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Johnson County Wastewater

Assessment of the Effects of Wastewater Discharge on Water Quality and Biological Conditions of the Upper Blue River in Johnson County, Kansas and Jackson County, Missouri

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Purpose and Scope

In 2007, the Johnson County Blue River Main Wastewater Treatment Facility was upgraded to include biological nutrient removal and increase capacity; regulatory requirements stipulate an evaluation to characterize the effects of wastewater discharge on the Blue River after upgrades are complete.

Assessment of Water Quality and Biological Conditions

The wastewater discharge likely impacted the water quality and biota of the Blue River; however, urbanization impacts also may play a role in the changing conditions downstream. Observed impacts include:

- Nutrient concentrations were an order of magnitude larger downstream from the wastewater discharge during low-flow conditions.
- The larger nutrient concentrations downstream likely caused increases in algal biomass at the downstream sites; decreased canopy cover (increased light penetration) also may have affected algal biomass at the downstream sites.
- Macroinvertebrate scores were substantially smaller at the downstream sites than the upstream site and the site immediately downstream from the wastewater discharge was nonsupporting of aquatic life during August, 2008.

Approach

During 2008–09, water-quality and biological conditions were assessed at 3 sites (1 upstream and 2 downstream) along a 6-kilometer (km) reach of the Blue River. Conditions were evaluated by:

- Collecting discrete water-quality samples for a range of flow conditions during 2008–09.
- Operating real-time water-quality monitoring sites located upstream and downstream from the wastewater discharge on Blue River during 2008–09.
- Conducting comprehensive habitat assessment during June, 2008.
- Collecting biological data, including macroinvertebrates and periphyton, during April and August, 2008. Chlorophyll samples were collected weekly during June–September, 2008.

Evaluation of substrate size and composition as part of the habitat assessment.

Study Area

The Blue River Basin is predominantly rural in Johnson County, Kansas, but receives wastewater discharge before entering Jackson County, Missouri, where the Basin becomes increasingly urban (fig. 1).

The three study sites, located along a 6-km reach of the Blue River (fig. 1), were:

- Kenneth Road, located approximately 2.5-km upstream from the wastewater discharge;
- 151st Street, located approximately 0.5-km downstream from the wastewater discharge; and
- Blue Ridge Boulevard, located approximately 2.5-km downstream from the wastewater discharge.

Urban land use (22 percent to 33 percent) and impervious surface area (3 percent to 16 percent) increased along the study reach (Poulton and others, 2007). The Blue River Main Wastewater Treatment Facility (fig. 1) discharges approximately 5.6 million gallons per day (8.7 cubic feet per second) and during low-flow (< 50 ft^3/s) conditions wastewater represents approximately 29 percent of total streamflow at Blue Ridge Boulevard.

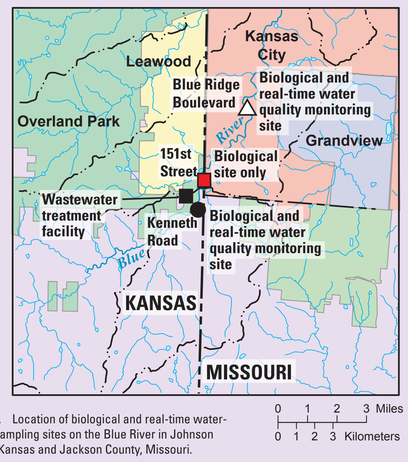

Figure 1. Location of biological and real-time water-quality sampling sites on the Blue River in Johnson County, Kansas and Jackson County, Missouri.

Water Quality

- Sites below the wastewater discharge had nutrient concentrations an order of magnitude larger than the upstream site during low-flow conditions, but not high flow conditions.
- Relations are being developed between continuously-monitored water-quality variables (dissolved oxygen, pH, temperature, specific conductance, and turbidity) and discrete water-quality samples to define average annual concentrations and loads of nutrients in the Blue River from waste-water effluent and non-point sources (fig. 3).
- Continuous dissolved oxygen data indicate that concentrations never fell below the Kansas Department of Health and Environment (KDHE) minimum criteria for aquatic life support (5 mg/L) in the Blue River during the study period.

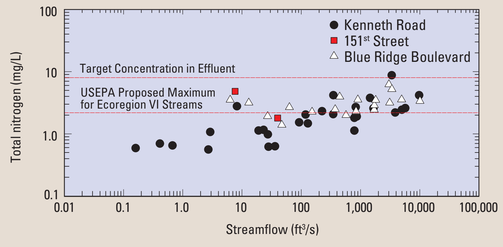

Figure 2. Relation between total nitrogen concentrations and streamflow in the Blue River. Kenneth Road data were collected during 2003-2008 and 151st Street and Blue Ridge Boulevard data were collected during 2008.

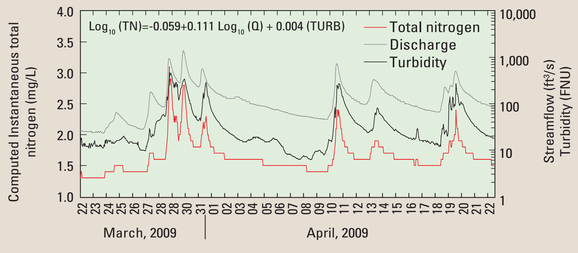

Figure 3. Real-time estimates of total nitrogen concentrations at the Kenneth Road site.

