Upper Kaskaskia River and Lake Fork Watershed Total Maximum Daily Load

Final Stage 1 Report

1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

Report Prepared by:

TETRA TECH

February 2019

Contents

Figures

Tables

Acronyms and Abbreviations

AFOs	animal feeding operations
AWQMN	Ambient Water Quality Monitoring Network
CAFO	confined animal feeding operation
CWA	Clean Water Act
Illinois EPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
MGD	millions of gallons per day
MS4	municipal separate storm sewer system
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
STP	sewage treatment plant
TMDL	total maximum daily load
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WQS	water quality standards
WWTP	wastewater treatment plant

1. Introduction

The Clean Water Act and U.S. Environmental Protection Agency (U.S. EPA) regulations require that Total Maximum Daily Loads (TMDLs) be developed for waters that do not support their designated uses. In simple terms, a TMDL is a plan to attain and maintain water quality standards in waters that are not currently meeting standards. This TMDL study addresses a portion of the Upper Kaskaskia River watershed in central Illinois. The project area, referred to as the Upper Kaskaskia River and Lake Fork watershed, is approximately 243 square miles and includes impairments in the Lake Fork and the Upper Kaskaskia River (Figure 1). A TMDL study has been completed in the larger Upper Kaskaskia River major watershed and relevant information from the study is included herein where applicable (Tetra Tech 2018 draft).

1.1 TMDL Development Process

The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also includes a margin of safety, which reflects uncertainty as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (U.S. EPA 1991).

The Illinois EPA will be working with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

1.2 Water Quality Impairments

Several waters in the Upper Kaskaskia River and Lake Fork watersheds have been placed on the State of Illinois §303(d) list (Table 1 and Figure 1) and require development of TMDLs. This TMDL project is intended to address documented water quality problems in these watersheds.

Table 1. Upper Kaskaskia River and Lake Fork watershed impairments and pollutants (2016 Illinois 303(d) Draft List)

Name	Segment ID	Segment Length (Miles)	Watershed Area (Sq. Miles)	Designated Uses	TMDL Parameters
Kaskaskia River	O-35	15.25	72	Aquatic Life	Dissolved Oxygen, *pH*
Lake Fork	OW-01	9.72	171	Aquatic Life	Chloride, Dissolved Oxygen
Lake Fork	OW-02	4.91	150	Aquatic Life	Chloride, Dissolved Oxygen

Italics – Based on evaluation of the last ten years of available data (2007–2016), it was determined that Kaskaskia River segment O-35 is not impaired for pH (see Appendix A – Unimpaired Stream Data Analysis).

1.3 TMDL Endpoints

This section presents information on the water quality standards (WQS) that are used for TMDL endpoints. WQS are designed to protect beneficial uses. The authority to designate beneficial uses and adopt WQS is granted through Title 35 of the Illinois Administrative Code. Designated uses to be protected in surface waters of the state are defined under Section 303, and WQS are designated under Section 302 (Water Quality Standards). Designated uses and WQS are discussed below.

