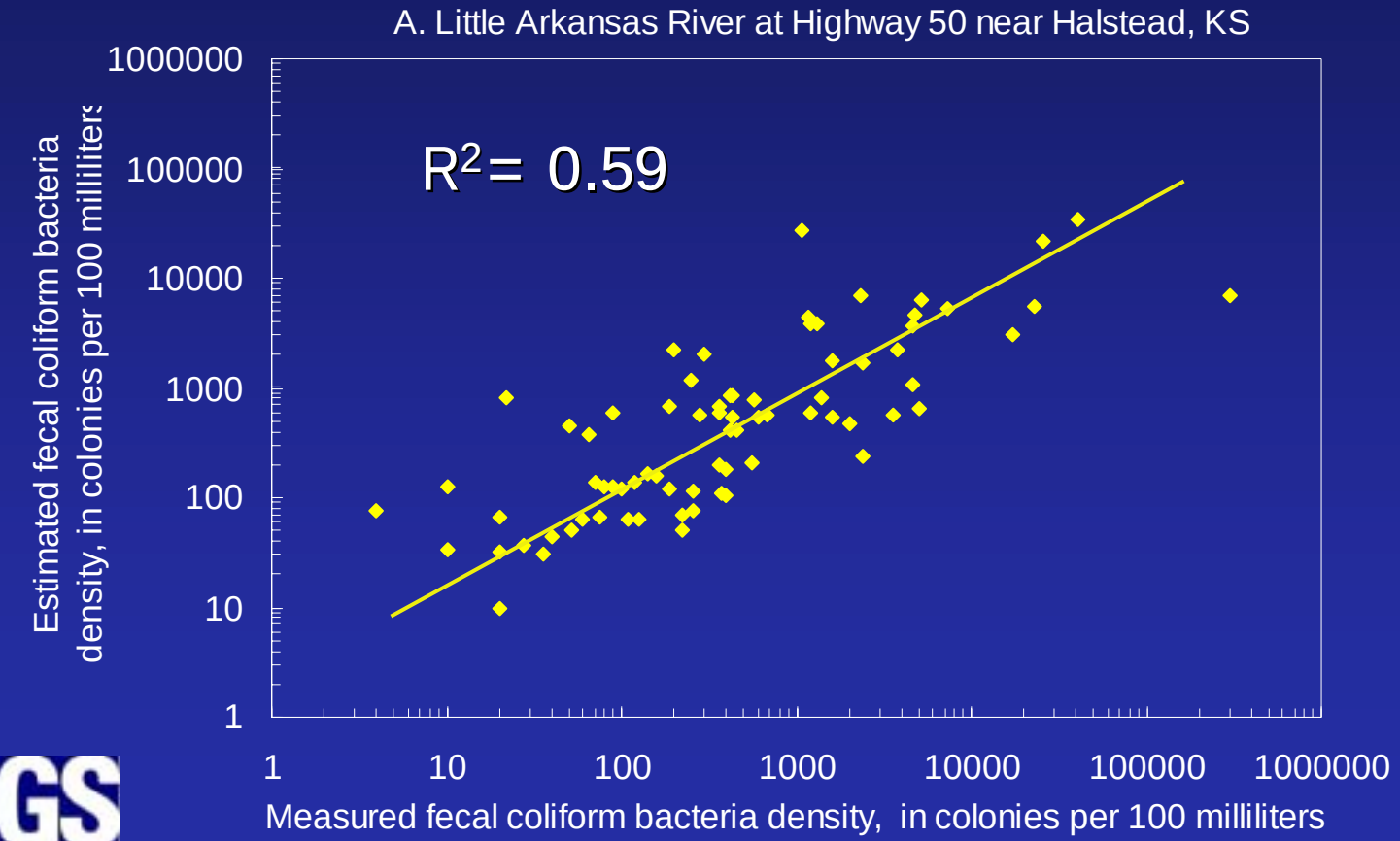
Instantaneous Measured vs. Estimated Bacterial Densities

$$\log_{10}(FCB) = -0.129\sin\left(2\pi\left(\frac{D}{365}\right)\right) - 0.325\cos\left(2\pi\left(\frac{D}{365}\right)\right) + 0.892\log_{10} NTU + 0.878$$



