Water Quality Analysis of the Kaskaskia River Watershed

Final Report to:
Heartlands Conservancy, Inc.

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INTRODUCTION

The Kaskaskia River is the second largest river system in Illinois and is approximately 325 miles long and drains 5,752 m² of central and southwestern Illinois. It is an important natural feature which traverses 22 counties covering 10.2% of the entire state. The watershed is an ecologically rich resource with 9% forest cover including the largest contiguous forest track in the state and 4.5% wetland resources. Additionally, the significant difference in climate between the headwaters and the mouth of the river system has contributed to increased biodiversity in terms of native flora and fauna. The Kaskaskia River watershed is commonly divided into 4 sub-basins or reaches flowing north to south: Upper Kaskaskia Watershed, Carlyle Watershed, Kaskaskia/Shoal Creek Watershed and Lower Kaskaskia Watershed, which will be used in this project report.

In addition to natural resources, the Kaskaskia River Watershed is an important agricultural area in southwestern Illinois. Historical agricultural development in the watershed has significantly modified the hydrology of the Kaskaskia River. Agriculture is the primary land use (82%) in the watershed. Of the agricultural land, 63% is cropland with corn and soybeans as the major crops produced. Livestock production is another significant land use in the basin. The significant agricultural production and urban and suburban development in the watershed has increased concern about non-point source pollution that contribute sediment and nutrients to surface waters. There has been significant interest in conservation practice adoption and afforestation of the agricultural land in the watershed. Water quality has been monitored in the region since the 1970’s or earlier. In 2006 and 2007, a baseline water quality trend analysis was conducted utilizing data from 1980 to 2004 from 14 monitoring stations grouped according to their location on a tributary or the main stem of the Kaskaskia River. The objective of this
project was to update the water quality trend analysis with data from 2005 to 2014 and develop a list of best management practices to address specific impairments and help target future restoration efforts.

METHODOLOGY

Land Cover Data

Land cover data were obtained from the United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS) Illinois Cropland Data Layer (CDL) Program (2007) which provides a geo-referenced, crop-specific land cover raster data layer. This report uses qualitative assessment of the land cover data for the watershed boundaries in relation to the water quality trend observed.

Water Quality Data (EPA STORET)

Existing records of 14 stream monitoring stations in the Kaskaskia River Watershed were used to compile the water quality data. The data from 2005-2014 were obtained from an official at the Illinois Environmental Protection Agency (IEPA) Storage and Retrieval (STORET) Legacy Data Center. The 14 monitoring stations were the same as those included in the initial water quality analysis in 2006 and 2007. These 14 stations had the most complete water quality data sets for the period of record and the breadth of parameters measured. The 14 stations were divided into four Illinois Department of Natural Resources (IDNR) Ecosystem Partnerships, as they were in the original analysis (Table 1).

Daily Discharge Data (USGS)

The daily discharge data for all the 14 monitoring stations were obtained from the United States Geological Survey’s (USGS) National Water Information System (NWIS) database. The
discharge data for one of the monitoring stations, Crooked Creek near Hoffman, IL (OJ-08), was only collected from 1974 to 1998, so discharge data from 2005 to 2014 was calculated using the 2005 to 2014 stage data and the rating curve developed in 1998.

Study Area

![Study area for the water quality assessment in the Kaskaskia River Watershed](image)

Figure 1 Study area for the water quality assessment in the Kaskaskia River Watershed
Table 1 Fourteen monitoring stations in the Kaskaskia River Watershed divided into four Illinois Department of Natural Resources (IDNR) Ecosystem Partnerships

<table>
<thead>
<tr>
<th>Monitoring Stations</th>
<th>Drainage Area (mi²)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Kaskaskia Ecosystem Partnership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaskaskia River at Cooks Mills, IL (O-02)</td>
<td>474.83</td>
<td>Main-Stem</td>
</tr>
<tr>
<td>Kaskaskia River at Shelbyville, IL (O-11)</td>
<td>1058.07</td>
<td>Main-Stem</td>
</tr>
<tr>
<td>West Okaw River near Lovington, IL (OT-02)</td>
<td>112.43</td>
<td>Tributary</td>
</tr>
<tr>
<td><strong>Carlyle Lake Ecosystem Partnership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaskaskia River at Carlyle, IL (O-07)</td>
<td>2729.5</td>
<td>Main Stem</td>
</tr>
<tr>
<td>Kaskaskia River at Vandalia, IL (O-08)</td>
<td>1947.49</td>
<td>Main-Stem</td>
</tr>
<tr>
<td>Kaskaskia River at Cowen, IL (O-10)</td>
<td>1335.14</td>
<td>Main-Stem</td>
</tr>
<tr>
<td>East Fork Kaskaskia River near Sandoval, IL (OK-01)</td>
<td>113.44</td>
<td>Tributary</td>
</tr>
<tr>
<td>Hurricane Creek near Mulberry, IL (OL-02)</td>
<td>152.59</td>
<td>Tributary</td>
</tr>
<tr>
<td><strong>Shoal Creek/Kaskaskia River Ecosystem Partnership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaskaskia River near Venedy Station, IL (O-20)</td>
<td>4393.01</td>
<td>Main-Stem</td>
</tr>
<tr>
<td>Shoal Creek near Breese, IL (OJ-08)</td>
<td>1947.49</td>
<td>Tributary</td>
</tr>
<tr>
<td>Crooked Creek near Hoffman, IL (OJ-08)</td>
<td>254.98</td>
<td>Tributary</td>
</tr>
<tr>
<td><strong>Lower Kaskaskia/Silver Creek Ecosystem Partnership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Richland Creek near Hecker, IL (OC-04)</td>
<td>129.49</td>
<td>Tributary</td>
</tr>
<tr>
<td>Silver Creek near Troy, IL (OD-06)</td>
<td>154.59</td>
<td>Tributary</td>
</tr>
<tr>
<td>Silver Creek near Freeburg, IL (OD-07)</td>
<td>465.79</td>
<td>Tributary</td>
</tr>
</tbody>
</table>

Water Quality Parameters

Table 2 Water quality parameters and the corresponding period of record analyzed

<table>
<thead>
<tr>
<th>Water Quality Parameters</th>
<th>Year of Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium-N</td>
<td>2005-2014</td>
</tr>
<tr>
<td>Dissolved Phosphorus</td>
<td>2005-2014</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>2005-2013</td>
</tr>
<tr>
<td>Fecal Coliform</td>
<td>2006-2014</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>2005-2014</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>2005-2014</td>
</tr>
<tr>
<td>Turbidity</td>
<td>2005-2013</td>
</tr>
</tbody>
</table>
Illinois Integrated Water Quality Report

IEPA published the Illinois Integrated Water Quality Report in 2006 that provides the federal government and the public with information about the condition of surface and ground water in Illinois. The study investigated 21.6 percent of stream miles and 46.1 percent of lake acres in Illinois. The report includes the 303(d) list which includes a list of impaired waters in the state, and the stream or river segments and lakes on the list are prioritized for Total Maximum Daily Load (TMDL) plan development under the authority of the Clean Water Act. The list specifies the potential sources of water quality impairment within the watershed, and the major sources of water quality impairment in the watershed are crop production, municipal point source discharges, urban runoff/storm sewers, animal feeding operations and livestock grazing.