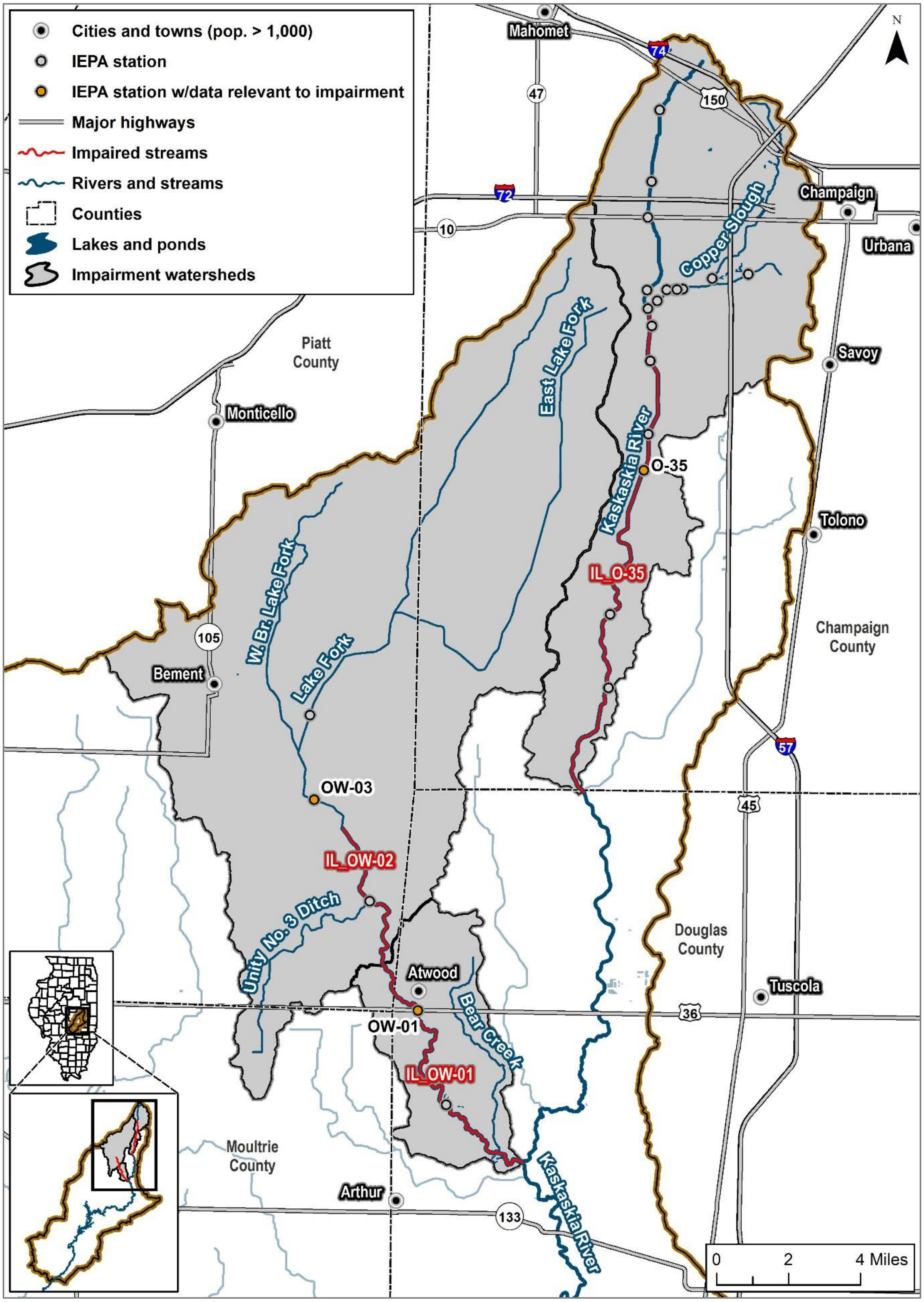


Figure 1. Upper Kaskaskia River and Lake Fork watershed, TMDL project area.

1.3.1 Designated Uses

Illinois EPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB) to assess the designated use support for Illinois waterbodies. The following are the use support designations provided by the IPCB that apply to waterbodies in the Upper Kaskaskia River and Lake Fork watershed:

General Use Standards – These standards protect for aquatic life, wildlife, agricultural uses, primary contact (where physical configuration of the waterbody permits it, any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing), secondary contact (any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity), and most industrial uses. These standards are also designed to ensure the aesthetic quality of the state's aquatic environment.

1.3.2 Water Quality Standards and TMDL Endpoints

Environmental regulations for the State of Illinois are contained in the Illinois Administrative Code, Title 35. Specifically, Title 35, Part 302 contains water quality standards promulgated by the IPCB. This section presents the standards applicable to impairments in the study area. Water quality standards are the endpoints to be used for TMDL development in the Upper Kaskaskia River and Lake Fork watershed (Table 2).

Table 2. Summary of water quality standards for the Upper Kaskaskia River and Lake Fork watersheds

Parameter	Units	General Use Water Quality Standard
Chloride	mg/L	500
Dissolved Oxygen [a]	mg/L	March-July > 5.0 min. and > 6.0- 7-day mean Aug-Feb > 3.5 min, > 4.0- 7-day mean and > 5.5- 30-day mean

a. Applies to the dissolved oxygen concentration in the main body of all streams, in the water above the thermocline of thermally stratified lakes and reservoirs, and in the entire water column of unstratified lakes and reservoirs.

