Character and Trends of Water Quality in the Blue River Basin, Kansas City Metropolitan Area, Missouri and Kansas, 1998 through 2007

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Abstract

Water-quality and ecological character and trends in the metropolitan Blue River Basin were evaluated from 1998 through 2007 to provide spatial and temporal resolution to factors that affect the quality of water and biota in the basin combined sewer control and basin management plans. Assessments included measurements of stream discharge, pH, dissolved oxygen, specific conductance, turbidity, nutrients (dissolved and total nitrogen and phosphorus species), fecal-indicator bacteria (*Escherichia coli* and fecal coliform), suspended sediment, organic wastewater and pharmaceutical compounds, and sources of these compounds as well as the quality of stream biota in the basin.

Because of the nature and myriad of factors that affect basin water quality, multiple strategies are needed to decrease constituent loads in streams. Strategies designed to decrease or eliminate combined sewer overflows (CSOs) would substantially reduce the annual loads of nutrients and fecal-indicator bacteria in Brush Creek, but have little effect on Blue River loadings. Nonpoint source reductions to Brush Creek could potentially have an equivalent, if not greater, effect on water quality than would CSO reductions. Nonpoint source reductions could also substantially decrease annual nutrient and bacteria loadings to the Blue River and Indian Creek. Methods designed to decrease nutrient loads originating from Blue River and Indian Creek wastewater treatment plants (WWTPs) could substantially reduce the overall nutrient load in these streams.

For the main stem of the Blue River and Indian Creek, primary sources of nutrients were nonpoint source runoff and WWTPs discharges; however, the relative contribution of each source varied depending on how wet or dry the year was and the number of upstream WWTPs. On Brush Creek, approximately two-thirds of the nutrients originated from nonpoint sources and the remainder from CSOs. Nutrient assimilation processes, which reduced total nitrogen loads by approximately 13 percent and total phosphorus loads by double that amount in a 20-kilometer reach of the Blue River during three synoptic base-flow sampling events between August through September 2004 and September 2005, likely are limited to selected periods during any given year and may not substantially reduce annual nutrient loads. Bacteria densities typically increased with increasing urbanization, and bacteria loadings to the Blue River and Indian Creek were almost entirely the result of nonpoint source runoff. WWTPs contributed, on average, less than 1 percent of the bacteria to these reaches, and in areas of the Blue River that had combined sewers, CSOs contributed only minor amounts (less than 2 percent) of the total annual load in 2005. The bulk of the fecal-indicator bacteria load in Brush Creek also originated from nonpoint sources with the remainder from CSOs. From October 2002 through September 2007, estimated daily mean *Escherichia coli* bacteria density in upper reaches of the Blue River met the State of Missouri secondary contact criterion standard approximately 85 percent of the time. However, in lower Blue River reaches, the same threshold was exceeded approximately 45 percent of the time.

The tributary with the greatest number of CSO discharge points, Brush Creek, contributed approximately 10 percent of the bacteria loads to downstream reaches. The tributary Town Fork Creek had median base-flow *Escherichia coli* densities that were double that of other basin sites and stormflow densities 10 times greater than those in other parts of the basin largely because approximately one-fourth of the runoff in the Town Fork Creek Basin is believed to originate in combined sewers. Genotypic source typing of bacteria indicated that more than half of the bacteria in this tributary originated from human sources with two storms contributing the bulk of all bacteria sourced as human. However, areas outside of the combined sewer system also contributed substantially to elevated bacteria densities in basin streams.

From 1998 through 2007, flow-adjusted concentration trends at six sites in the basin were determined for as many as 22 constituents using fitted linear regression models that included concentration, flow, time, and in some cases, yearly or seasonal terms. Flow-adjusted concentration trends were not significant for approximately two-thirds of the constituents indicating that, in general, basin-level changes did not affect many constituent concentrations from 1998 through 2007. Where statistically significant flow-adjusted trends were detected, most (88 percent) were declines. Trend declines occurred primarily in flow-adjusted suspended sediment concentrations and water-quality constituents that have strong associations with suspended sediment. Flow-adjusted concentration declines may be related to a number of measures implemented in the basin since 1998 that were designed to control erosion and reduce sediment in runoff.

Nutrient and organic wastewater compound loads in the effluent-dominated Blue River were on average about 20 times greater than for the CSO-dominated Brush Creek. Seasonally, the largest contributions of nutrients, caffeine, n,n-diethyl-meta-toluamide (DEET), sterol (cholesterol plus coprostanol), and triclosan occurred between March to August, in part, because this mirrored the basin precipitation pattern and runoff was a primary component of loads. In effluent-dominated stream reaches of the Blue River and Indian Creek, reductions in WWTP removal efficiencies from December to February likely resulted in increased contributions during winter months, and increased biogeochemical activity during the summer resulted in increased efficiencies and proportionally smaller contributions. Peaks in DEET loads corresponded to the period (June to August) when expected use would be the highest.

Biological assessments included measurements of macroinvertebrate community diversity and abundance, habitat assessments, and toxicity evaluations. The diversity of benthic aquatic communities in the upper Blue River stream reaches was similar to sites in adjacent Johnson County, Kansas, which were least impacted by human disturbance. However, no stream reaches in the Blue River Basin or the outside control site met the criteria for full support of aquatic life from 2002 to 2007. Sites in lower basin reaches had the least diversity, the largest percentage of pollution tolerant organisms, and were considered nonsupportive of biologic life. Declines in aquatic community and health followed a pattern of increasing urbanization and, in general, these trends were reflected by similar declines in stream physical habitat quality. Channel modifications and riparian habitat loss accounted for the greatest difference between physical habitat scores at sites. Low-head dams in Brush Creek reduced stream circulation, increased sediment accumulation, and resulted in significantly lower median monthly dissolved-oxygen concentrations in Brush Creek than on the Blue River. Sediment trapping in Brush Creek impoundments likely resulted in median monthly turbidity values on the Blue River being approximately twice that of those measured in Brush Creek. The median monthly specific conductance on the Blue River was double that of Brush Creek because treated effluent comprised a large percentage of the flow in the Blue River and increased impervious cover in Brush Creek resulted in reduced infiltration and greater runoff. Large spikes in specific conductance values followed the application of road deicers and subsequent runoff events.