Comprehensive Monitoring Approaches to Assess Changing Stream Conditions in Urbanizing Watersheds of Northeastern Kansas

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In cooperation with the Johnson County Stormwater Management Program

Background

Urbanization has contributed to degraded biological communities and excessive sediment, nutrients, and bacteria in streams of Johnson County, Kansas. Many factors contribute to impairments in urban streams, leading to challenges in identifying causes of degradation. Stream quality in Johnson County has been monitored since 2002 in a cooperative study between the U.S. Geological Survey and the Johnson County Stormwater Management Program. Multiple monitoring approaches have been combined to achieve project objectives, including to:

- characterize water quality in streams throughout the county and identify contaminant sources,
- describe annual, seasonal, and storm-event variability in concentrations and loads,
- describe biological conditions,
- identify relations among biological conditions and environmental variables, and
- explain specific stream-quality issues identified during monitoring.

Extensive water and streambed-sediment sampling characterize water quality and identify contaminant sources

- During base flow, wastewater discharges were the primary source of nutrients, dissolved solids, pesticides, and other organic compounds.
- Sediment concentrations and indicator bacteria densities (fig. 1) were larger during stormflow than base flow in both urban and rural streams.
- During base flow, urban streams had the largest number of pesticides, and rural streams had the largest total concentrations of pesticides.
- More than 1/2 of the total concentration of 54 organic compounds tested in base flow from 45 stream sites consisted of musk fragrance, caffeine, mosquito repellent, and detergent surfactants.
- The largest concentrations of many organic compounds in streambed sediment occurred in urban areas and included chlordane, DDT, and PAHs (polycyclic aromatic hydrocarbons).

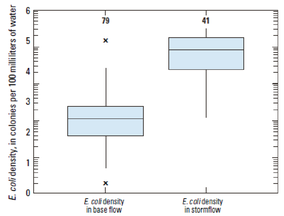


Figure 1. *E. Coli* bacteria density in urban and rural streams during base flow and stormflow.

Continuous water-quality monitoring and regression models estimate real-time chemical concentrations and loads and describe variability during storm runoff

- At least 90% of the sediment transported in the county's 5 largest watersheds occurred in less than 2% of the time (during large stormflows, fig. 2).
- In 2 watersheds with wastewater discharges, wastewater contributed at least 1/3 of the annual total nitrogen load and less than 3% of the annual indicator bacteria load
- The probability of exceeding primary contact criteria for *E. coli* bacteria was nearly 100% during four runoff events in June 2010 (fig. 3).
- Dissolved oxygen was less than the minimum state criteria of 5 mg/L about 15% of the time at the most urban site, and less than 5% at most other sites.
- About 10% of the time chloride concentrations in urban watersheds were elevated as a result of road-salt runoff.

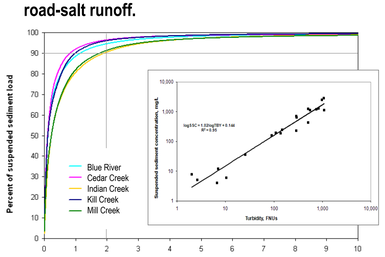


Figure 2. Example of regression model used to compute continuous suspended sediment and cumulative load duration curves for 5 stream sites.

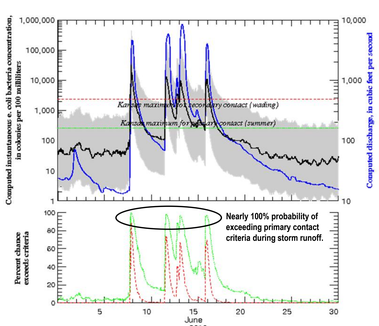


Figure 3. Computed *E. coli* density and probability of exceeding criteria.

Macroinvertebrate, periphyton, and habitat surveys describe biological conditions

- 5 of 22 streams met State criteria for full-support of aquatic life at least one year of the study (fig. 4).
- Each year biological samples were collected, about 1/2 of the stream sites monitored were non-supporting of aquatic life according to State criteria.
- Biological metrics generally reflected a gradient in land use, with the most disturbed streams located in the most urban areas and less disturbed streams located in rural areas (fig.5).