Eutrophication and Hypoxia

Agricultural runoff in the eastern and Midwestern U.S. have been identified as a major source of nutrients to the Mississippi River (Table 3). Export of large quantities of nitrogen and phosphorus due to extensive fertilization and artificial drainage such as tile drainage have contributed to the eutrophication of downstream water bodies such as the Gulf of Mexico. Eutrophication is the process of over-enrichment of a water body with nutrients that enhances primary production through plant and algal growth (Figure 2). The subsequent bacterial decomposition of the increased organic matter increases oxygen consumption resulting in hypoxic conditions (less than 2 mg L$^{-1}$ dissolved oxygen) in the water body. The hypoxic conditions in the Gulf of Mexico create a seasonal “dead zone” that affects both fish and other aquatic ecosystems. The process is natural, but anthropogenic activities can accelerate the rate and extent of the process. Freshwater eutrophication generally occurs in lakes and ponds due to longer residence times, but can also occur in streams.
Table 3 Typical nutrient levels in streams of the Eastern U.S. (Adapted from: Omernik 1976. The influence of land use on stream nutrient levels. U.S. Environmental Protection Agency. EPA-600/3-76-014.)

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Total N (mg L(^{-1}))</th>
<th>Nitrate-N (mg L(^{-1}))</th>
<th>Total-P (mg L(^{-1}))</th>
<th>Dissolved-P (mg L(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>4.17</td>
<td>3.19</td>
<td>0.132</td>
<td>0.058</td>
</tr>
<tr>
<td>Forest</td>
<td>0.95</td>
<td>0.23</td>
<td>0.014</td>
<td>0.006</td>
</tr>
<tr>
<td>Urban</td>
<td>1.29</td>
<td>1.25</td>
<td>0.06</td>
<td>0.033</td>
</tr>
</tbody>
</table>

Figure 2 In-lake relationship between phosphorus and chlorophyll-a (Adapted from: US EPA, 1974)

Data Analysis

The periodic daily concentration of each parameter was compiled, and flow weighted averages were calculated for each day using Equation 1. An annual mean flow-weighted average for each station was determined and plotted over time, and compared with the baseline data. Linear lines were fitted to the baseline and current data to display and compare the water quality trends. Water quality parameter data for the West Okaw River near Lovington, IL were only available for the year 2005 and 2006, so the water quality trend was not analyzed. Among the
Ecosystem Partnerships, the overall mean values for each parameter were compared by main-stem and tributary stations with an ANOVA procedure in a statistical software program (SAS) version 9.4. The statistical significance for the test was set at alpha = 0.05.

Equation 1:

\[
\text{Flow weighted average} = \frac{\text{Daily Concentration (mg L}^{-1}\text{)} \times \text{Daily Discharge (L s}^{-1}\text{)}}{\text{Average Monthly Discharge (L s}^{-1}\text{)}}
\]

Illinois EPA Standards

Under title 35, section 302 of the Illinois Administrative Code, the water quality parameters analyzed in the study, except for turbidity, are regulated with IEPA standards (Table 4).

Table 4 Federal criteria and Illinois Environmental Protection Agency (IEPA) standards for water quality parameters under title 35, section 302 of the Illinois Administrative Code

<table>
<thead>
<tr>
<th>Parameters</th>
<th>IEPA Standard</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium-N</td>
<td>Total ammonia nitrogen as N must in no case exceed 15 mg L(^{-1}). National Criteria for Ammonia in freshwater is 1.9 mg L(^{-1}).</td>
<td>302.212</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Dissolved oxygen shall not be less than 6.0 mg L(^{-1}) during at least 16 hours of any 24-hour period, nor less than 5.0 mg L(^{-1}) at any time</td>
<td>302.206</td>
</tr>
<tr>
<td>Fecal Coliform</td>
<td>During the months of May through October, based on a minimum of five samples taken over not more than a 30-day period, fecal coliform shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 ml in protected waters</td>
<td>302.209</td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>10 mg L(^{-1}) shall not be exceeded for drinking water intake</td>
<td>302.304</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>The USEPA standard for phosphorus in streams or rivers is 0.1 mg L(^{-1}). Phosphorus shall not exceed 0.05 mg L(^{-1}) in any reservoir or lake with a surface area of 20 acres or more, or in any stream at the point where it enters any such lake or reservoir</td>
<td>302.205</td>
</tr>
</tbody>
</table>
Best Management Practices and Water Quality

Based on the observed water quality trends, appropriate Best Management Practices (BMPs) are discussed for each Ecosystem Partnership. Table 5 shows the various applicable BMPs based on water quality impairments used for the analysis.

Table 5 Various applicable Best Management Practices (BMPs) based on water quality impairments

<table>
<thead>
<tr>
<th>Water Quality Impairments</th>
<th>Animal Feeding Operations BMPs</th>
<th>Conservation Tillage</th>
<th>Conservation Buffers</th>
<th>Livestock BMPs</th>
<th>Nutrient Management</th>
<th>Tile Drainage Management</th>
<th>Urban BMPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium-N</td>
<td>Green</td>
<td></td>
<td></td>
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<tr>
<td>Dissolved Oxygen</td>
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<tr>
<td>Fecal Coliform</td>
<td>Green</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrate-N</td>
<td>Green</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Phosphorus</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
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</tbody>
</table>
RESULTS

Upper Kaskaskia River Ecosystem Partnership

Stations

- Kaskaskia River at Cooks Mills, IL (474.83 mi²)
- West Okaw River near Lovington, IL (112.43 mi²)
- Kaskaskia River at Shelbyville, IL (1058.07 mi²)

303d List Streams

18 streams segments/lakes included on the list (Appendix)

Potential sources of water quality impairments

- 17 unknown
- 8 crop production
- 1 littoral/shore area modifications
- 1 runoff from forest/grassland/parkland
- 1 other recreational pollution

Water Quality Analysis

Figure 3a Ammonium-N

Figure 3b Dissolved Oxygen
Figure 3c Fecal Coliform

Figure 3d Nitrate-N

Figure 3e Turbidity

Figure 3f Total Phosphorus
The Upper Kaskaskia Ecosystem Partnership includes the headwaters of the watershed and drains the area north of Lake Shelbyville. The basin has more agricultural area than forest cover compared to the portions of the watershed to the south. In many areas in the basin, one of the common agricultural practices is tile drainage that enhances direct delivery of agricultural runoff along with sediment and nutrients to stream systems. The nitrate-N levels indicate that nitrate is the nutrient of concern in this basin. The Illinois EPA 303(d) list has indicated crop land as the leading potential source and nitrogen as the leading cause of stream impairment in the basin.

Similar to the baseline data, the overall mean nitrate-N was observed to be highest in the Upper Kaskaskia Ecosystem Partnership (16.49 ±1.25 mg L⁻¹, N=117) (Appendix A-1) but with a decreasing trend over time (Figure 3d). Among the stations in the region, Kaskaskia River at
Cooks Mills had the highest level of nitrate-N (19.59 ± 3.47 mg L⁻¹), exceeding the IL EPA safe drinking water standard of 10 mg L⁻¹ in approximately 60% of the annual mean values (Figure 4d).

Overall mean total phosphorus was lowest in the region (0.13 ± 0.04 mg L⁻¹, N=141) (Appendix A-1) and showed an increasing trend over time (Figure 3f). Similarly, the overall mean dissolved phosphorus was lowest in the region (0.08 ± 0.02 mg L⁻¹, N=140) and showed a slightly increasing trend over time (Figure 3g). Among the three stations, Kaskaskia River at Cooks Mills had the highest levels for both total and dissolved phosphorus, 0.18± 0.02 mg L⁻¹ and 0.13± 0.02 mg L⁻¹, respectively. Both phosphorus levels exceeded the IL EPA standard of 0.05 mg L⁻¹ over the entire study period.

Mean turbidity was lowest in the region (18.73 ± 13.52 mg L⁻¹, N=164) (Appendix-A1) and showed a strongly decreasing trend over time (Figure 3e). The highest levels were measured in the West Okaw River (48.19 ± 10.18 NTU).

