

Assessment of Biological Conditions in Streams of Johnson County, Kansas

*Teresa Rasmussen, U.S. Geological Survey,
Lawrence, Kansas*

*Barry Poulton, U.S. Geological Survey,
Columbia Environmental Research Center,
Columbia, Missouri*

*Casey Lee, U.S. Geological Survey,
Lawrence, Kansas*



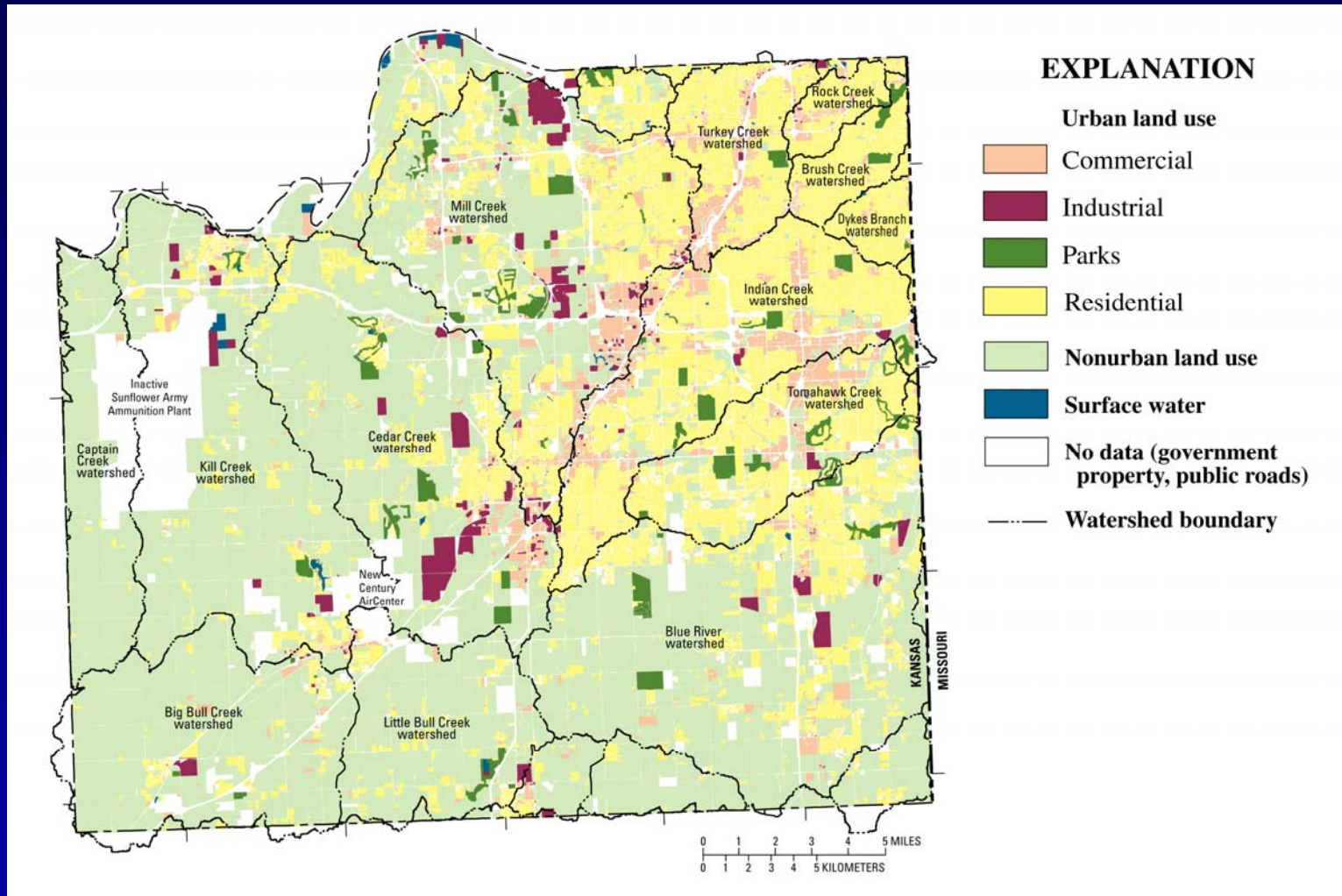
***Kansas Water
Environment Association
(KWEA) Annual Meeting***

April 4, 2007

Topeka, Kansas



Johnson County is undergoing rapid development



Urban development affects stream communities

- Alters stream hydrology
- Changes stream geomorphology
- Affects water chemistry
- Changes habitat



Tomahawk Creek



Indian Creek



Indian Creek

Johnson County municipalities are subject to requirements of the Clean Water Act

- National Pollutant Discharge Elimination System (NPDES) permitting –point and nonpoint sources
- 303(d) listings – identifying streams that do not meet water-quality standards
- Total maximum daily loads (TMDLs)
- Best management practices (BMPs)



Most water-quality impairments in Johnson County are related to excessive bacteria, nutrients, and sediment

High priority impairments

Fecal coliform bacteria	Cedar Creek, Kill Creek, Mill Creek
Nitrates/nitrites	Cedar Creek (in EPA review)
Ammonia	Turkey Creek
Biological	Mill Creek (in EPA review)
Eutrophication	Lakes - Gardner City, Hillsdale, Olathe and Cedar (in EPA review)

Cooperative water-quality study between USGS and the Johnson County Stormwater Management Program

- To characterize water-quality of Johnson County streams
- To identify contaminant source areas
- To estimate contaminant concentrations and loads
- To evaluate effects of urbanization on water quality
- To monitor changes in water quality
- To provide information for developing effective water-quality management plans
- To help meet requirements of the Clean Water Act



Mill Creek near
Shawnee Mission Park

Overall study approach – 3 components

1. Water and sediment sampling to identify contaminant sources



2. Continuous water-quality monitoring to estimate chemical concentrations and loads



3. Biological assessment to describe biological conditions



Riffle beetle



Stonefly

Biological information is valuable to water-quality programs



Fish



Aquatic plants
(macrophytes)



Algae (periphyton)



Bottom-dwelling
(benthic)
invertebrates

- Determines how well water bodies support aquatic life
- Aquatic life integrates cumulative effects including variable streamflow, habitat, chemistry, sediment
- Can be used to develop criteria and establish long-term goals

Basics of biological assessments using macroinvertebrates

1. Macroinvertebrate samples are collected using specific protocols



**Kansas protocol – two independent 100-count
samples, multiple habitats, limited time, lab ID**

Basics of biological assessments using macroinvertebrates (continued)

2. After organisms are identified and counted in the lab, the information is used to calculate various metrics

- Calculated according to published literature
- Used to measure and evaluate macroinvertebrate response to various factors such as human disturbance



Metrics are values used to describe specific attributes of a community (such as diversity, composition, abundance, tolerance)

Basics of biological assessments using macroinvertebrates (continued)

Common metrics include:

- * • Macroinvertebrate Biotic Index (MBI) – tolerance levels
- * • Kansas Biotic Index (KBI-NO) – tolerance to nutrient (N) and oxygen-demanding substances (O)
- * • EPT richness – total number of Ephemeroptera (mayflies) Plecoptera (stoneflies) Trichoptera (caddisflies) taxa
- * • EPT abundance – EPT as percent of total number of organisms
- Total taxa richness – total number of different types of organisms
- Multimetric combinations