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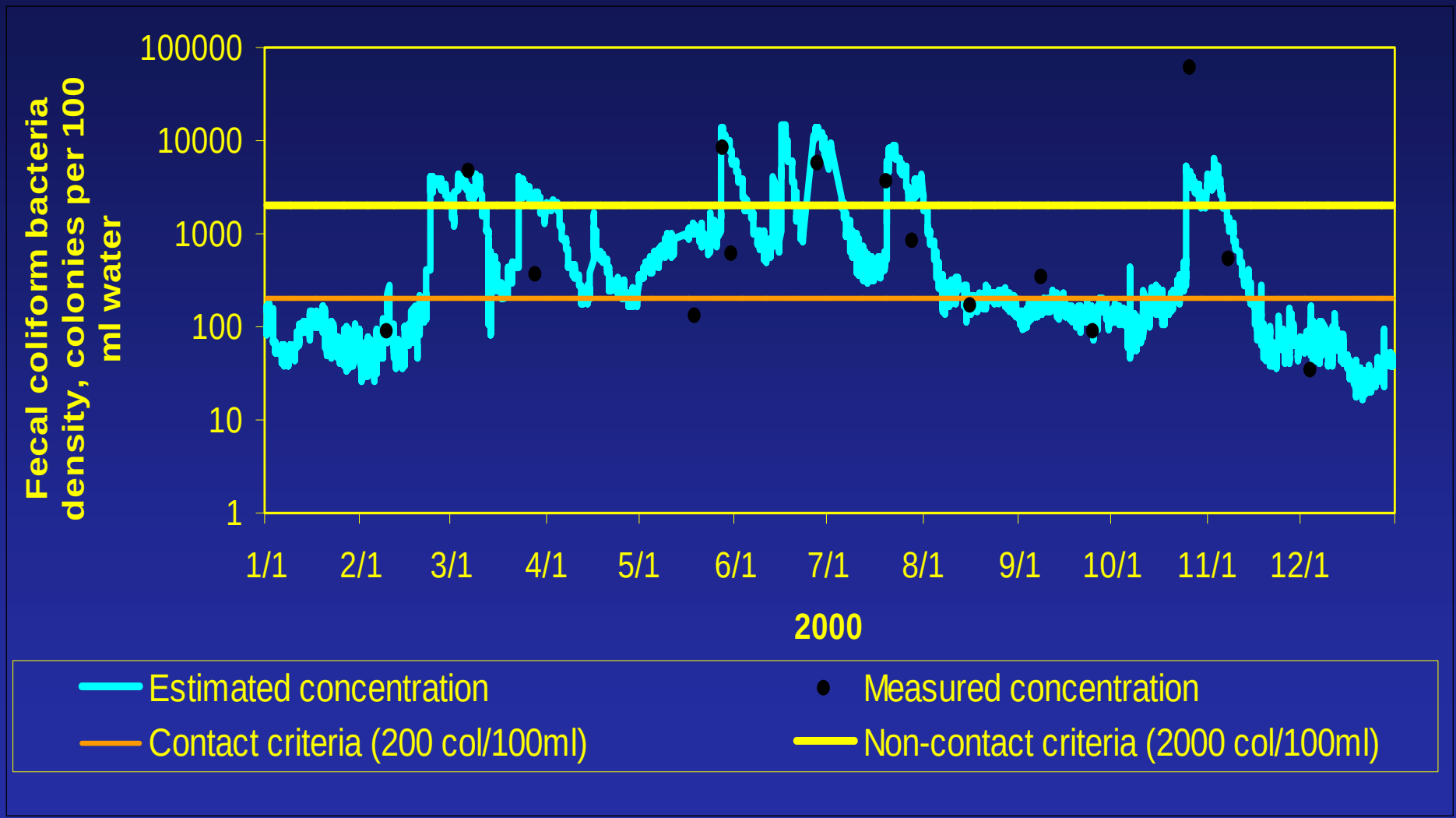
Little Arkansas River near Sedgwick, Kansas
Fecal Coliform Densities, 2000