Mean fecal coliform levels in the region were the highest among the ecosystem partnerships (2687.16 ± 564.62 CFU/100ml, N=73) (Appendix-A1), and showed no evident trend over time. Kaskaskia River at Cooks Mills had the highest fecal coliform level (4675.21 ± 982.9 CFU/100ml), exceeding the IL EPA standard of 400 CFU/100ml over the entire study period.

The region had the highest ammonium levels (0.14 ± 0.02 mg L⁻¹, N=99) (Appendix-A1), with no apparent trend over time. Though, it was apparent that total nitrogen levels were dominated by nitrate rather than ammonium, as expected. Among the three stations in the
region, the highest ammonium level was observed in Kaskaskia River at Shelbyville (0.21 ± 0.06 mg L$^{-1}$).

Best Management Practices for the Upper Kaskaskia Ecosystem Partnership

BMPs in the regions should be focused on minimizing the transport of nitrate-N since the region has relatively high levels of nitrate-N. Nutrient management practices that reduce fertilizer inputs and drainage management methods that increases denitrification processes before the agricultural runoff enters any stream system should be targeted in the region.

- Nutrient management planning (variable rate technology)
- Tile drainage management (saturated buffers, control structures, in-field bioreactors, constructed wetlands)
Kaskaskia River at Cooks Mills, IL

Location: Upper Kaskaskia Ecosystem Partnership
Main-stem Station

Drainage Area: 474.83 mi²

USGS Gauging Station Number: 05591200

IL EPA Identification Number: O-02

Water Quality Analysis

Figure 4a Ammonium-N

Figure 4b Dissolved Oxygen
The Cooks Mills station is the northern most station on the Kaskaskia River located above Lake Shelbyville. It has small drainage area compared to other main-stem stations, so it experiences lesser dilution effect compared to the downstream stations. The station, hence, functions like a tributary with the trends of water quality similar to that of other tributaries. This station had higher values of all parameters, except ammonium and turbidity, compared to other stations in the Ecosystem Partnership.

The highest level of mean nitrate-N (28.39 ±2.29 mg L⁻¹, N=51) was observed in the station compared to other main-stem stations. Intense row-crop agriculture and tile drainage in the region may contribute to the high level of nitrate. However, the station did show a recent,
significant decreasing trend in nitrate-N levels, below the standard for years 2011 to 2014 (Figure 4d).

Mean total phosphorus was 0.18 ±0.03 mg L\(^{-1}\) (N=69) and the mean dissolved phosphorus was (0.12±0.02 mg L\(^{-1}\)) (N=68) at the station. Both total and dissolved phosphorus showed similar, slightly decreasing, trends over time. The mean levels of both types of phosphorus exceeded the IL EPA standard 0.05 mg L\(^{-1}\) over the entire study period (Figure 4f & 4g).

Compared to other main stems, mean fecal coliform level was highest at the station (4880.51± 921.1 CFU/100ml, N=35). Compared to the baseline data that were closer to the IL EPA standard 400 CFU/100ml, the fecal coliform levels remained above the standard throughout the study period (Figure 4c).

Mean dissolved oxygen level (8.04 ±0.73 mg L\(^{-1}\), N=79) at the station did not differ significantly from other main-stem stations and was above the IL EPA standard of 4 mg L\(^{-1}\) and showed a slightly increasing trend (Figure 4b). Similarly, mean ammonium (0.10 ±0.03 mg L\(^{-1}\), N=49) at the station was not significantly different from other main stations, showed a decreasing trend, and was below the national criteria for ammonia in fresh water 1.9 mg L\(^{-1}\) over the entire study period (Figure 4a).

Mean turbidity (25.31 ±6.25 NTU, N=79) was lower than the overall mean value for all the main-stem stations (52.43 ±22.18 NTU, N=443). No significant change in the turbidity level compared to the baseline data was observed and no apparent trend was observed over the study period (Figure 4e).
Management Implications

The main water quality concerns were nitrate and phosphorus, so BMPs should focus specifically on nutrient management and tile drainage management to reduce the amount of nitrate and phosphorus in agricultural runoff. Since fecal coliform level is highest at the station and above the IL EPA standard, BMPs should also focus on reducing fecal contamination through manure management and limiting access of animals to water resources.

Kaskaskia River at Shelbyville, IL

Location: Carlyle Lake Ecosystem Partnership

Main-stem Station

Drainage Area: 1058.07 mi²

USGS Gauging Station Number: 05592000

IL EPA Identification Number: O-11

Water Quality Analysis

![Figure 5a Ammonium-N](image1)

![Figure 5b Dissolved Oxygen](image2)
Figure 5 Mean annual flow-weighted values of the water quality parameters for the Kaskaskia River at Cooks Mills, IL

The station is located directly below Lake Shelbyville. Compared to other stations in the Ecosystem Partnerships, the station had lower values of all parameters except for dissolved oxygen and ammonium. This is likely attributed to deposition of sediment and associated contaminants (nutrients and fecal coliform) within the reservoir. The observed water quality is indicative of discharges below large impoundments.

The mean nitrate-N level (3.44 ±2.62 mg L⁻¹, N=39) was below the EPA standard throughout the study period. Similar to the baseline, the nitrate-N levels showed a decreasing trend (Figure 5d). Mean total phosphorus was (0.07 ±0.05 mg L⁻¹, N=55) was below the standard 0.1 mg L⁻¹ except for the years 2009 and 2013. Mean dissolved phosphorus (0.04±0.03 mg L⁻¹,
N=55) was below the EPA standard 0.1 mg L\(^{-1}\). Both total and dissolved phosphorus showed a similar, increasing trend over time (Figure 5f & 5g).

Compared to other main stems, mean fecal coliform level was lowest at this station (40.02± 803.45 CFU/100ml, N=29). The fecal coliform levels remained below the IL EPA standard 400 CFU/100ml throughout the entire study period. In contrast to the increasing trend showed by the baseline data, the fecal coliform levels showed a slightly decreasing trend over the study period (Figure 5c).

Mean dissolved oxygen level (10.44 ±1.05 mg L\(^{-1}\), N=66) at the station did not differ significantly from other main-stem stations and was above the IL EPA standard of 4 mg L\(^{-1}\) and showed a slightly decreasing trend (Figure 5b).

Mean ammonium (0.19 ±0.03 mg L\(^{-1}\), N=39) at the station was the highest compared to the other main-stem stations and showed an increasing trend. However, all the ammonium levels were below the national criteria for ammonia in fresh water 1.9 mg L\(^{-1}\) over the entire study period (Figure 5a).

Mean turbidity (10.86 ±19.86 NTU, N=66) was lowest among all the main-stem stations. Compared to the increasing trend in the baseline data, the turbidity levels showed a decreasing trend over the study period (Figure 5e).