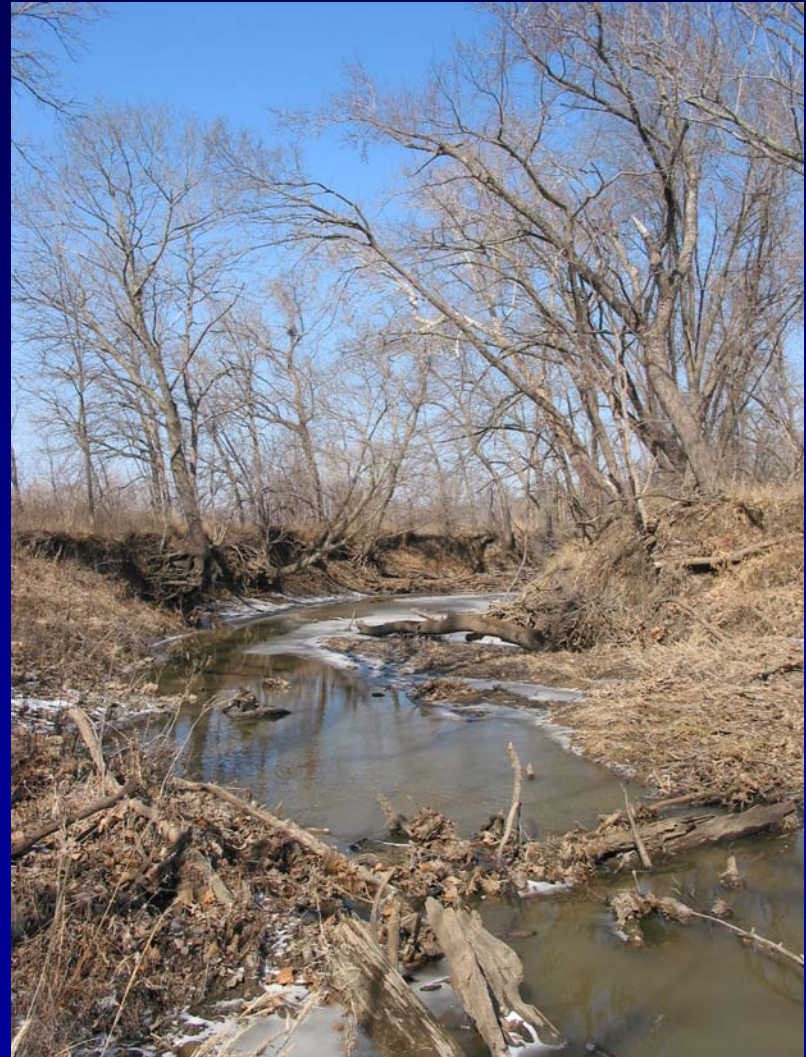
* Used by KDHE for aquatic-life-support status

Basics of biological assessments using macroinvertebrates (continued)

3. Reference sites are often used as a basis for comparison when evaluating nearby sites

Reference site – limited number of sites designated by the State as being minimally affected by human disturbance

Captain Creek,
Kansas reference site



Basics of biological assessments using macroinvertebrates (continued)

4. The type and number of macroinvertebrates are indicative of water quality conditions

Macroinvertebrates generally associated with **healthy streams** include:



Stoneflies
(Plecoptera)



Mayfly
(Ephemeroptera)



Caddisfly (Trichoptera)

Macroinvertebrates generally associated with more **polluted streams** include:



Leech



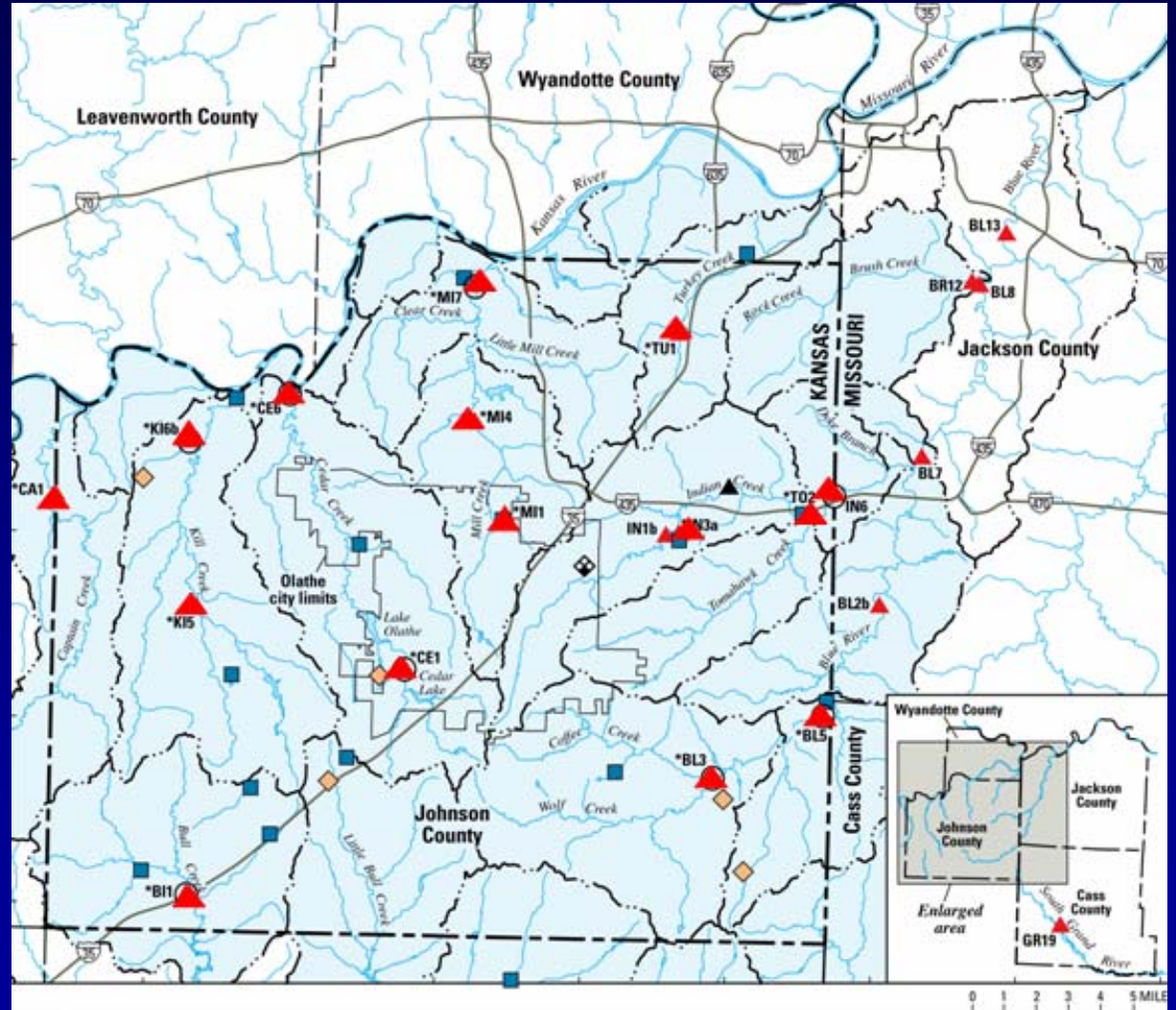
Midges
(Chironomidae)



Worm
(Oligochaeta)

Johnson County biological assessment

- Sampled 15 stream sites in Johnson County in early spring of 2003 and 2004
- Also evaluated published data from 7 additional sites, mostly in Missouri
- Available land use and water- and streambed-sediment quality data also evaluated



Relative biological conditions were assessed by:

- Examining macroinvertebrate community composition
- Scoring, ranking and grouping sites according to metrics
- Describing relations between macroinvertebrates and land use, water and stream quality
- Evaluating effects of urbanization on macroinvertebrate communities
- Comparing conditions at Johnson County sites to downstream sites in Missouri
- Comparing stream conditions to State biological criteria



Mill Creek near Shawnee Mission Park

Results

Most rural sites contained a diversity of insects including those normally associated with healthy streams