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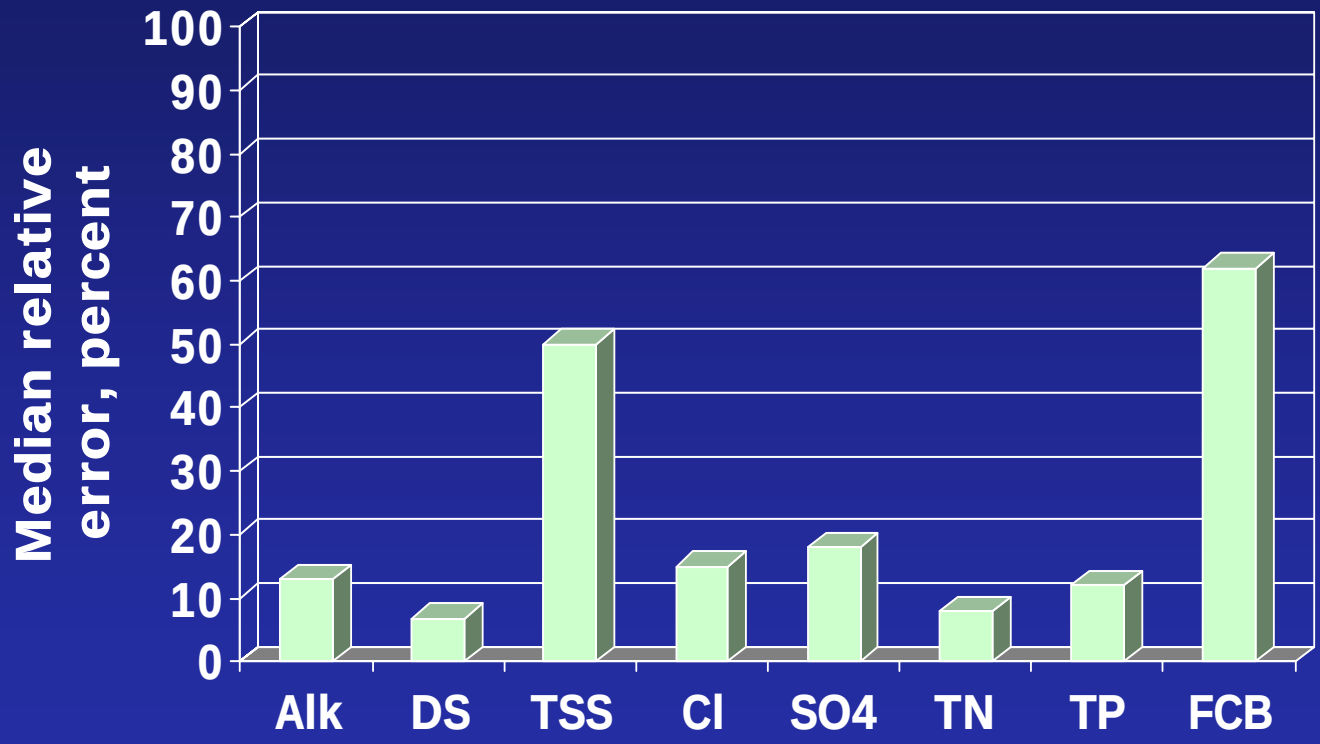
Uncertainty Between Instantaneous Measured and Estimated Concentrations