Management Implications

Similar to the station at Cooks Mills, the main concern at Shelbyville appeared to be nitrate and phosphorus. Hence, BMPs should primarily focus on nutrient management and tile drainage management to reduce the amount of nitrate and phosphorus in agricultural runoff.
Carlyle Lake Ecosystem Partnership

Stations:
- Kaskaskia River at Cowen, IL (1335.14 mi²)
- Kaskaskia River at Vandalia, IL (1947.49 mi²)
- Hurricane Creek near Mulberry, IL (152.59 mi²)
- East Fork Kaskaskia River near Sandoval, IL (113.44 mi²)
- Kaskaskia River at Carlyle, IL (2729.498 mi²)

303d Streams:
- 17 streams/lakes included on list (complete list in Appendix)

Potential Sources of Impairment
- 14 unknown sources
- 8 crop production
- 2 surface mining
- 2 abandoned mine lands (inactive)
- 2 littoral / shore area modifications
- 1 municipal point source discharge
- 1 urban runoff / storm sewers
- 1 other recreational pollution sources
- 1 runoff from forest / grassland / parkland
Water Quality Analysis

Figure 6a Ammonium-N

Figure 6b Dissolved Oxygen

Figure 6c Fecal Coliform

Figure 6d Nitrate-N
Figure 6 Mean annual flow-weighted values of the water quality parameters for the Carlyle Lake Ecosystem Partnership

Figure 6e Turbidity

Figure 6f Total Phosphorus

Figure 6g Dissolved Phosphorus
The Carlyle Lake Ecosystem Partnership is located between Lake Shelbyville and Carlyle Lake, and drains the land in the Kaskaskia River basin above Carlyle Lake. Similar to the Upper Kaskaskia Ecosystem Partnership, agriculture is the primary land use, but there are other significant land uses such as forested areas in the region. The Illinois 303(d) list shows crop production as the major source of stream impairment in the region.

Similar to the baseline data, the overall mean nitrate-N (1.78 ±1.04 mg L⁻¹, N=200) was lower than the Upper Kaskaskia Ecosystem Partnership but higher than the Shoal Creek/Kaskaskia River Ecosystem Partnership (0.89 ±1.75 mg L⁻¹, N=137) (Appendix A-1). A slightly increasing trend over time was observed for nitrate-N levels (Figure 6d).

Overall mean total phosphorus (0.23 ± 0.03 mg L⁻¹, N=296) was higher than the mean for the Upper Kaskaskia Ecosystem Partnership but lower than the Shoal Creek/Kaskaskia River Ecosystem Partnership (0.42 ±0.05 mg L⁻¹, N=188) (Appendix A-1). Total phosphorus levels showed a slightly increasing trend whereas dissolved phosphorus levels showed no apparent trend over time (Figure 6f). Both phosphorus levels exceeded the IL EPA standard of 0.05 mg L⁻¹ over the entire study period.

Mean turbidity (63.49 ± 10.90 mg L⁻¹, N=326) was higher than the mean for the Upper Kaskaskia Ecosystem Partnership but lower than the Shoal Creek/Kaskaskia River Ecosystem Partnership (84.71 ± 18.79 mg L⁻¹, N=326) (Appendix-A1). There was a slightly increasing trend in turbidity (Figure 6e). The highest turbidity levels were measured in the West Hurricane Creek near Mulberry (185.77 ± 57.28 NTU).

Mean fecal coliform levels in the region was lowest compared to the other ecosystem partnerships (513.21 ± 442.92 CFU/100ml, N=148) (Appendix-A1). The overall trend was
increasing and 50% of the mean values were above the IL EPA standard (400 CFU/100ml) (Figure 6c).

Mean ammonium level (0.11 ± 0.02 mg L\(^{-1}\), N=193) was lower than the mean for the Upper Kaskaskia Ecosystem Partnership but higher than the Shoal Creek/Kaskaskia River Ecosystem Partnership (0.08 ± 0.03 mg L\(^{-1}\), N=133) (Appendix-A1). Although the ammonium levels remained below the national criteria for ammonia in freshwater (1.9 mg L\(^{-1}\)), an overall increasing trend was observed (Figure 6a).

Best Management Practices for the Carlyle Lake Ecosystem Partnership

Most stations in the region showed high total phosphorus levels compared to dissolved phosphorus levels indicating transport of more sediment bound particulate phosphorus than dissolved phosphorus. The region also has an increasing trend for turbidity. Further, nitrate levels indicate an increasing trend although they remain below the IL EPA standard. Hence, BMPs in the region should focus on decreasing nutrient inputs to prevent phosphorus loss and reducing erosion and surface runoff to prevent transport of sediment bound phosphorus. This can be accomplished through adoption of no-till and conservation tillage practices and establishment of cover crops and riparian buffers. To address increasing trend of high fecal coliform levels, BMPs should also focus on proper management of waste and surface runoff from animal feeding operations.

- Reducing erosion by surface runoff (no-till and conservation tillage, grassed waterways, cover crops, riparian buffers)

Kaskaskia River at Cowden, IL

Location:  Carlyle Lake Ecosystem Partnership
Main-stem Station
Drainage Area: 1335.14 mi²
USGS Gauging Station Number: 05592100
IL EPA Identification Number: O-10

Water Quality Analysis

Figure 7a Ammonium-N

Figure 7b Dissolved Oxygen

Figure 7c Fecal Coliform

Figure 7d Nitrate-N
Figure 7c Fecal Coliform

Figure 7d Nitrate-N

Figure 7e Turbidity

Figure 7f Total Phosphorus
The Cowden monitoring station is located close to the station at Shelbyville, Illinois. The water quality parameters show a similar trend observed at the Shelbyville station, except for nitrate and phosphorus and turbidity, possibly because of the effect of the Lake Shelbyville reservoir.

Mean nitrate-N levels remained below the IL EPA standard 10 mg L\(^{-1}\) but showed an increasing trend (Figure 7d). Similar to the baseline data, mean total phosphorus levels showed no evident change and annual means were higher compared to that of station at Shelbyville. Total phosphorus levels remained closer to the IL EPA standard (0.1 mg L\(^{-1}\)) (Figure 7f). Dissolved phosphorus levels remained below the IL EPA standard (0.1 mg L\(^{-1}\)) and showed a decreasing trend (Figure 7g).
Mean fecal coliform level was significantly higher at the station (274.98±927.8 CFU/100ml, N=31). Similar to the Shelbyville station, fecal coliform levels showed decreasing trend over time and the fecal coliform levels remained below the IL EPA standard 400 CFU/100ml standard, except in 2006 and 2010 (Figure 7c).

Management Implications

Although nitrate-N and phosphorus levels were below their respective IL EPA standards, BMPs in the drainage area should focus on nutrient management to reduce the nutrient loads in agricultural runoff.
Kaskaskia River at Vandalia, IL

Location: Carlyle Lake Ecosystem Partnership
Main-stream Station

Drainage Area: 1947.49 mi²

USGS Gauging Station Number: 05592500

IL EPA Identification Number: O-08

Water Quality Analysis

**Figure 8a Ammonium-N**

**Figure 8b Dissolved Oxygen**
Figure 8c Fecal Coliform

Figure 8d Nitrate-N

Figure 8e Turbidity

Figure 8f Total Phosphorus
Figure 8g Dissolved Phosphorus

Figure 8 Mean annual flow-weighted values of the water quality parameters for the Kaskaskia River at Vandalia, IL.

The Vandalia station represents the midpoint between Lake Shelbyville and Carlyle Lake on the main-stem of the Kaskaskia. Smaller tributaries are located south of Lake Shelbyville and north of this monitoring station.

Mean nitrate-N levels remain below the IL EPA standard of 10 mg L$^{-1}$, but show a slightly increasing trend (Figure 8d). Annual means of both total and dissolved phosphorus showed an increasing trend and exceeded the IL EPA standard 0.05 mg L$^{-1}$, except for dissolved phosphorus in 2006 and 2013 (Figure 8f & 8g).

Mean turbidity levels showed an increasing trend (Figure 8e). Similarly, the overall trend for mean fecal coliform level is an increasing trend with a sudden increase in 2009 exceeding the
IL EPA standard 400 CFU/100ml, but followed a decreasing trend afterwards that dropped below the standard in 2013 (Figure 8c).