Kill Creek at 95th St



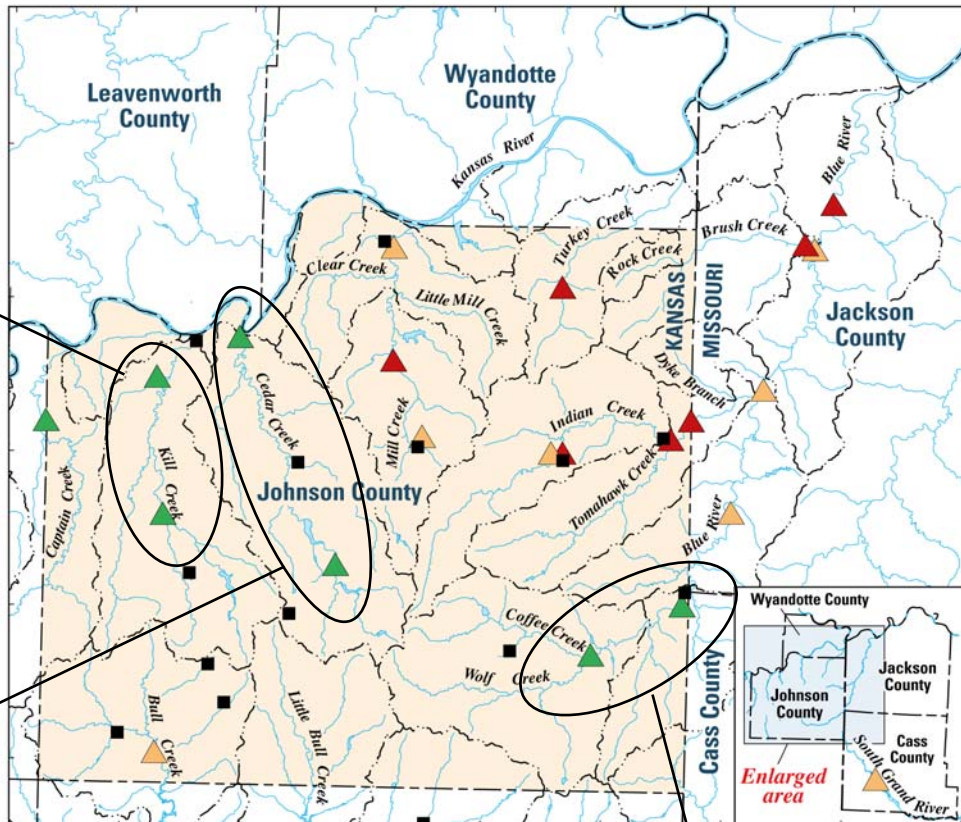
Indian Creek at State Line Rd

More urban sites had none or few insects associated with healthy streams and were dominated by pollution-tolerant insects

Rural sites consistently scored among those least adversely affected

Kill Creek sites

Cedar Creek sites



EXPLANATION

Watershed boundary

Biological sampling site:

▲ Most adversely affected by human disturbance

▲ Moderate amounts of adverse effects from human disturbance

▲ Least adversely affected by human disturbance

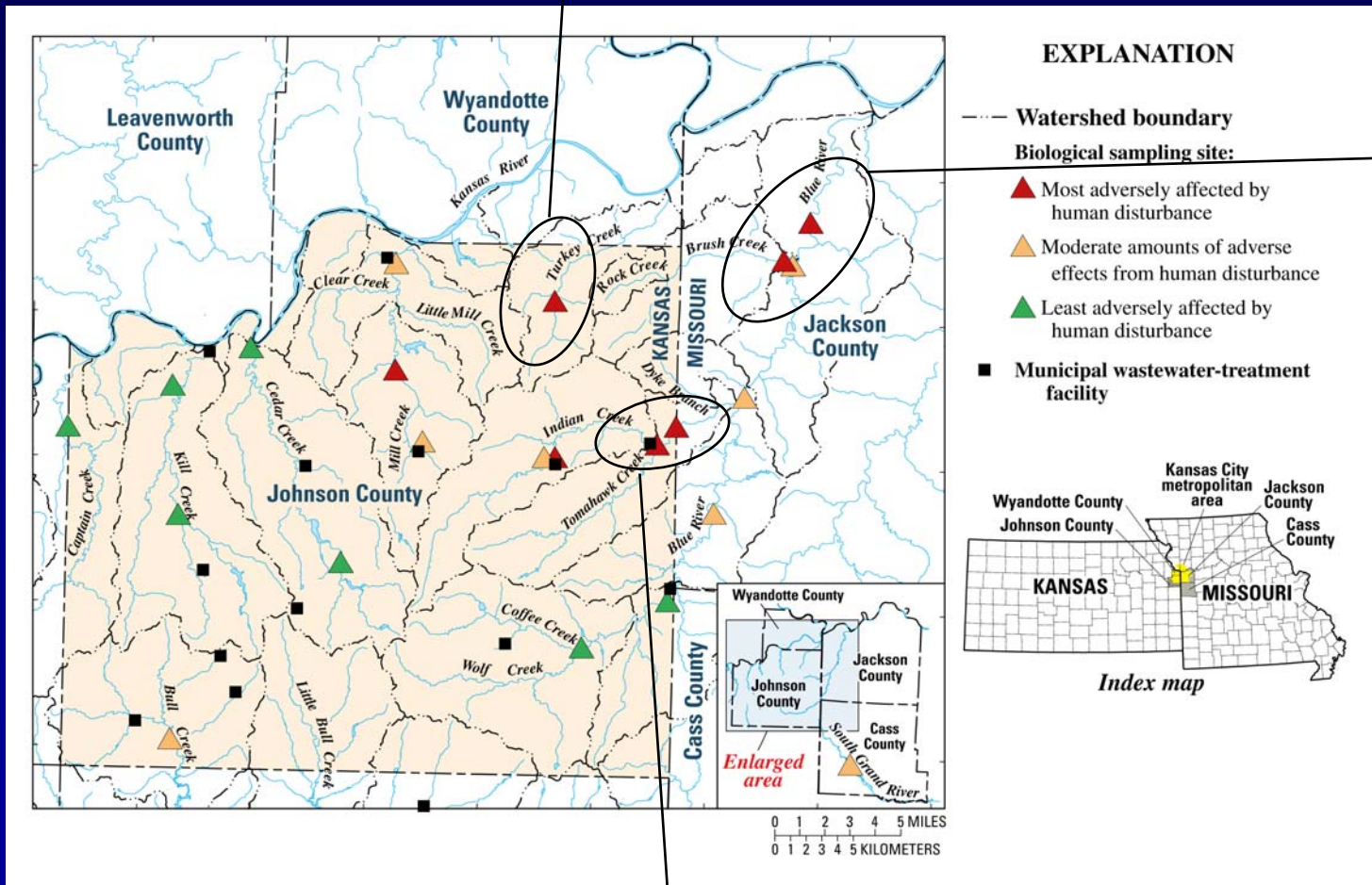
■ Municipal wastewater-treatment facility



Upstream Blue River sites

Sites downstream from treatment facilities and large impervious areas consistently scored among those most adversely affected