Aquatic life use assessments in streams are typically based on the interpretation of biological information, physicochemical water data and physical-habitat information from the Intensive Basin Survey, Ambient Water Quality Monitoring Network or Facility-Related Stream Survey programs. The primary biological measures used are the fish Index of Biotic Integrity (fIBI; Karr et al. 1986; Smogor 2000, 2005), the macroinvertebrate Index of Biotic Integrity (mIBI; Tetra Tech 2004) and the Macroinvertebrate Biotic Index (MBI; Illinois EPA 1994). Physical habitat information used in assessments includes quantitative or qualitative measures of stream bottom composition and qualitative descriptors of channel and riparian conditions. Physicochemical water data used include measures of —conventional parameters (e.g., dissolved oxygen, pH and temperature), priority pollutants, non-priority pollutants, and other pollutants (USEPA 2002 and www.epa.gov/waterscience/criteria/wqcriteria.html). In a minority of streams for which biological information is unavailable, aquatic life use assessments are based primarily on physicochemical water data.

When a stream segment is determined to be Not Supporting aquatic life use, generally, one exceedance of an applicable Illinois WQS (related to the protection of aquatic life) results in identifying the parameter as a potential cause of impairment. Additional guidelines used to determine potential causes of impairment include site-specific standards (35 Ill. Adm. Code 303, Subpart C), or adjusted standards (published in the ICPB's Environmental Register at http://www.ipcb.state.il.us/ecll/environmentalregister.asp).

2. Watershed Characterization

The Upper Kaskaskia River and Lake Fork watershed is located in central Illinois (Figure 1). The headwaters begin near Champaign, IL. Lake Fork joins the Upper Kaskaskia river upstream of Shelbyville Lake and the Kaskaskia River eventually joins the Mississippi River south of St. Louis, Missouri. A TMDL has recently been developed for the larger Upper Kaskaskia River watershed (Tetra Tech 2018 draft) and much of the information presented in that report is applicable to the Upper Kaskaskia River and Lake Fork project area. There have been no known changes in the project area, therefore the Upper Kaskaskia River Watershed TMDL provides much of the basis for the watershed characterization and source assessment for the Upper Kaskaskia River and Lake Fork project area below.

2.1 Jurisdictions and Population

Relevant information on jurisdictions and population can be found in the recently completed Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft). The project area is located in Champaign, Douglas, Moultrie and Piatt counties, with the city of Champaign located in the headwaters of the Upper Kaskaskia River and the villages of Atwood and Bement draining to Lake Fork.

2.2 Climate

In general, the climate of the region is continental with hot, humid summers and cold winters. Relevant information on climate can be found in the recently completed Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft).

2.3 Land Use and Land Cover

Relevant information on land use and land cover can be found in the recently completed Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft). Cultivated crops make up the majority of the land cover in the project area. Developed areas are also present surrounding Champaign, Atwood and Bement.

2.4 Topography

Relevant information on topography can be found in the recently completed Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft).

2.5 Soils

Relevant information on soils can be found in the recently completed Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft). Soils are primarily silt loam or loam with moderate infiltration rates when there is no high water table. Much of the area appears to have a high water table that has been drained through agricultural tiling.

2.6 Hydrology

Relevant information on hydrologic conditions can be found in the recently completed Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft). Active U.S. Geological Survey (USGS) flow gage sites are located along Lake Fork segment OW-01 (05590800) and downstream of Upper Kaskaskia River segment O-35 (05590520).

2.7 Watershed Studies and Information

Relevant information for this section can be found in the recently completed Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft). In addition, the U.S. Army Corps of Engineers completed a river morphology study of Kaskaskia River (USACE 2010). County soil and water conservation districts and health departments were contacted for additional information; no new information was provided.

3. Watershed Source Assessment

Source assessments are an important component of water quality management plans and TMDL development. This section provides a summary of potential sources that contribute listed pollutants to the Upper Kaskaskia River and Lake Fork project area.

3.1 Pollutants of Concern

Pollutants of concern evaluated in this source assessment include chloride and parameters influencing dissolved oxygen such as biochemical oxygen demand, phosphorus, and ammonia. These pollutants can originate from an array of sources including point and nonpoint sources. Eutrophication (high levels of algae) is also often linked directly to low dissolved oxygen conditions and therefore nutrients are also a pollutant of concern. Point sources typically discharge at a specific location from pipes, outfalls, and conveyance channels. Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters, particularly overland runoff. This section provides a summary of potential point and nonpoint sources that contribute to the impaired waterbodies.