Management Implications

Beginning at the Vandalia station, phosphorus become the nutrient of concern compared to nitrate. Further, an increasing trend in turbidity level is also observed, so BMPs should also focus in reducing surface runoff to prevent sediment and sediment bound phosphorus transport by agricultural runoff. Although fecal coliform levels are decreasing and the most recent data show the level is below the IL EPA standard, it should be monitored to ensure the levels remain below the standard.
Hurricane Creek near Mulberry, IL

Location: Carlyle Lake Ecosystem Partnership
Tributary Station

Drainage Area: 152.59 mi²

USGS Gauging Station Number: 05592600

IL EPA Identification Number: OL-02

Water Quality Analysis

Figure 9a Ammonium-N

Figure 9b Dissolved Oxygen
Hurricane Creek drains directly into the north portion of Carlyle Lake. Compared to other tributaries, the drainage area is comprised of larger portions of upland and forest areas.

Annual means for both total and dissolved phosphorus showed a slightly increasing trend (Figure 9f & 9g). The overall mean value total phosphorus (0.37 ±0.13 mg L⁻¹, N=70) is seven times and the overall mean dissolved phosphorus (0.16 ±0.03 mg L⁻¹, N=64) is three times the IL EPA standard (0.05 mg L⁻¹).

Mean dissolved oxygen levels showed no apparent trend and were above the IL EPA standard 4 mg L⁻¹, except in 2006 and 2009, but were very close to the standard level (Figure 9b). Similarly, mean fecal coliform levels were below the IL EPA standard (400 CFU/100ml), except in 2005, 2009 and 2010, but were very close to the standard level (Figure 9c). Mean
turbidity level in the station showed a slightly increasing trend with a sudden spike in 2011 (Figure 9e).

Management Implications

The main concern at the station was phosphorus, so BMPs should focus specifically on nutrient management and reducing runoff to reduce the amount of phosphorus entering the creek. Since Hurricane Creek is a direct tributary of Carlyle Lake, high phosphorus levels are of particular concern, as they can contribute to eutrophication of freshwater systems.
Kaskaskia River at Carlyle, IL

Location: Carlyle Lake Ecosystem Partnership Main-stem Station

Drainage Area: 2729.50 mi$^2$

USGS Gauging Station Number: 05593000

IL EPA Identification Number: O-07

Water Quality Analysis

Figure 10a Ammonium-N

Figure 10b Dissolved Oxygen

*National Criteria for Ammonia in Fresh Water is 1.9 mg L$^{-1}$
Figure 10c Fecal Coliform

Figure 10d Nitrate-N

Figure 10e Turbidity

Figure 10f Total Phosphorus
Figure 10 Mean annual flow-weighted values of the water quality parameters for the Kaskaskia River at Vandalia, IL

This monitoring station lies directly below Carlyle Lake. Similar to the station at Shelbyville, IL that lies immediately below Lake Shelbyville, the drainage area also experiences settling and dilution effects.

Mean turbidity levels show an overall increasing with a sharp increase in 2011. Annual means for both total and dissolved phosphorus show a decreasing trend (Figure 10f & 10g). Both phosphorus level remained well above the IL EPA standard (0.1 mg L$^{-1}$), except for dissolved phosphorus in 2013.

Management Implications

Of particular concern for eutrophication issues, dissolved phosphorus accounted for the majority of total phosphorus. Therefore, BMPs in this region should focus on nutrient
management and conservation practices to reduce dissolved phosphorus loads, such as cover crops and riparian buffers.

Shoal Creek/Kaskaskia River Ecosystem Partnership

Stations:
- Shoal Creek near Breese, IL (1947.49 mi²)
- Crooked Creek near Hoffman, IL (254.98 mi²)
- Kaskaskia River near Venedy Station, IL (4393 mi²)

303d List Streams:
- 52 streams/lakes included on list (complete list in Appendix)

   Potential Sources of Impairment
   - 34 crop production
   - 27 unknown
   - 16 municipal point source discharges
   - 15 animal feeding operations
   - 14 urban runoff / storm sewers
   - 4 littoral / shore area modifications
   - 3 other recreational pollution sources
   - 3 runoff from forest / grassland / parkland
   - 2 contaminated sediments
   - 2 on-site treatment systems (septic systems and similar decentralized systems)
   - 1 waterfowl
   - 1 industrial point source discharge

Note the increased importance of municipal point source discharges, animal feeding operations, and urban runoff / storm sewers in this region.
Water Quality Analysis

Figure 11a Ammonium-N

Figure 11b Dissolved Oxygen

Figure 11c Fecal Coliform

Figure 11d Nitrate-N
Figure 11 Mean annual flow-weighted values of the water quality parameters for the Shoal Creek/Kaskaskia River Ecosystem Partnership
Agriculture is the main land use in the Shoal Creek/Kaskaskia River Ecosystem Partnership. However, the influence of urban areas and livestock in the drainage area are also apparent according to the Illinois EPA Section 303(d) list. The ecosystem partnership contains the largest contiguous tract of forest land in Illinois. The forest area is 7000 acres in area that includes a bottomland forest component along the Kaskaskia River. Shoal Creek is a large tributary compared to other tributaries in the study area with the largest drainage area of 1947.49 mi².

Similar to the baseline data, overall mean nitrate-N (0.89 ±1.74 mg L⁻¹, N=137) was the lowest among the 4 ecosystem partnerships (Appendix A-1). Mean nitrate-N levels showed an overall decreasing trend with all the annual means below IL EPA standard of 10 mg L⁻¹ (Figure 11 d).

Mean total phosphorus levels (0.42 ± 0.05 mg L⁻¹, N=188) and mean dissolved phosphorus levels (0.24±0.03 mg L⁻¹, N=180) were the highest in this ecosystem partnership (Appendix A-1). The annual means of both phosphorus levels show an overall decreasing trend but exceeded the IL EPA standard 0.05 mg L⁻¹ over the entire study period with a sharp increase in 2010, 2012 and 2014 (Figure 11f and 11g).

Mean fecal coliform levels in the region showed an overall decreasing trend, but the annual mean values remained above the IL EPA standard (400 CFU/100ml), except in 2011. A sudden increase in fecal coliform in the region was observed in 2009 and 2010 (Figure 11c).

Mean ammonium concentration in the region (0.08 ± 0.30 mg L⁻¹, N=133) was lowest among the ecosystem partnerships (Appendix A-1). Although the annual means of ammonium were below the national criteria for ammonia in fresh water (1.9 mg L⁻¹), an overall increasing trend was observed for the ecosystem partnership (Figure 11a).
Best Management Practices for the Shoal Creek/Kaskaskia River Ecosystem Partnership

BMPs in this ecosystem partnership should focus on addressing the high phosphorus levels. Nutrient management in row-crop areas and livestock operations and conservation practices such as cover corps and riparian buffers could help reduce phosphorus loads. Improved urban storm water management as well as municipal wastewater treatment should also help decrease phosphorus loads. Increased use of storm water detention basins will not only help improve water quality, but can help alleviate flooding concerns. Further, fecal coliform levels showed a decreasing trend with most recent annual mean values close to the IL EPA standard, so BMPs that ensure proper management of animal manure and surface runoff from animal feeding operations could help prevent increases in fecal coliform levels.

Shoal Creek near Breese, IL

Location: Kaskaskia River/Shoal Creek Ecosystem Partnership Tributary Station

Drainage Area: 1947.49 mi²
USGS Gauging Station Number: 05594000
IL EPA Identification Number: OI-08
Water Quality Analysis

Figure 12a Ammonium-N

Figure 12b Dissolved Oxygen

Figure 12c Fecal Coliform

Figure 12d Nitrate-N
Figure 12 Mean annual flow-weighted values of the water quality parameters for the Shoal Creek near Breese, IL

Figure 12e Turbidity

Figure 12f Total Phosphorus

Figure 12g Dissolved Phosphorus
Shoal Creek is a large tributary compared to other tributaries in the study area, so it has larger influence on the main-stem Kaskaskia River. Based on the Illinois EPA Section 303(d) list, potential sources of impairments in the region were crop production and livestock and animal feeding operations. The leading cause of water quality impairment was fecal coliform with 42.86 miles of streams impaired by fecal coliform.