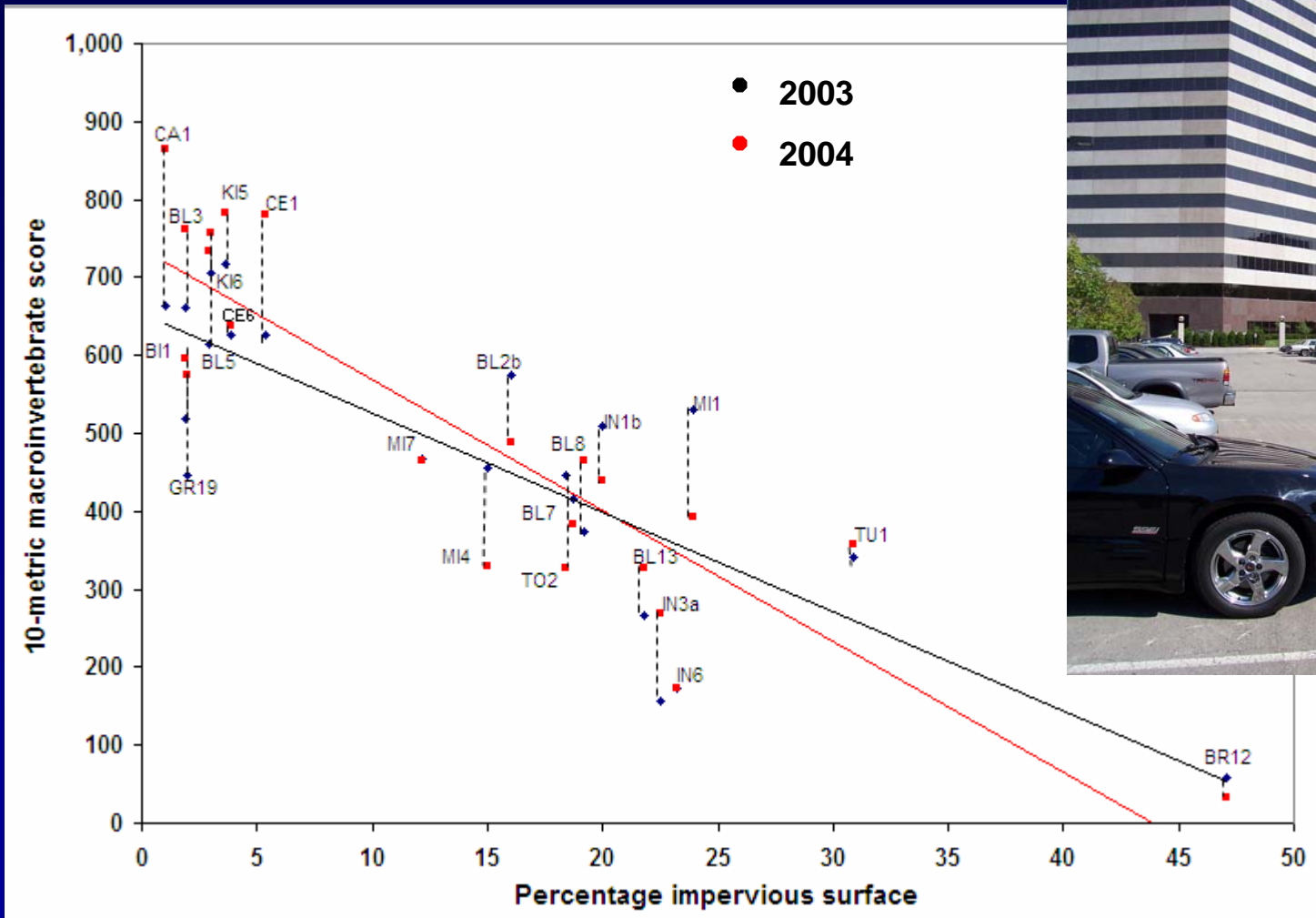
Turkey Creek



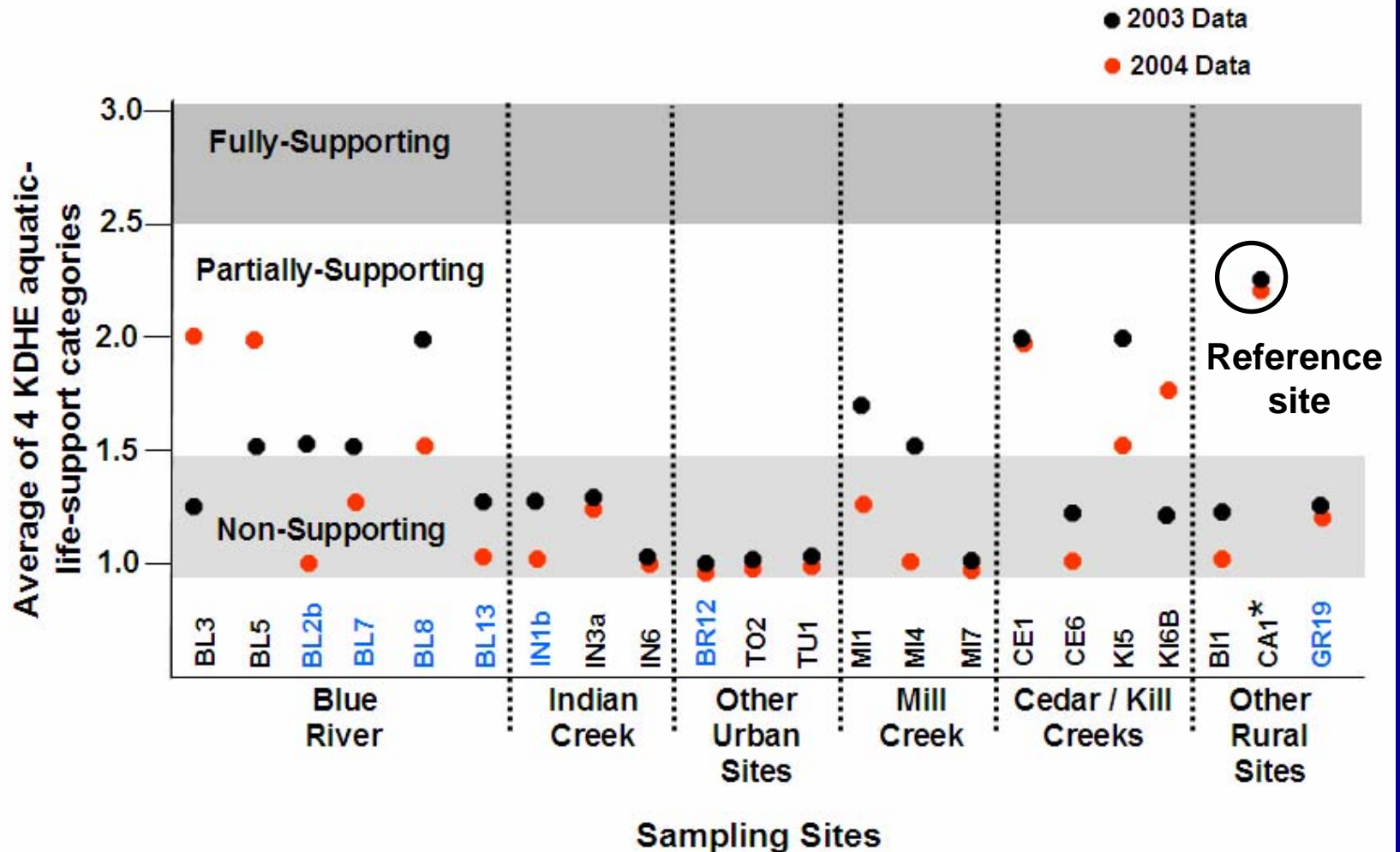
Downstream Blue River sites

Indian and Tomahawk Creek sites

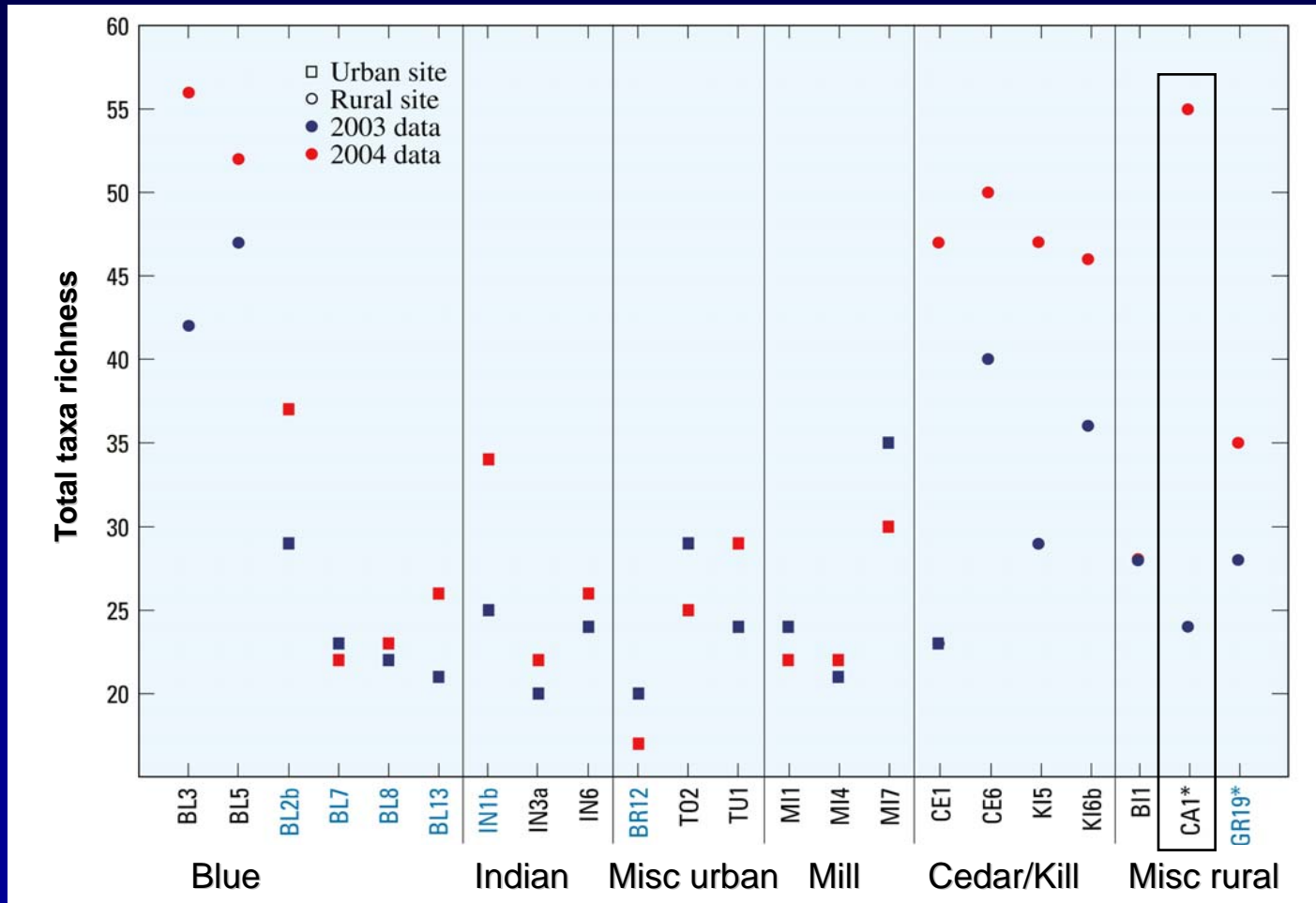
Generally, as urban land use (percent impervious surface) upstream from the sampling sites increased, biological quality decreased