3.2 Point Sources

Point source pollution is defined by the Federal Clean Water Act (CWA) §502(14) as:

> *"any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation [CAFO], or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture storm water discharges and return flow from irrigated agriculture."*

Under the CWA, all point sources are regulated under the NPDES program. A municipality, industry, or operation must apply for an NPDES permit if an activity at that facility discharges wastewater to surface water. Point sources can include facilities such as municipal wastewater treatment plants (WWTPs), industrial facilities, CAFOs, or regulated storm water including municipal separate storm sewer systems (MS4s). There are no permitted CAFOs in the watershed.

There are seven individual NPDES permitted facilities in the Upper Kaskaskia and Lake Fork project area (Table 3). Average and maximum design flows and downstream impairments are included in the facility summaries. Three industrial wastewater facilities and one municipal wastewater facility drain to tributaries to Kaskaskia River segment O-35. One municipal wastewater facility drains directly to Lake Fork OW-01 and one municipal and one industrial facility drains to tributaries to OW-02. All facilities with the exception of Atwood Village STP (IL0025097) in Table 3 discharge to upstream unimpaired tributaries and are therefore not contributing to project impairments.

Table 3. Individual NPDES permitted facilities discharging to impaired segments

IL Permit ID	Facility Name	Type of Discharge	Receiving Water	Downstream Impairment(s)	Average Design Flow (MGD)	Maximum Design Flow (MGD)
IL0004227	*KRAFT FOODS GLOBAL-CHAMPAIGN*	*Stormwater and non-contact cooling water*	*COPPER SLOUGH*	*O-35*	*0.289*	*--*
IL0025097	ATWOOD, VILLAGE OF	STP	LAKE FORK BRANCH OF KASKASKIA RIVER	OW-01	0.2	0.5
IL0031526	*URBANA-CHAMPAIGN SD SW STP*	*STP*	*COPPER SLOUGH*	*O-35*	*7.98*	*17.25*
IL0032549	*BEMENT, VILLAGE OF*	*STP*	*UNNAMED TRIB OF W BRANCH LAKE FORK*	*OW-02, OW-01*	*0.176*	*0.480*
IL0062812	*MARATHON PETROLEUM-CHAMPAIGN*	*Hydrostatic test water and stormwater*	*UNNAMED DITCH*	*O-35*	*0.0073 (sum of outfall 001 and 002)*	*--*
IL0067202	*COMMERICAL FLOORING, INC*	*Treated sanitary waste and water soften backwash*	*UNNAMED STREAM TRIB TO KASKASKIA RV*	*O-35*	*0.008*	*--*
ILG640209	*IVESDALE, VILLAGE OF*	*Public water supply*	*EAST LAKE FORK OF KASKASKIA RIVER*	*OW-02, OW-01*	*0.0014*	*--*

Italics – NPDES facility draining to unimpaired segment.
STP – Sewage treatment plant
MGD – Million gallons per day

There are three MS4 communities and two MS4 road authorities discharging to unimpaired tributaries to Kaskaskia River segment O-35 and are therefore not contributing to project impairments. Additional information on existing permitted sources can be found in the Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft).

3.3 Nonpoint Sources

The term nonpoint source pollution is defined as any source of pollution that does not meet the legal definition of point sources. Nonpoint source pollution typically results from overland stormwater runoff that is diffuse in origin, as well as background conditions. It should be noted that stormwater collected and conveyed through a regulated MS4 is considered a controllable point source. As part of the water resource assessment process, Illinois EPA has identified several sources as contributing to the Upper Kaskaskia River and Lake Fork watershed impairments (Table 4). These sources include channelization that is a non-pollutant source. Channelization can result in low dissolved oxygen conditions due to lack of in-stream structure that would reaerate the water column. Nonpoint pollutant sources potentially contributing to chloride and low dissolved oxygen impairments include stormwater and agricultural runoff (including road salt application), onsite wastewater treatment systems, and animal agriculture activities.

Table 4. Potential sources in project area based on the draft 2016 305(b) report

Watershed	Segment	Sources
Kaskaskia River	O-35	Channelization and source unknown
Lake Fork	OW-01	Channelization, crop production (crop land or dry land), and source unknown
Lake Fork	OW-02	Channelization, crop production (crop land or dry land), and source unknown

3.3.1 Stormwater Runoff

During wet-weather events (snowmelt and rainfall), pollutants are incorporated into runoff and can be delivered to downstream waterbodies. The resultant pollutant loads are linked to the land uses and practices in the watershed. Agricultural and developed areas can have significant effects on water quality if proper best management practices are not in place, specifically contributing to high biochemical oxygen demand and nutrients that can affect the dissolved oxygen conditions in streams. The application and storage of road salt is often linked to high chloride concentrations in streams.