The overall mean value total phosphorus (0.65 ±0.13 mg L\(^{-1}\), N=70) was thirteen times and the overall mean dissolved phosphorus (0.23 ±0.03 mg L\(^{-1}\), N=64) was four times the IL EPA standard (0.05 mg L\(^{-1}\)). Annual means for both total and dissolved phosphorus showed a slightly decreasing trend (Figure 12f & 12g). Mean fecal coliform levels showed a slightly decreasing trend but were above the IL EPA standard (400 CFU/100ml) (Figure 12c).

Management Implications

The main concern in the sub-watershed was phosphorus and fecal coliform, so BMPs should focus specifically on nutrient management in row-crop areas and livestock operations and proper management of animal waste and runoff from animal feeding operations to minimize fecal coliform entering stream systems.

**Crooked Creek near Hoffman, IL**

**Location:**

Kaskaskia River/Shoal Creek Ecosystem Partnership Tributary Station

**Drainage Area:** 254.98 mi\(^2\)

**USGS Gauging Station Number:** 05593520

**IL EPA Identification Number:** OJ-09
Water Quality Analysis

**Figure 13a** Ammonium-N

**Figure 13b** Dissolved Oxygen

**Figure 13c** Fecal Coliform

**Figure 13d** Nitrate-N
Figure 13 Mean annual flow-weighted values of the water quality parameters for the Crooked Creek near Hoffman, IL.
Crooked Creek drains southeast of Lake Carlyle that comprises large areas of agriculture, forest cover and urban areas. The Illinois EPA Section 303(d) list indicate crop production and municipal point source discharges as the two largest sources of potential impairments to the creek. The water quality parameters showed similar trends to Shoal Creek.

The overall mean value total phosphorus \((0.60 \pm 0.12 \text{ mg L}^{-1}, N=64)\) was twelve times and the overall mean dissolved phosphorus \((0.41 \pm 0.06 \text{ mg L}^{-1}, N=62)\) was four times the IL EPA standard \((0.05 \text{ mg L}^{-1})\). An overall decreasing trend in mean total and dissolved phosphorus levels was observed (Figure 13f & 13g). Mean fecal coliform levels showed a slightly decreasing trend but were above the IL EPA standard \((400 \text{ CFU/100ml})\) (Figure 12c), except in 2010 and 2011.

Management Implications

Again, the main concern in the sub-watershed was phosphorus and fecal coliform, so BMPs should focus specifically on nutrient management in row-crop areas and livestock operations and proper management of animal waste and runoff from animal feeding operations to minimize fecal coliform entering stream systems. Municipal point source discharges should be improved as well to limit phosphorus export.

Kaskaskia River near Venedy Station, IL

Location: Kaskaskia River/Shoal Creek Ecosystem Partnership
Main-stem Station

Drainage Area: \(4393 \text{ mi}^2\)

USGS Gauging Station Number: 05594100

IL EPA Identification Number: O-20
Water Quality Analysis

**Ammonia-Kaskaskia River (Venedy Station, IL)**

- **Figure 14a Ammonium-N**
  - Plot showing the concentration of Ammonium-N (1980-2004) and Ammonium-N (2005-2014) over the years.
  - Overall Trendline indicated.
  - National Criteria for Ammonia in Fresh Water is 1.9 mg L⁻¹

**Dissolved Oxygen-Kaskaskia River (Venedy Station, IL)**

- **Figure 14b Dissolved Oxygen**
  - Plot showing the concentration of Dissolved Oxygen (1980-2003) and Dissolved Oxygen (2005-2013) over the years.
  - Overall Trendline and IL EPA Standard indicated.

**Fecal Coliform-Kaskaskia River (Venedy Station, IL)**

- **Figure 14c Fecal Coliform**
  - Plot showing the concentration of Fecal Coliform (1982-1998) and Fecal Coliform (2005-2013) over the years.
  - Overall Trendline and IL EPA Standard (400 CFU/ml) indicated.

**Nitrate-Kaskaskia River (Venedy Station, IL)**

- **Figure 14d Nitrate-N**
  - Plot showing the concentration of Nitrate-N (1980-2004) and Nitrate-N (2005-2014) over the years.
  - Overall Trendline indicated.
  - *IL EPA Standard is 10 mg L⁻¹*
Figure 14 Mean annual flow-weighted values of the water quality parameters for the Kaskaskia River near Venedy, IL
The Venedy monitoring station is the farthest downstream monitoring station in the study area, so the levels of water quality parameters can be considered as an indicator for the entire Kaskaskia River basin.

The overall mean value total phosphorus \((0.42 \pm 0.11 \text{ mg L}^{-1}, \text{ N}=70)\) was eight times and the overall mean dissolved phosphorus \((0.24 \pm 0.06 \text{ mg L}^{-1}, \text{ N}=64)\) was four times the IL EPA standard \((0.05 \text{ mg L}^{-1})\). Mean total and dissolved phosphorus showed an overall increasing trend (Figure 14f & 14g). Fecal coliform levels were highest in 2005 and followed a decreasing trend afterwards. The annual means of fecal coliform remained below the IL EPA standard \((400 \text{ CFU/100ml})\) (Figure 12c), except in 2005, 2006, 2008 and 2012.

Management Implications

Similar to the other monitoring stations in the ecosystem partnership, the main concerns were phosphorus and fecal coliform. Hence, BMPs in the region should focus on nutrient management, storm water management, proper management of animal manure, and improvement in municipal point source discharges.
Lower Kaskaskia Ecosystem Partnership

Stations:

- Silver Creek near Troy, IL (154.59 mi²)
- Silver Creek near Freeburg, IL (465.79 mi²)
- Richland Creek near Hecker, IL (129.49 mi²)

303d List Streams:

- 24 streams/lakes included on list (complete list in Appendix)

Potential Sources of Impairment

- 14 municipal point source discharge
- 14 crop production
- 11 urban run-off / storm sewers
- 8 unknown
- 4 animal feeding operations
- 4 combined sewer overflows
- 1 stream bank modifications / destabilization
- 1 surface mining
Water Quality Analysis

Figure 15a Ammonium-N

Figure 15b Dissolved Oxygen

Figure 15c Fecal Coliform

Figure 15d Nitrate-N
Figure 15 Mean annual flow-weighted values of the water quality parameters for the Lower Kaskaskia Ecosystem Partnership

Figure 15e Turbidity

Figure 15f Total Phosphorus

Figure 15g Dissolved Phosphorus
No data for the main stem of the Kaskaskia River was available for the Lower Kaskaskia/Silver Creek Ecosystem Partnership. The water quality analysis in this study is only for the tributary stations and are compared to tributary stations in other ecosystem partnerships. The drainage area of the monitoring stations in this ecosystem partnership is largely influenced by urban areas.

Similar to the baseline data, mean nitrate-N level (3.78 ±0.40 mg L\(^{-1}\), N=142) was second highest next to the mean of the only tributary in the Upper Kaskaskia Ecosystem Partnership on the West Okaw River (5.35 ±3.75 mg L\(^{-1}\), N=19) (Appendix A-1). Annual means of nitrate-N levels showed a slightly increasing trend but remained below the IL EPA standard of 10 mg L\(^{-1}\) (Figure 15 d).