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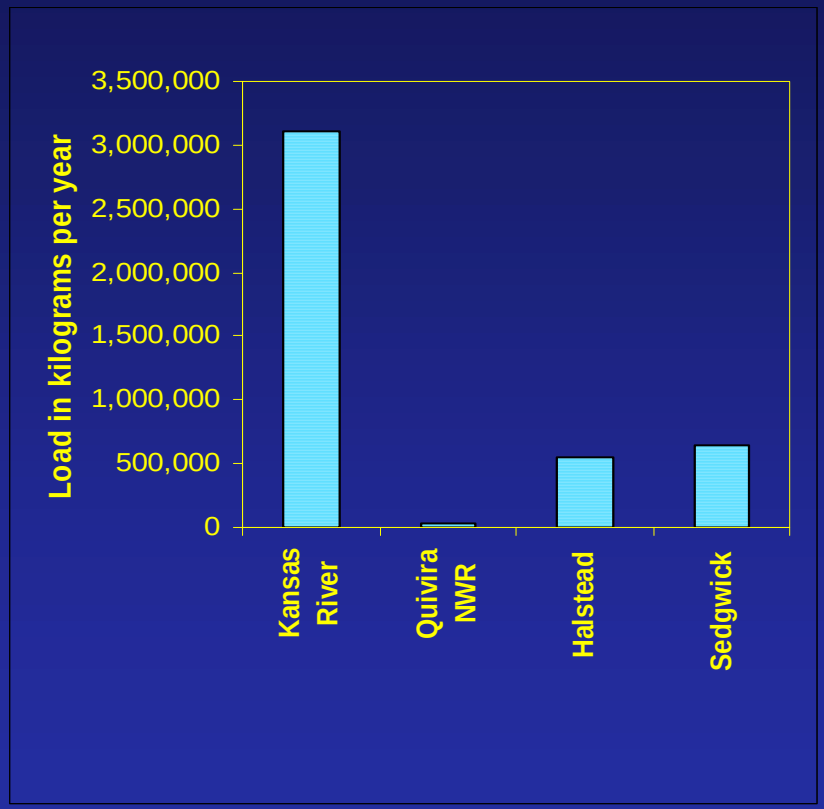
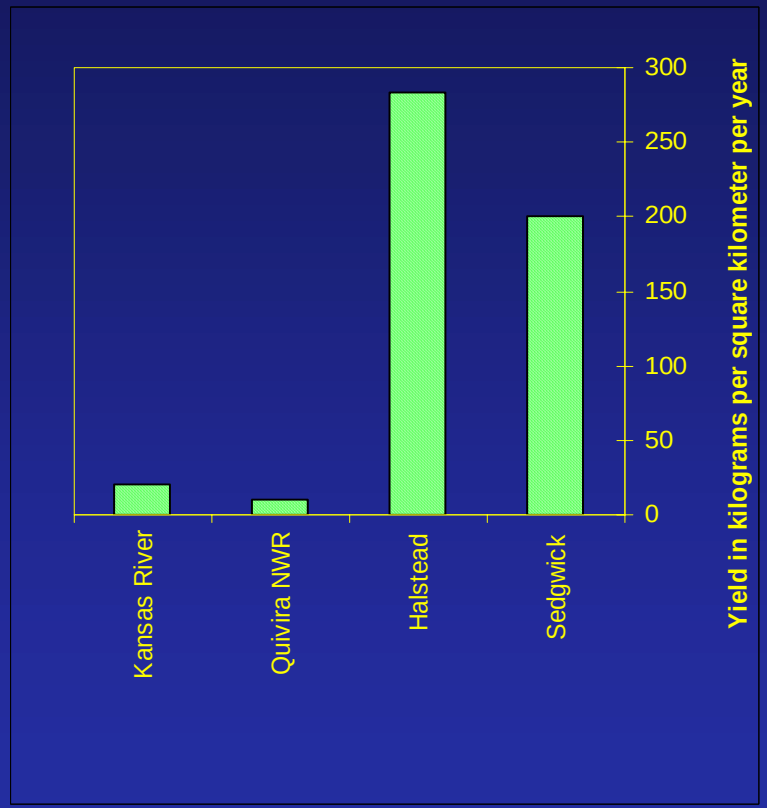
Nitrogen Load and Yields





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Benefits of Real Time Water Quality Surrogates

- Continuously measure water-quality in real time similar to streamflow
- Estimate selected constituent concentrations and loads more accurately
- Provide early warning of changes in chemical conditions in recreational and source waters
- Optimize timing of sample collection

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Regression Analysis for Water Quality - Netscape

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Real-time Water-Quality Concentration and Load Estimated by Regression Analysis