Habitat

- Total habitat scores indicate overall habitat condition was optimal at all sites (fig. 5).
- Canopy cover and riparian buffer width scores were suboptimal or marginal at the downstream sites likely because of increased urbanization (fig. 5).
- Riffle substrate fouling scores were suboptimal at the upstream site and marginal at the extreme downstream site corresponding to increases in algal biomass along the downstream gradient (fig. 5).

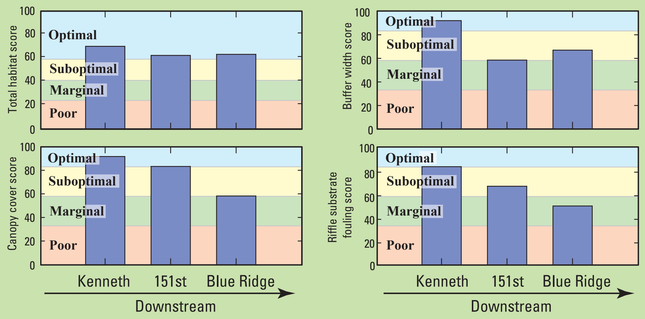

Figure 5. Site scores for selected habitat variables.

Periphyton

- Chlorophyll concentrations, an estimate of algal biomass, were twice as large at the extreme downstream site than the upstream site during April and August, 2008 though differences were not statistically significant (April p=0.27, August p=0.09) (fig. 6).
- April chlorophyll concentrations exceeded the nuisance threshold value of 100 milligrams per square meter (mg/m^2) (Welch and others, 1988) at all sites and were an order of magnitude larger than August chlorophyll concentrations (fig. 6).
- Chlorophyll concentrations consistently were larger at the downstream site than the upstream site (fig. 7), likely due to larger nutrient concentrations and reduced canopy cover.
- The relative abundance of nitrogen-heterotrophic diatoms, indicative of increased organic nitrogen concentrations, were significantly larger (all p<0.01) at the extreme downstream site than at the other sites (fig. 8).

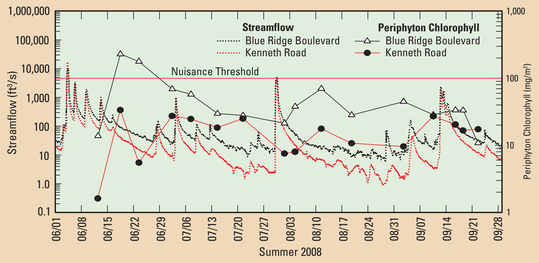

Figure 7. Periphyton chlorophyll concentrations at the Kenneth Road and Blue Ridge Boulevard sites during June through September, 2008.

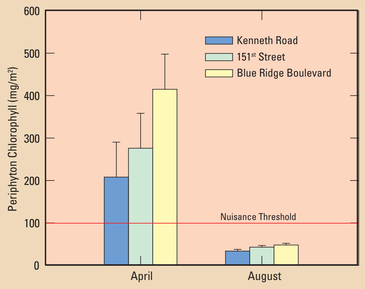

Figure 6. Periphyton chlorophyll concentrations during April and August, 2008.

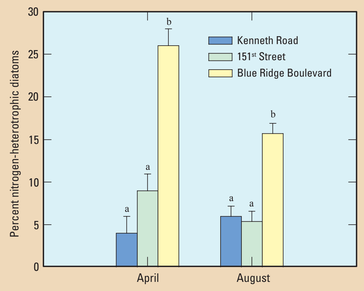

Figure 8. Percent nitrogen-heterotrophic diatoms during April and August, 2008.

Macroinvertebrates

- Based on the KDHE aquatic life support score for macroinvertebrates (KDHE, 2000), all three sites were characterized as partially supporting aquatic life in April, 2008; however, scores at the two downstream sites were significantly (p<0.01) smaller than the score at the upstream site (fig. 9).
- Scores at all sites were lower in August than in April and the site immediately downstream of the wastewater discharge was characterized as nonsupporting of aquatic life (fig. 9).

Macroinvertebrate sample collection.

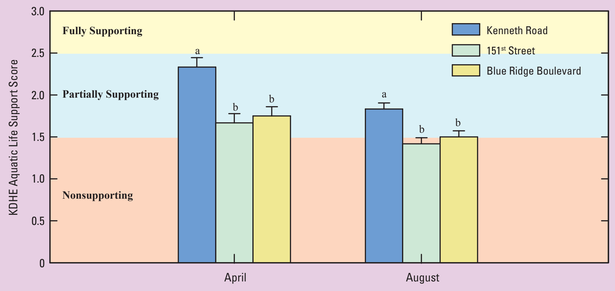

Figure 9. Kansas Department of Health and Environment aquatic life support scores during April and August, 2008.

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Blue River at Kenneth Road (upstream site).

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