Mean total phosphorus levels (0.79 ± 0.09 mg L\(^{-1}\), N=202) and mean dissolved phosphorus levels (0.51±0.05 mg L\(^{-1}\), N=188) was highest in this ecosystem partnership (Appendix A-1). The annual means of both phosphorus levels show an overall decreasing trend but exceeded the IL EPA standard 0.05 mg L\(^{-1}\). A sudden drop in the total and dissolved phosphorus values was observed in 2008 and 2009, a sudden increase in 2010, followed by a decreasing trend (Figure 15f and 15g).

Overall mean fecal coliform level (16559 ± 4690 CFU/100ml, N=96) was highest in this ecosystem partnership. Annual means of the fecal coliform in the region showed an overall decreasing trend, and the annual mean values remained above IL EPA standard (400 CFU/100ml). A sudden increase in fecal coliform in the region was observed in 2010 (Figure 15c).

Similarly, mean ammonium level in the region (0.20 ± 0.04 mg L\(^{-1}\), N=139) was highest among the ecosystem partnerships (Appendix A-1). The annual means of ammonium were below
the national criteria for ammonia in fresh water (1.9 mg L\(^{-1}\)) and showed an overall decreasing trend (Figure 15a).

Best Management Practices for the Shoal Creek/Kaskaskia River Ecosystem Partnership

The primary water quality concerns in the ecosystem partnership were phosphorus and fecal coliform. Given the prevalence of urban area, improvements in municipal point source discharges and storm water management is warranted. Combined sewer overflows are also an issue in this partnership which can lead to significant nutrient and bacteria loading to surface waters. Addressing combined sewer overflows requires significant capital investment in piping and wastewater treatment plant infrastructure. Additional agricultural nutrient and manure management is also needed.
Silver Creek near Troy, IL

Location: Lower Kaskaskia/Silver Creek Ecosystem Partnership
Tributary Station

Drainage Area: 154.59 mi²

USGS Gauging Station Number: 05594450

IL EPA Identification Number: OD-06

Water Quality Analysis

Figure 16a Ammonium-N

Figure 16b Dissolved Oxygen
Figure 16g Dissolved Phosphorus

Figure 16 Mean annual flow-weighted values of the water quality parameters for the Silver Creek near Troy, IL

Water quality parameters from the monitoring station near Troy represent the values for the upper drainage area of Silver Creek. It is located approximately 40 km north of the monitoring station near Freeburg, and approximately 103 km from the confluence of Silver Creek and the Kaskaskia River.

Annual mean nitrate-N levels remained below the IL EPA standard 10 mg L$^{-1}$ but showed an increasing trend (Figure 16d). Mean total phosphorus levels showed slightly increasing trend (Figure 16f) while mean dissolved phosphorus levels showed an overall decreasing trend with sudden increase in 2012 and 2014 (Figure 16g). Both phosphorus levels were very high and remained above the IL EPA standard (0.05 mg L$^{-1}$) over the entire study period.
The annual means of dissolved oxygen remained above the IL EPA standard (4 mg L\(^{-1}\)), except in 2009 and 2010, but a slightly decreasing trend was observed (Figure 16b). Mean fecal coliform levels showed an overall decreasing trend, but the annual means exceeded the IL EPA standard of 400 CFU/100ml (Figure 16c). A sudden drop in fecal coliform levels was observed after 2004.

Management Implications

The main water quality concern was phosphorus. Levels of total and dissolved phosphorus were very high. Improvements in municipal point source discharges and storm water management is needed, as well as agricultural nutrient management.
Silver Creek near Freeburg, IL

Location: Lower Kaskaskia/Silver Creek Ecosystem Partnership Tributary Station

Drainage Area: 465.79 mi²

USGS Gauging Station Number: 05594800

IL EPA Identification Number: OD-07

Water Quality Analysis

Figure 17a Ammonium-N

Figure 17b Dissolved Oxygen
Figure 17c Fecal Coliform-Silver Creek (Freeburg, IL)

Figure 17d Nitrate-N (Silver Creek (Freeburg, IL))

Figure 17e Turbidity-Silver Creek (Freeburg, IL)

Figure 17f Total Phosphorus-Silver Creek (Freeburg, IL)
Figure 17g Dissolved Phosphorus

Figure 17 Mean annual flow-weighted values of the water quality parameters for the Silver Creek near Freeburg, IL

The monitoring station near Freeburg lies approximately 13.5 km from the confluence of Silver Creek with the Kaskaskia River. It drains most of the Silver Creek drainage area that comprises large areas of urban areas compared to other tributary stations in the study area.

Annual means of nitrate-N levels remained below the IL EPA standard 10 mg L\(^{-1}\) but showed an increasing trend (Figure 17d). The overall mean nitrate-N level (1.98 ±0.99 mg L\(^{-1}\), N=51) was lowest compared to other monitoring stations in the ecosystem partnership. Annual means for both phosphorus levels remained above the IL EPA standard (0.05 mg L\(^{-1}\)) over the entire study period and showed a slightly increasing trend (Figure 17f and 17g).

The annual means of dissolved oxygen remained above the IL EPA standard (4 mg L\(^{-1}\)), except in 2008 and 2009. Although an overall increasing trend is observed for the dissolved
oxygen levels, a sudden increase in 2010 is followed by a decreasing trend (Figure 17b). Mean fecal coliform levels showed an overall decreasing trend, with most recent values that remain below the IL EPA standard 400 CFU/100ml (Figure 17c).

Management Implications

Similar to the monitoring station at Troy, phosphorus is the main concern. The flow weighted concentrations of total and dissolved phosphorus are relatively high, but are significantly lower than at Freeburg, possibly due to dilution effects. Improvements in municipal point source discharges and storm water management is needed, as well as agricultural nutrient management.
Richland Creek near Hecker, IL

Location: Lower Kaskaskia/Silver Creek Ecosystem Partnership

Tributary Station

Drainage Area: 129.49 mi²

USGS Gauging Station Number: 05595200

IL EPA Identification Number: OC-04

Water Quality Analysis

Figure 18a Ammonium-N

Figure 18b Dissolved Oxygen
Figure 18c Fecal Coliform

Figure 18d Nitrate-N

Figure 18e Turbidity

Figure 18f Total Phosphorus
Richland Creek was the second smallest drainage area (129.49 mi²) of the tributaries in the study area. The creek also drains some of the highly urbanized areas of the Kaskaskia watershed.

Overall means for both total phosphorus (0.96±0.15 mg L⁻¹, N=74) and dissolved phosphorus (0.61±0.10 mg L⁻¹, N=66) were very high. Annual means for both phosphorus levels showed an overall decreasing trend and remained above the IL EPA standard (0.05 mg L⁻¹) over the entire study period (Figure 18f and 18g).

Overall mean dissolved oxygen (6.97±1.17 mg L⁻¹, N=80) was the lowest in the ecosystem partnership. The annual means of dissolved oxygen showed an overall decreasing trend. Mean dissolved oxygen levels remained above the IL EPA standard (4 mg L⁻¹), except in
A sudden increase in 2006 and 2010 in dissolved oxygen is observed that is followed by a decreasing trend (Figure 18b).

The highest overall mean fecal coliform level (21492±12234 CFU/100 ml, N=32) was observed in this station. An overall decreasing trend is observed for the mean fecal coliform levels showed an overall decreasing trend, but all values exceed the IL EPA standard 400 CFU/100ml (Figure 18c).

Management Implications

The major water quality concern in Richland Creek was phosphorus and fecal coliform, similar to the other monitoring stations in the Lower Kaskaskia/Silver Creek Ecosystem Partnership. Improvements in municipal point source discharges and storm water management is needed, as well as agricultural nutrient and manure management.