No sites, including the reference site, met State criteria for full support of aquatic life

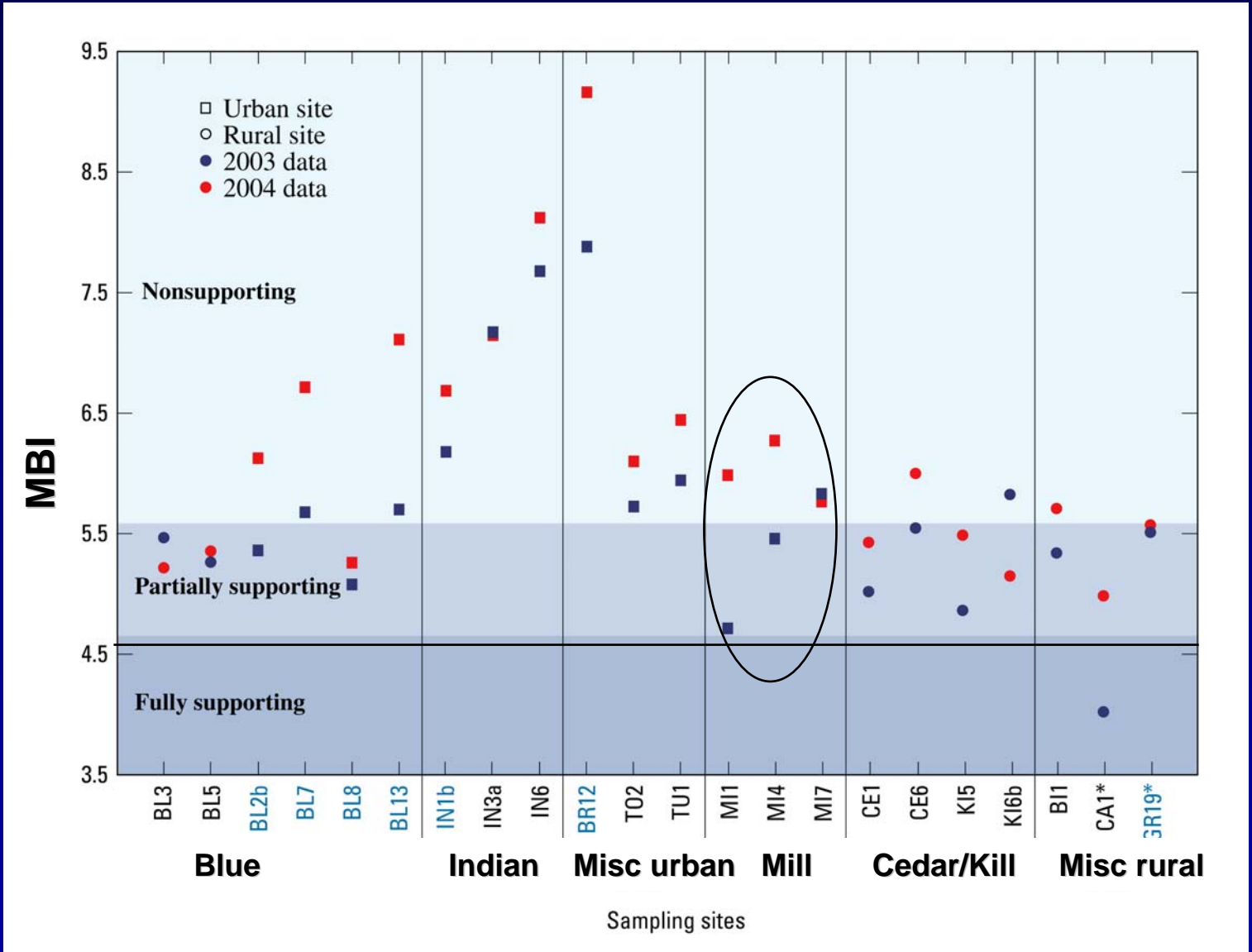


Species diversity at rural sites was comparable to that of the reference site

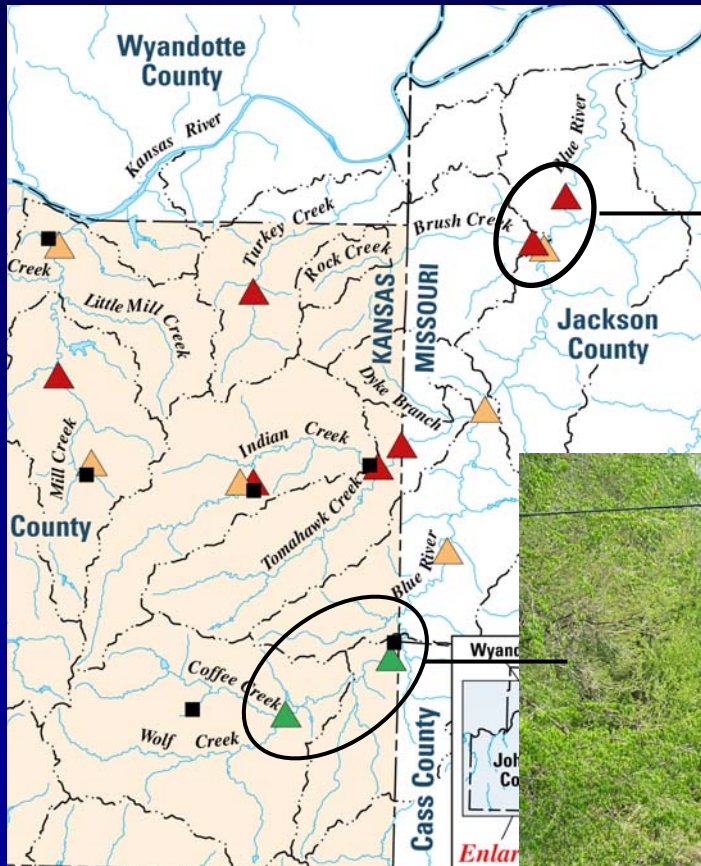


- High annual variability in richness metrics

Mill Creek did not meet desired MBI endpoint of 4.5 or less listed in draft (Jan 2006) TMDL for biological impairment



Biological conditions in the Blue River watershed range from minimum adverse effect (upstream) to maximum adverse effect (downstream)