Water Quality and Regression Analysis

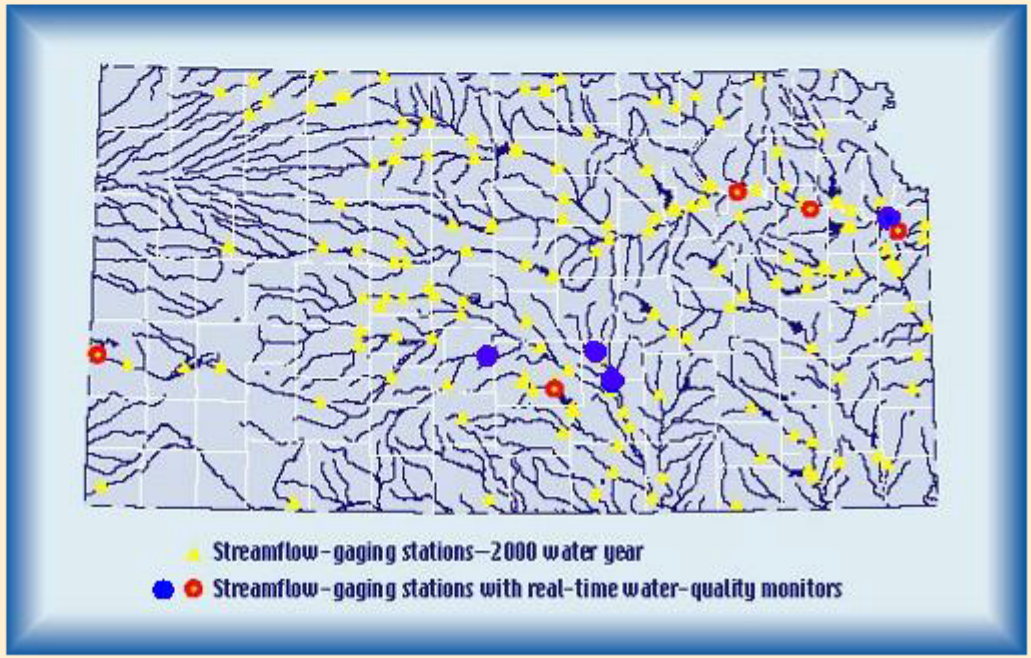
- Water quality parameters and standards in Kansas
- Regression analysis
- Regression equation table

QW Studies in Kansas

- Real-time water quality
- Equus Bed GW Recharge
- Quivira QW
- Kansas River QW
- Publications

Additional Information

- KDHE home page



The above map shows USGS streamflow gaging stations (yellow triangle) and streamflo

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USGS station: 07143672 Little Arkansas River at Highway 50 near Halstead, KS

Parameter: Real-time | Discharge | Concentration

Output format: Time series plot only

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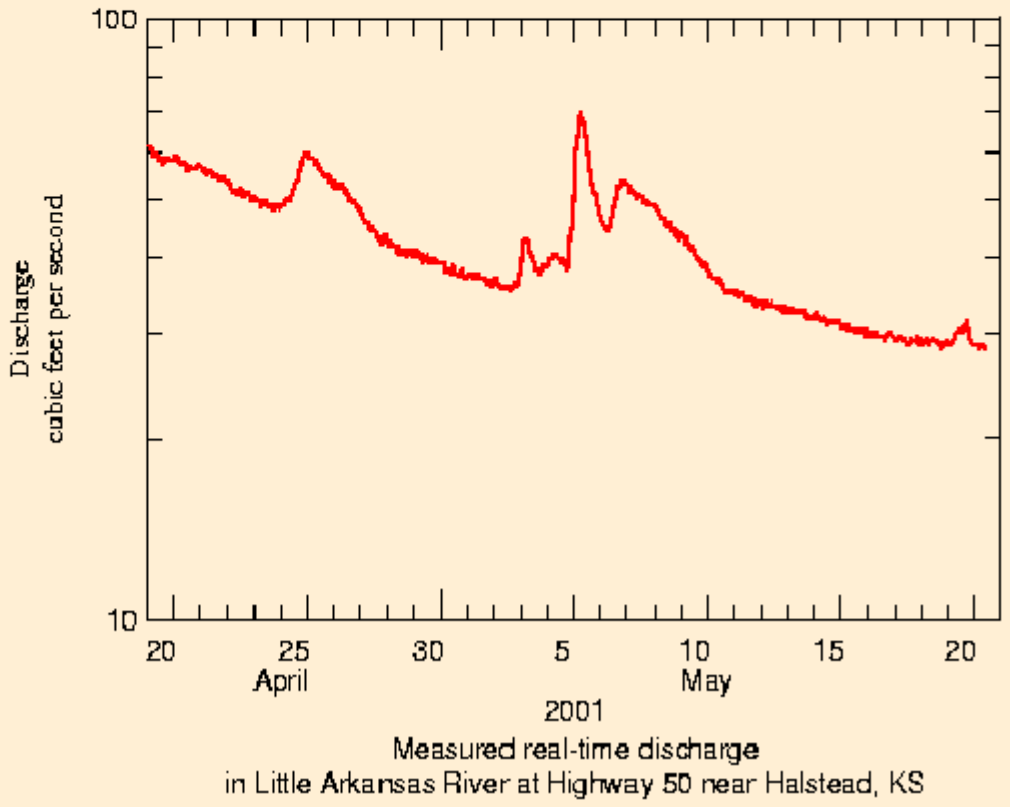