OVERALL WATERSHED SUMMARY

As the Kaskaskia River flows southwest, it transitions from having relatively high nitrate levels in its headwaters to having high phosphorus levels in its lower reaches. In a broad sense, this is indicative of the presence of intense row-crop agriculture with tile drainage in the upper reach to a mix of row-crop agriculture, livestock operations, and urban areas in the mid and lower reaches. This is supported by an analysis of the IEPA 303d list data of the identified sources of water quality impairment. In the upper two reaches, crop production was the dominant source of water quality impairment. In the Shoal Creek/Kaskaskia River reach, crop production remained the most common source of water quality impairment, however municipal point source discharges, animal feeding operations, and urban runoff / storm sewers were important sources as well. In the lower reach, municipal point source discharges joined crop production as the leading sources of impairment, and urban runoff / storm sewers and
combined sewers overflows were notable sources. Fecal coliform levels remained a parameter of concern throughout the entire watershed. Levels commonly exceeded the IL EPA standard of 400 CFU/100 mL. Possible sources of fecal coliform include animal feeding operations, pastures, urban runoff (pet waste), storm sewers, combined sewer overflows, and wildlife (waterfowl).

Based upon these water quality findings, best management practices (BMPS) in the upper reaches of the watershed should be targeted to address tile drainage (drainage management, saturated buffers, constructed wetlands, and bioreactors) and fertilizer applications (4 R’s, right source, right rate, right time, right place) to reduce nitrate export to surface waters. In the middle portion of the watershed, livestock and animal feeding operations gain prominence, so BMP’s to reduce manure transport to surface waters (proper manure storage and application, streambank fencing) and excess nutrient build-up in soils by over application of manure (manure nutrient testing, manure application) should be the focus to limit phosphorus and fecal coliform export. Lastly, BMP’s in the lower reach should focus on mix of urban, crop production, and livestock manure associated practices. In particular, row-crop agricultural BMP’s to reduce phosphorus transport to surface waters should focus on proper fertilizer management (4R’s) and reducing surface runoff through the encouraged adoption of no till, conservation tillage practices, and cover crops and edge of field practices such as riparian buffers and grass filter strips. Urban BMP’s to reduce runoff and phosphorus levels include storm water retention basins, wet ponds, storm water wetlands, rain gardens, porous pavement, sand filters, cisterns, filter strips, and improved piping and wastewater treatment plant infrastructure to address combined sewer overflows.

The two large reservoirs in the watershed, Lake Shelbyville and Carlyle Lake had a significant influence on water quality. As expected, turbidity levels and a sediment bound nutrient (Total phosphorus) were significantly lower immediately below the impoundments than stations above the reservoirs (Cooks Mills and Vandalia) due to sediment settling and deposition in the reservoirs. The relatively sediment free-water discharge from the impoundments is commonly referred to as hungry water as it will erode sediment from in-stream sources to satisfy its sediment carrying capacity based upon its
energy level. Nitrate and dissolved phosphorus levels also tended to be lower below the reservoirs compared to above. These nutrients were likely utilized to support primary production (algae) in these large reservoirs.

Lastly, one of the objectives of this project was to answer the question of whether water quality in the watershed has improved over the last decade (2005-2014) compared to the baseline period of the prior project (1980-2004). To help answer this question, a summary of trend line data for each of the stations was created showing whether the water quality parameters improved, degraded, or did not change from the recent decade compared to the baseline period and over the recent decade alone (Table 6).

Table 6 Summary of the change in water quality parameters (except dissolved oxygen) in the Kaskaskia River watershed

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<thead>
<tr>
<th></th>
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<tr>
<td>Dissolved Phosphorus</td>
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*Only 2 to 3 data points available for ammonia and fecal coliform, so no trend was observed for one of the monitoring stations, E Fork Kaskaskia River near Sandoval, IL. Under the Recent trend category an improved trend in water quality refers to a decreasing trend.

The analysis shows that nitrate, ammonium, and fecal coliform levels have generally improved (decreased) over the last decade compared to the baseline period, while turbidity, total phosphorus, and dissolved phosphorus levels have increased (degraded). The most recent decadal water quality trends show a slightly different picture with fecal coliform, nitrate,
turbidity, and dissolved phosphate showing general improvements (decreasing trends) and total phosphorus showing general degradation over time (increasing trends). So, it is difficult to say definitively that water quality is improving in the basin, as it depends on the parameter and period one is assessing, though, the trend analysis does point to water quality improving in the watershed. This is certainly a testament to all the efforts made by federal, state, and local government agencies and programs, public-private partnerships, and non-governmental organizations in the region. The Kaskaskia Watershed region is fortunate to have so many dedicated people who care about the quality of their waters and we anticipate that increased future, cooperative efforts will lead to continued improvements in water quality.
APPENDIX I

**Figure A-1)** Mean ammonium-N for the three Ecosystem Partnerships with main-stem monitoring stations in the Kaskaskia River watershed.

**Figure A-2)** Mean dissolved oxygen for the three Ecosystem Partnerships with main-stem monitoring stations in the Kaskaskia River watershed.

**Figure A-3)** Mean fecal coliform for the three Ecosystem Partnerships with main-stem monitoring stations in the Kaskaskia River watershed.

**Figure A-4)** Mean nitrate-N coliform for the three Ecosystem Partnerships with main-stem monitoring stations in the Kaskaskia River watershed.
Figure A-5) Mean turbidity for the three Ecosystem Partnerships with main-stem monitoring stations in the Kaskaskia River watershed.

Figure A-6) Mean total phosphorus for the three Ecosystem Partnerships with main-stem monitoring stations in the Kaskaskia River watershed.

Figure A-7) Mean dissolved phosphorus for the three Ecosystem Partnerships with main-stem monitoring stations in the Kaskaskia River watershed.

Figure A-8) Mean ammonium-N for tributary stations in all four Ecosystem Partnerships in the Kaskaskia River watershed.
Figure A-9) Mean dissolved oxygen for tributary stations in all four Ecosystem Partnerships in the Kaskaskia River watershed.

Figure A-10) Mean fecal coliform for tributary stations in all four Ecosystem Partnerships in the Kaskaskia River watershed.

Figure A-11) Mean nitrate-N for tributary stations in all four Ecosystem Partnerships in the Kaskaskia River watershed.

Figure A-12) Mean turbidity for tributary stations in all four Ecosystem Partnerships in the Kaskaskia River watershed.
Figure A-13) Mean total phosphorus for tributary stations in all four Ecosystem Partnerships in the Kaskaskia River watershed.

Figure A-14) Mean dissolved phosphorus for tributary stations in all four Ecosystem Partnerships in the Kaskaskia River watershed.

Figure: Mean annual flow weighted values of water quality parameters for the main-stem monitoring stations (Figure A1-A7) and tributary monitoring stations (Figure A8-A14). Means with different letters indicate statistical significance at alpha=0.05.
APPENDIX II

Table: Mean annual flow-weighted values of the water quality parameters for the 14 monitoring stations in the Kaskaskia River watershed

<table>
<thead>
<tr>
<th>Ecosystem Partnership Regions</th>
<th>Stations</th>
<th>Ammonium-N (mg L⁻¹)</th>
<th>Dissolved Oxygen (mg L⁻¹)</th>
<th>Fecal Coliform (CFU/100ml)</th>
<th>Nitrate-N (mg L⁻¹)</th>
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<td>Std Error</td>
<td>Mean</td>
<td>Std Error</td>
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**APPENDIX III**

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<td>O-20</td>
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- Mercury
- Fecal Coliform
- Atrazine
- Phosphorus (Total)
- Temperature, water
- Total Suspended Solids (TSS)
- Iron
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