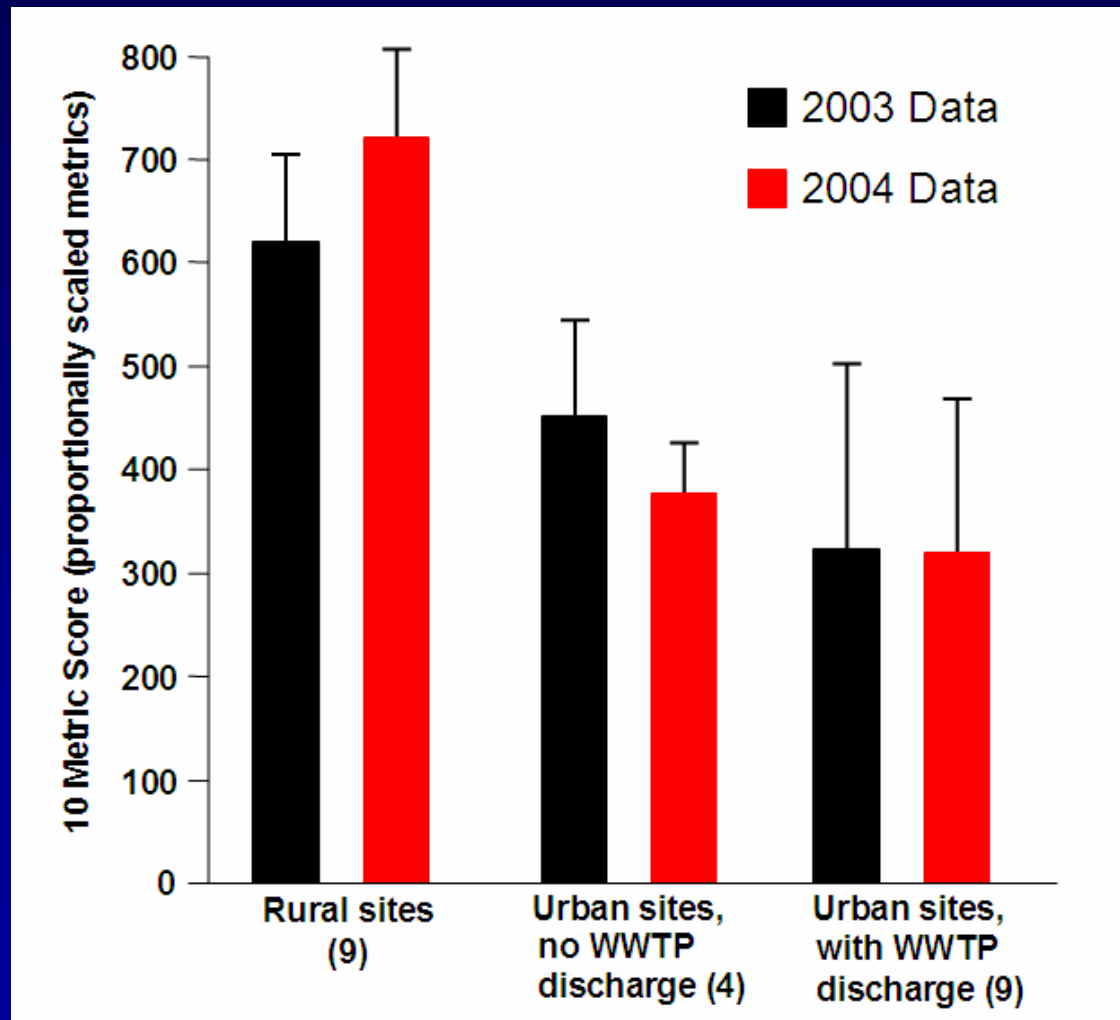


Blue River near Stadium Drive



Blue River at Kenneth Road

Macroinvertebrate scores at urban sites with wastewater treatment facility discharges were slightly lower than at other urban sites with no discharges



Biological conditions are being adversely affected by both general urbanization and effects of wastewater discharges, but these 2 factors were not evaluated separately



Harold Street wastewater treatment plant

Sites less than 3 miles downstream from WWTF discharges (Indian Creek at College Blvd and at State Line) consistently scored among the most adversely affected sites

Other urban sites with no WWTF discharge but the largest impervious surface area (Turkey, Tomahawk, downstream Brush Creek) also scored among the most adversely affected sites



Turkey Creek near 67th St

Wastewater discharges affect biological communities

- **Alter natural variability in streamflow**
- **Increase nutrient concentrations resulting in excessive algae growth**
 - **decreases DO and increases magnitude of diel fluctuations**
 - **retains fine particulates leading to more substrate embeddedness**
- **May increase concentrations of dissolved solids, metals, organic compounds**

Environmental variables that were significantly correlated with adversely affected biological conditions included:

Land use

- Percent impervious surface
- Percent urban land use
- Percent agricultural land use

Water quality

- Total nitrogen, total phosphorus
- Total concentration of organic wastewater compounds

Streambed-sediment quality

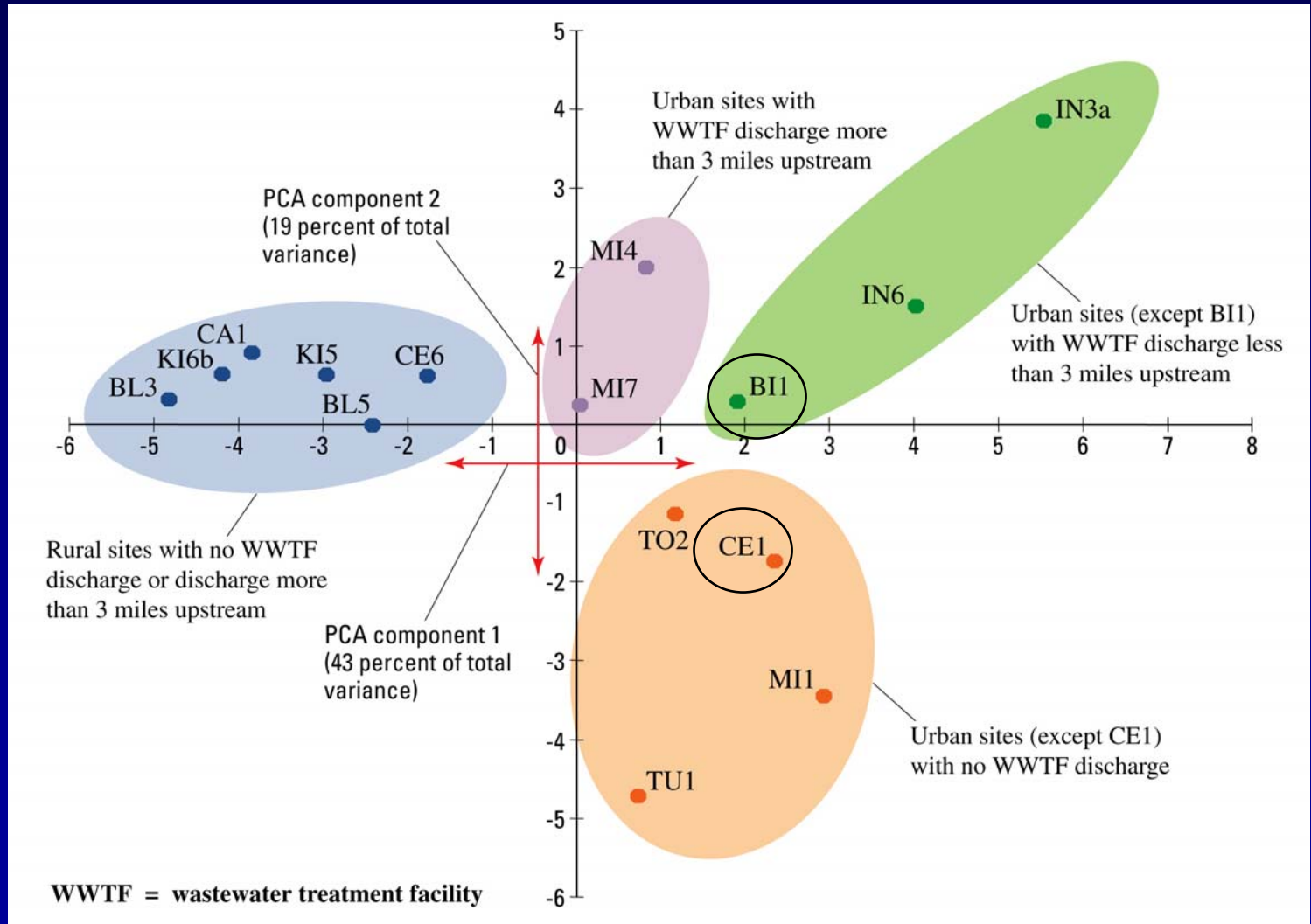
- PAHs
- Nonylphenol diethoxylate
- Fecal coliform