Measured real-time discharge
in Little Arkansas River at Highway 50 near Halstead, KS

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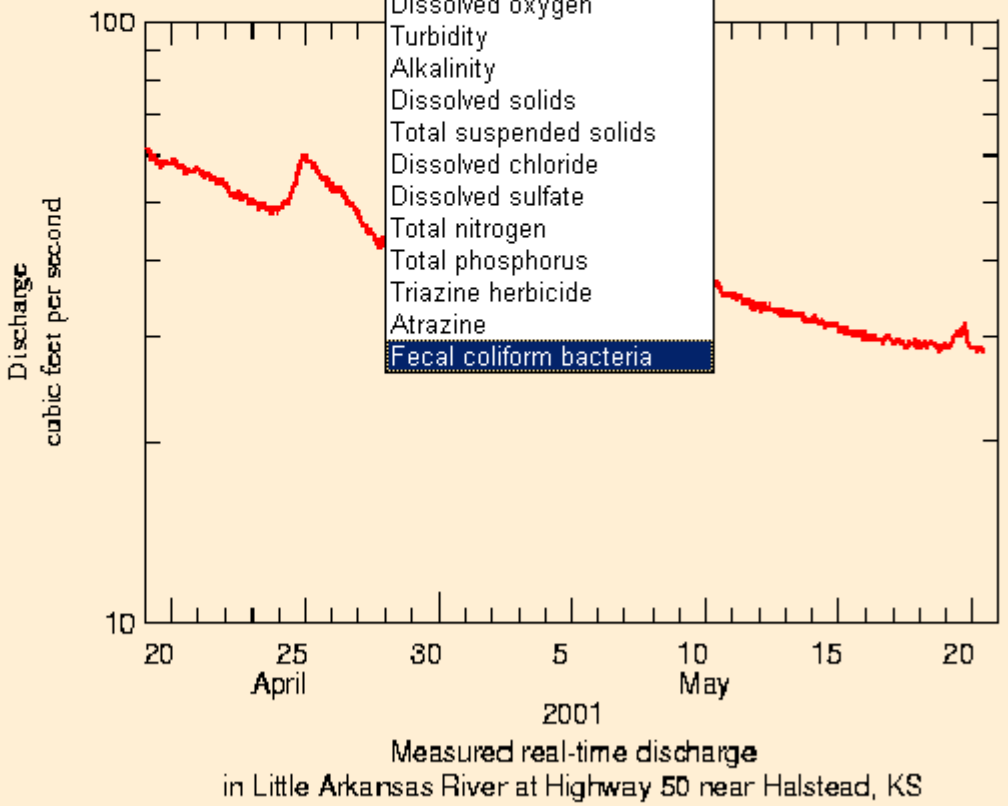
< Go >

Discharge
Water temperature
pH, field
Specific conductance
Dissolved oxygen
Turbidity
Alkalinity
Dissolved solids
Total suspended solids
Dissolved chloride
Dissolved sulfate
Total nitrogen
Total phosphorus
Triazine herbicide
Atrazine
Fecal coliform bacteria



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USGS station: 07143672 Little Arkansas River at Highway 50 near Halstead, KS