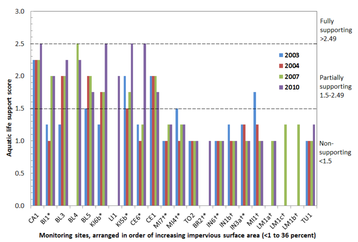
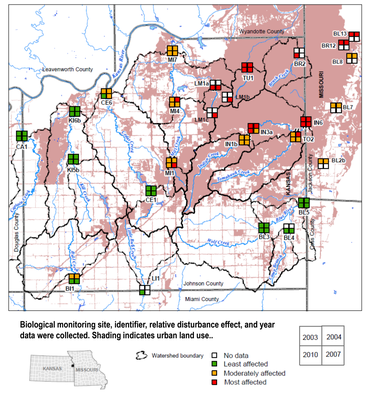


Figure 4. Aquatic life support scores for monitored stream sites.



Biological monitoring site, identifier, relative disturbance effect, and year data were collected. Shading indicates urban land use..

Figure 5. Relative disturbance on the basis of a 10-metric invertebrate score.

Data analyses identify relations among biological conditions and environmental variables and lead to suggestions for stream-quality improvement

- Invertebrate response to urbanization was generally linear rather than showing identifiable thresholds (fig. 6).
- Environmental factors most strongly correlated (Spearman's $r > 0.5$, $p < 0.001$) with favorable metric scores included :
  - Amount of upstream urbanization (-)
  - Dissolved solids in stream water (-)
  - PAHs in streambed sediment (-)
  - Density of stormwater entry points adjacent to streams (-)
  - Habitat measures related to sinuosity (+), healthy buffer conditions (+), substrate diversity (+), and sediment deposition (-)

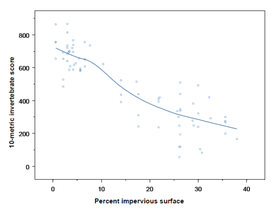


Figure 6. Invertebrate metric responses to watershed impervious surface using LOWESS smoothing.

Focused studies improve understanding of identified stream issues

Sediment transport and sources

- Larger, extended turbidity conditions occurred at sites affected by construction (fig. 7).
- Among smaller watersheds (3-17 mi^2), construction-affected sites transported more sediment than mature urban sites, and headwater sites transported more sediment than downstream sites.
- Among larger watersheds (49-66 mi^2), the oldest and most mature urban watershed transported double the sediment of urbanizing and nonurban watersheds.
- In addition to construction, sediment transport was affected by rainfall amount and intensity, streambed and bank erosion, channel slope, and legacy sediment deposition.

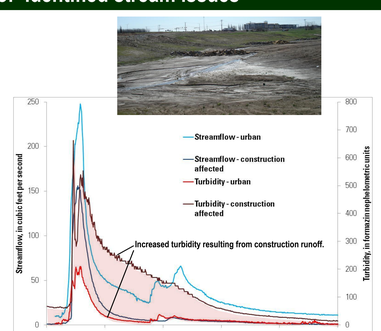


Figure 7. Effects of construction on turbidity at urban stream sites.

Summary

Multiple stream monitoring approaches that include discrete and continuous water-quality monitoring, streambed-sediment sampling, macroinvertebrate and periphyton sampling, in-stream and riparian habitat surveys, and land-use data provide the foundation for a comprehensive assessment of stream conditions in complex urbanizing watersheds.

This approach leads to important information for documenting current and changing stream conditions, evaluating compliance with water-quality standards and goals, and developing effective water-quality management programs.

In Johnson County, Kansas this approach led to the following general results:

- Stormwater runoff is a primary source of suspended sediment, nitrogen, phosphorus, indicator bacteria, and pesticides in both urban and rural areas.
- Generally, as impervious surface area increases, stream quality decreases.
- The most important management practices for protecting streams include reducing the effects of impervious surface, protecting stream corridors, and reducing sediment, nutrients, and chemicals at their sources and along transport pathways.

Important factors affecting quality of Johnson County streams include stormwater runoff, wastewater discharges, impervious surface, buffer conditions, and sediment deposition.

For additional information: http://ks.water.usgs.gov/studies/qw/joco/

References

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