Photos from <http://photogallery.nrcs.usda.gov>



When environmental variables were evaluated against metrics, similar sites grouped together, with a few notable exceptions (upper Cedar Creek, Big Bull)



Ongoing work

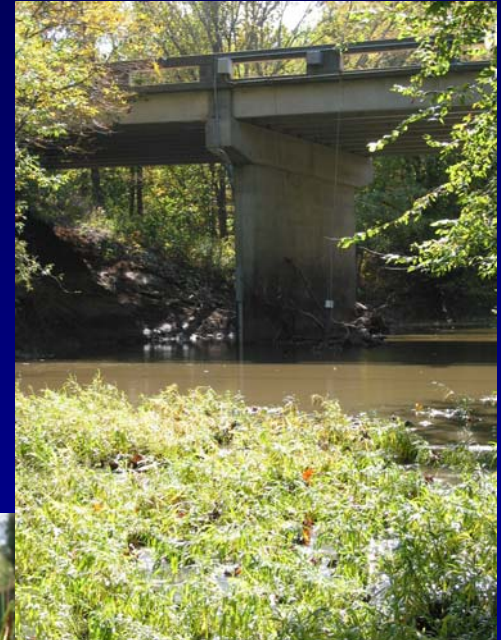
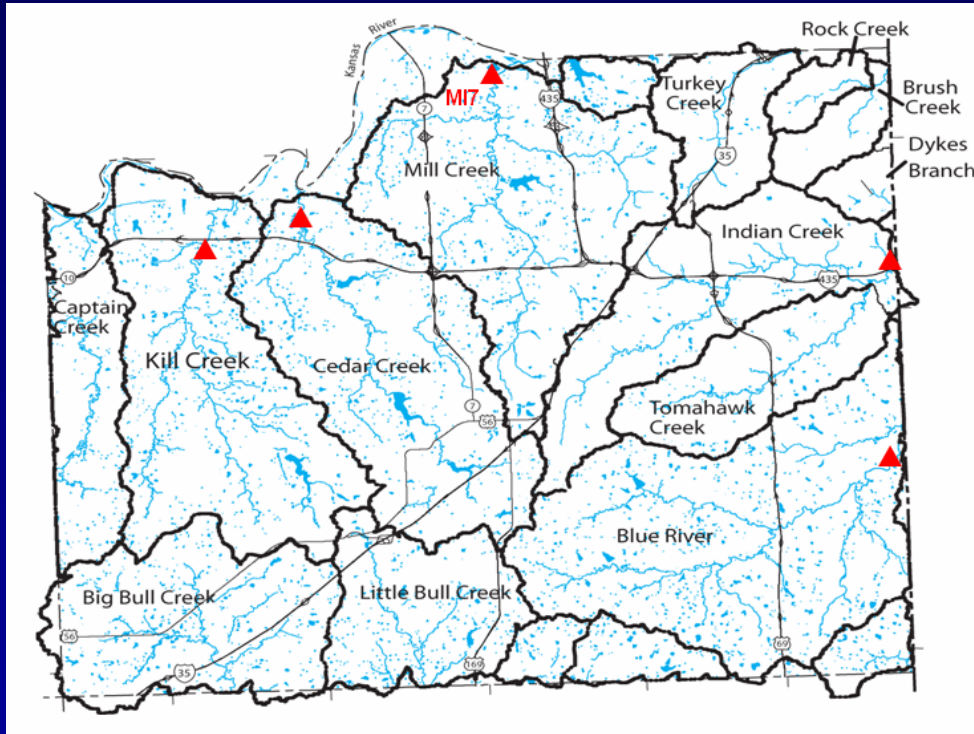
Collected samples at 20 Johnson County sites – March 2007

- Macroinvertebrates
- Water
- Streambed sediment
- Periphyton

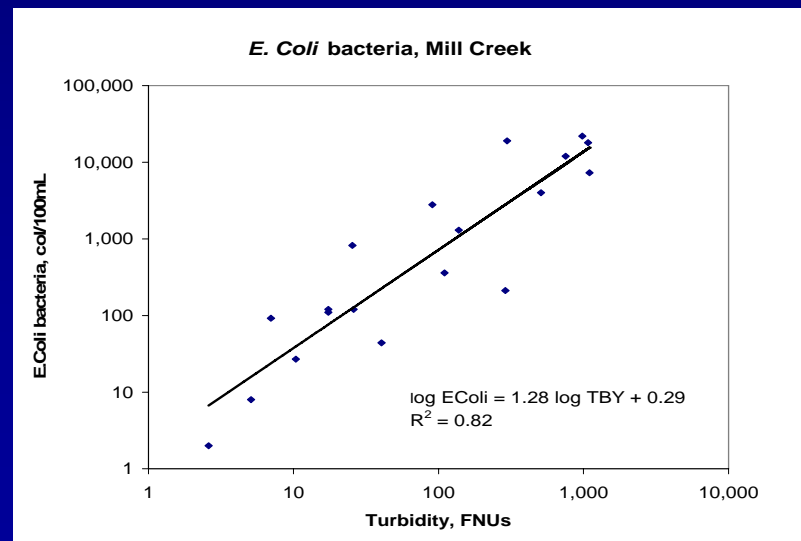
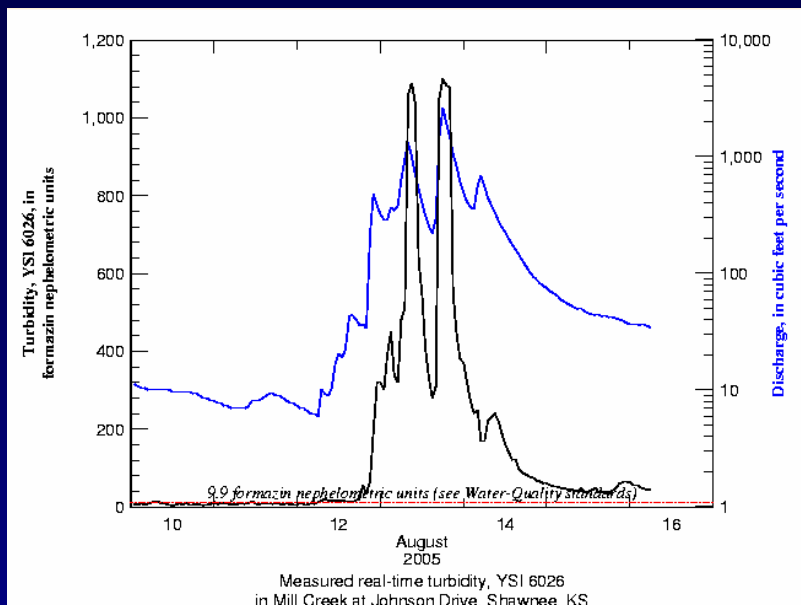


Ongoing work

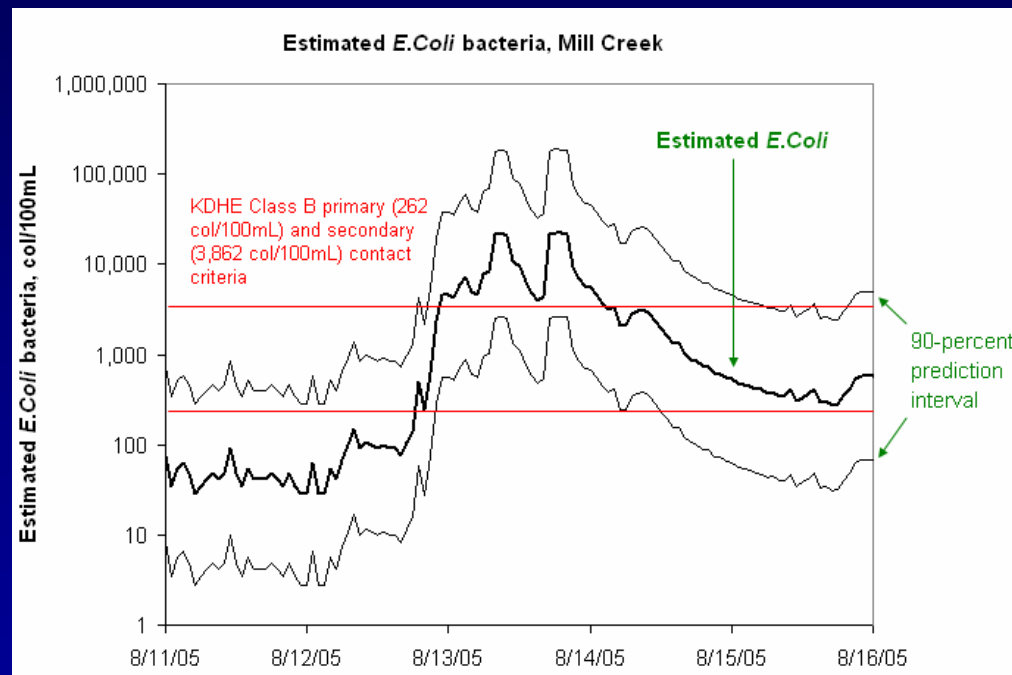
Continuous water-quality monitoring at 5 sites – to provide continuous estimates of chemical concentrations and loads, define variability, and monitor changes