Parameter: Real-time | Fecal coliform bacteria | Concentration

Output format: Time series plot only

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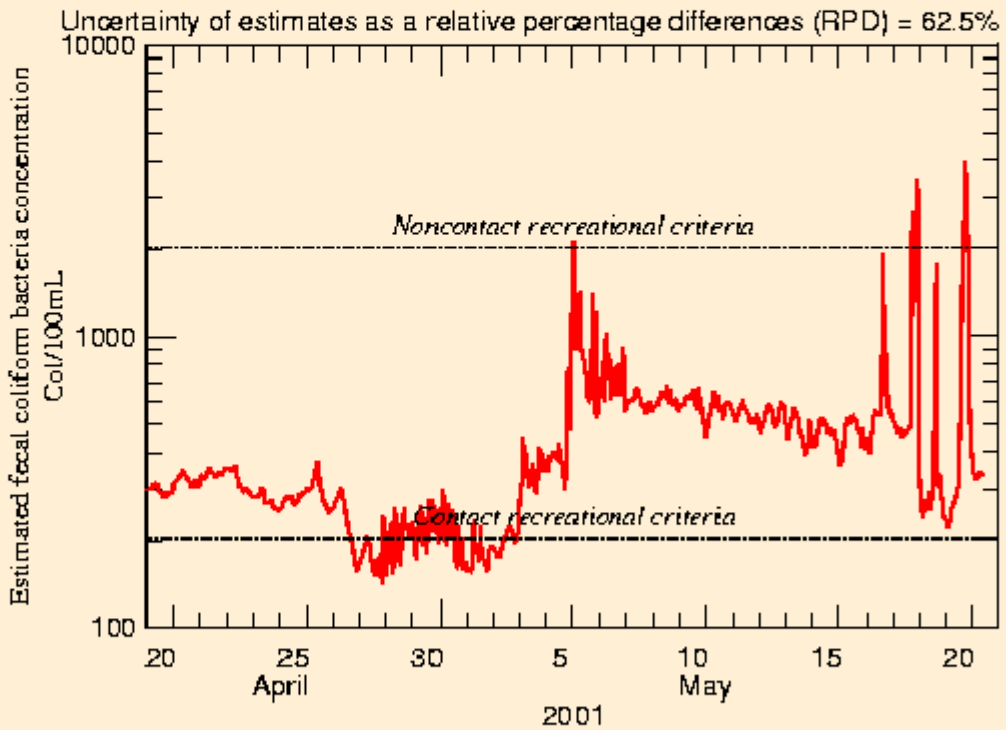
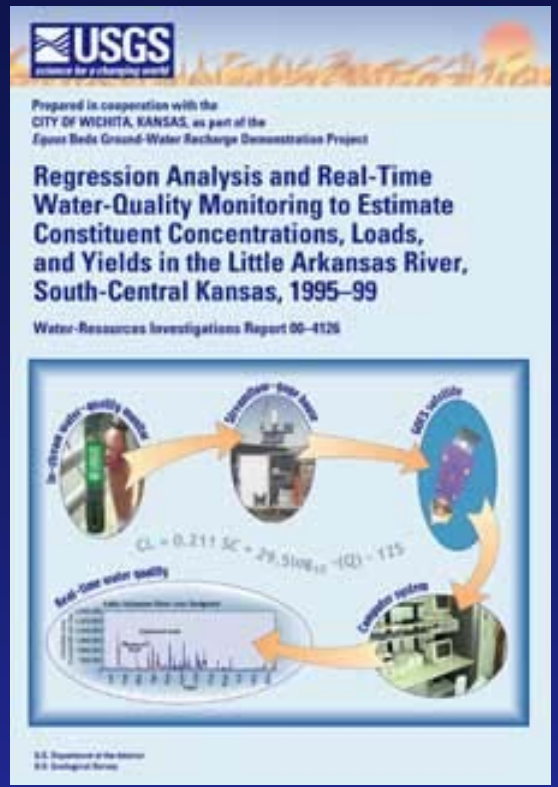


Estimated real-time fecal coliform bacteria concentration in Little Arkansas River at Highway 50 near Halstead, KS

Important notes: The data used to produce this plot are **provisional** and have not been reviewed or edited. They may be subject to significant change

For more information on real-time water quality in Kansas:



http://ks.water.usgs.gov/Kansas/qw/

http://water.usgs.gov/ks/nwis/current?type=qw

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