Ongoing work (continued)



Continuous stream-water quality monitoring

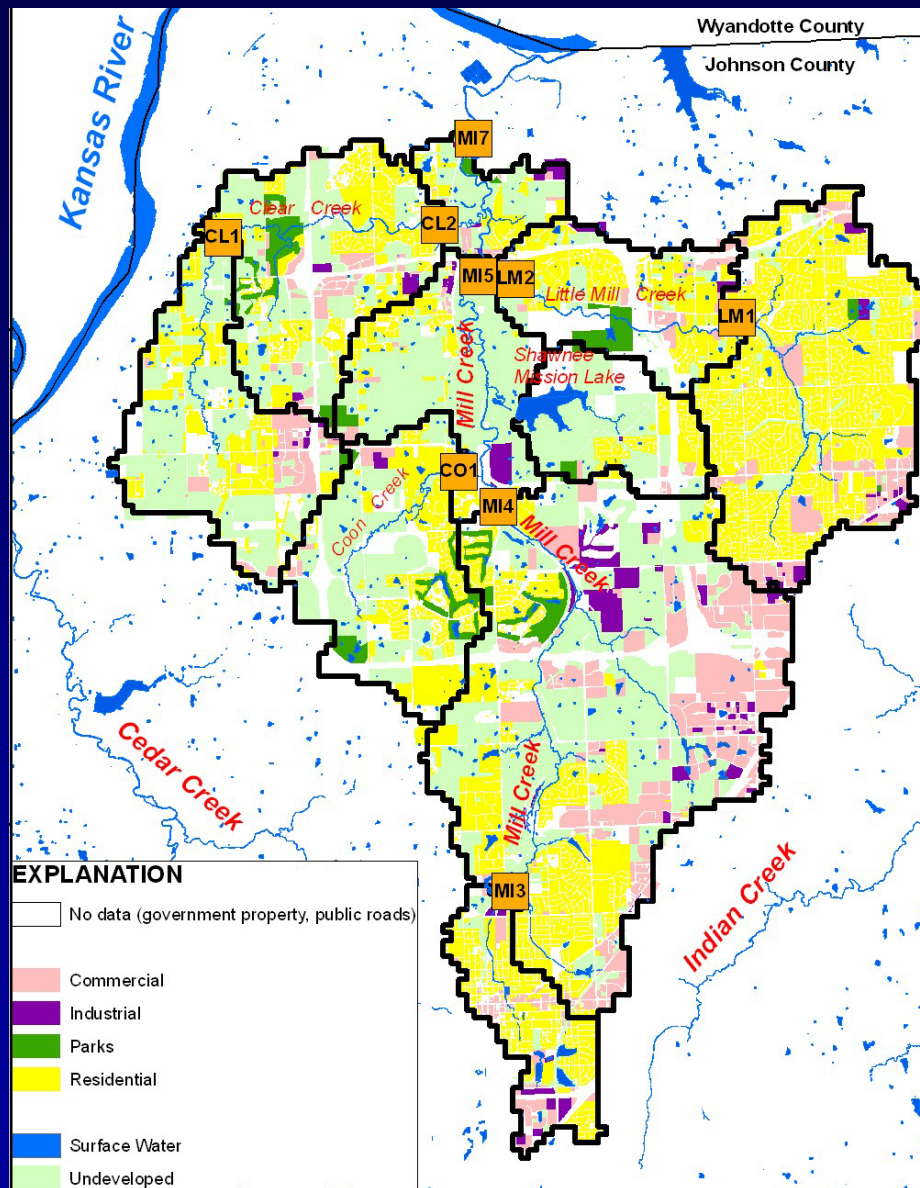


Continuous data available in real time at:
<http://ks.water.usgs.gov/Kansas/rtqw>

Ongoing work (continued)

Mill Creek watershed sediment sources study

- Monitor sediment loads throughout the Mill Creek watershed
- Use chemical tracers to estimate sources of suspended sediment
- Will help county officials evaluate appropriate best management practices



Summary

- **Biological conditions generally reflected a gradient in upstream land use; as urbanization (impervious area, wastewater) increased, biological quality decreased**
- **In Johnson County, rural stream sites had healthier invertebrate communities than urban sites**
- **Several (all rural) stream sites had biological conditions similar to the State reference site**
- **No sites met State criteria for full support of aquatic life**
- **Macroinvertebrate measures were most strongly related to upstream land use and PAHs in streambed sediment**
- **Water-quality studies are ongoing**
- **Information is important for effective management of water resources**

For more information

<http://ks.water.usgs.gov/Kansas/studies/qw/joco>

USGS
science for a changing world

Prepared in cooperation with the Johnson County Stormwater Management Program

Effects of Contaminant Sources on Stream-Water Quality and Relation to Land Use in Johnson County, Northeastern Kansas, June 2004

—Cecily J. Lee, David P. Masi, and Teresa J. Rasmussen

The U.S. Geological Survey (USGS) and Johnson County Stormwater Management Program conducted a water-quality investigation in Johnson County, Kansas, to determine the effects of point- and nonpoint-source contamination on stream-water quality and their relation to land use. Johnson County streams are an important source of drinking water, aquatic life, and quality conditions were determined by collection of stream-water and streambed-sediment samples were located in urban areas of the City of Topeka, including Shawnee Park, and the riparian areas of the county (Blue River and Little Blue River and Little Blue Creek). The information from this study can be used by Johnson County officials to evaluate existing water-quality conditions, identify areas of potential point- and nonpoint-source contamination, and develop strategies to improve water-quality conditions.

This fact sheet summarizes the results of a water-quality investigation conducted in Johnson County from October 2002 through June 2004 (Lee and others, 2005). The complete report is available on the World Wide Web at: <http://ks.water.usgs.gov/Kansas/studies/qw/joco>

Introduction

Johnson County, located in northeastern Kansas, is the most populous and fastest growing county in the State (U.S. Census Bureau, 2004). Increasing population has caused changes in land use, resulting in more residential, commercial, and industrial developments and increased impervious surface areas (such as roads, lawns, businesses, and parking lots), which may have a substantial effect on

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

Prepared in cooperation with the JOHNSON COUNTY STORMWATER MANAGEMENT PROGRAM

Effects of Nonpoint and Selected Point Contaminant Sources on Stream-Water Quality and Relation to Land Use in Johnson County, Northeastern Kansas, October 2002 Through June 2004

Scientific Investigations Report 2005-5144

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

Real-time water quality - Windows Internet Explorer

http://ks.water.usgs.gov/Kansas/rqw/sites/06892360/htmls/31d/p00300_31d_all_uv.shtml

303(d) listings

Real-time water quality

USGS
science for a Changing World

USGS Background Info Related Studies Related Links USGS-KS

Kansas Real-Time Water Quality

Select desired options for data display:

USGS station: 06892360 Kill Creek at 95 Street near DeSoto, KS

Parameter: Dissolved oxygen Concentration Hourly < Go >

Time period: Last 31 days All January

Other info: Data Go Statistics: Summary Go

Note: Because of daily variation in some parameters, daily data may be better to view for Year-to-date and annual plots.

Dissolved oxygen, in milligrams per liter

Discharge, in cubic feet per second

Minimum Kansas aquatic-life support criteria

Done Internet 100%

Teresa Rasmussen
rasmuss@usgs.gov
(785) 832-3576