In addition to pollutants, alterations to a watershed's hydrology as a result of land use changes, ditching, and stream channelization can detrimentally affect habitat and biological health. Imperviousness associated with developed land uses and agricultural field tiling can result in increased peak flows and runoff volumes and decreased base flow as a result of reduced ground water discharge. Drain tiles also transport agricultural runoff directly to ditches and streams, whereas runoff flowing over the land surface may infiltrate to the subsurface and may flow through riparian areas.

3.3.2 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. Common soil-type limitations which contribute to failure include seasonally high water tables, compact glacial till, bedrock, and fragipan. When these septic systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters (Horsley and Witten 1996). Septic systems contain all the water discharged from homes and business and can be significant sources of pollutants.

Relevant information for this section can be found in the recently completed Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft). County health departments were contacted for information on septic systems and unsewered communities; no new information was provided.

3.3.3 Animal Feeding Operations (AFOs)

Animal feeding operations that are not classified as CAFOs are known as animal feeding operations (AFOs) in Illinois. Non-CAFO AFOs are considered nonpoint sources by U.S. EPA. AFOs in Illinois do not have state permits. However, they are subject to state livestock waste regulations and may be inspected by the Illinois EPA, either in response to complaints or as part of the Agency's field inspection responsibilities to determine compliance by facilities subject to water pollution and livestock waste regulations. The animals raised in AFOs produce manure that is stored in pits, lagoons, tanks and other storage devices. The manure is then applied to area fields as fertilizer. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer.

AFOs, however, can pose environmental concerns, including the following:

- Manure can leak or spill from storage pits, lagoons, tanks, etc.
- Improper application of manure can contaminate surface or ground water.
- Manure over application can adversely impact soil productivity.

Livestock are potential sources of bacteria and nutrients to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations. However, county wide data available from the 2012 Census of Agriculture were downloaded and area weighted to estimate the animal population in the project area. An estimated 6,615 animals are in the project area.

4. Water Quality

Background information on water quality monitoring can be found in the recently completed Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies report (Tetra Tech 2018 draft). In the Upper Kaskaskia River and Lake Fork watershed, water quality data were found for numerous stations that are part of the Illinois EPA Ambient Water Quality Monitoring Network (AWQMN). Monitoring stations with data relevant to the impaired segments are presented in Figure 1 and Table 5. Parameters sampled in the streams include field measurements (e.g., water temperature) as well as those that require lab analyses (e.g., nutrients, chloride).

The most recent 10 years of data collection, 2007–2016, were used to evaluate impairment status. Data that are greater than 10 years old are not included. Each data point was reviewed to ensure the use of quality data in the analysis below. Many sites have historical data that are greater than 10 years old. Data were obtained directly from Illinois EPA.

Table 5. Upper Kaskaskia River and Lake Fork watershed water quality data

Waterbody	Impaired Segment	AWQMN Sites	Location	Period of Record
Kaskaskia River	O-35	O-35	RM 283.1, Co Rd. 900N Br. 3 Mi. N of Sadorus	*2002*, 2007, 2012
Lake Fork	OW-01	OW-01	RT 36 Br. at Atwood	*2002*, 2007, 2012
	OW-02	OW-03	5 Mi. NW Atwood	2007

Italics – Data are greater than 10 years old
RM – River Mile

An important step in the TMDL development process is the review of water quality conditions, particularly data and information used to list segments. Examination of water quality monitoring data is a key part of defining the problem that the TMDL is intended to address. This section provides a brief review of available water quality information provided by the Illinois EPA.

4.1 Kaskaskia River (O-35)

Kaskaskia River is impaired for aquatic life due to low levels of dissolved oxygen. One Illinois EPA sampling site is present on segment O-35 of the Kaskaskia River (Table 6 and Figure 2). Six samples were collected at the site from 2007–2012, and continuous data were collected in 2012 and 2017. The violations of the general use water quality standard verify impairment.

Table 6. Data summary, Kaskaskia River O-35

Sample Site	No. of samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV (standard deviation/ average)	Number of exceedances of general use water quality standard (>5 mg/L (Mar-Jul) and >3.5 mg/L (Aug-Feb))
Dissolved Oxygen						
O-35	6	4.4	7.5	11.4	0.36	1

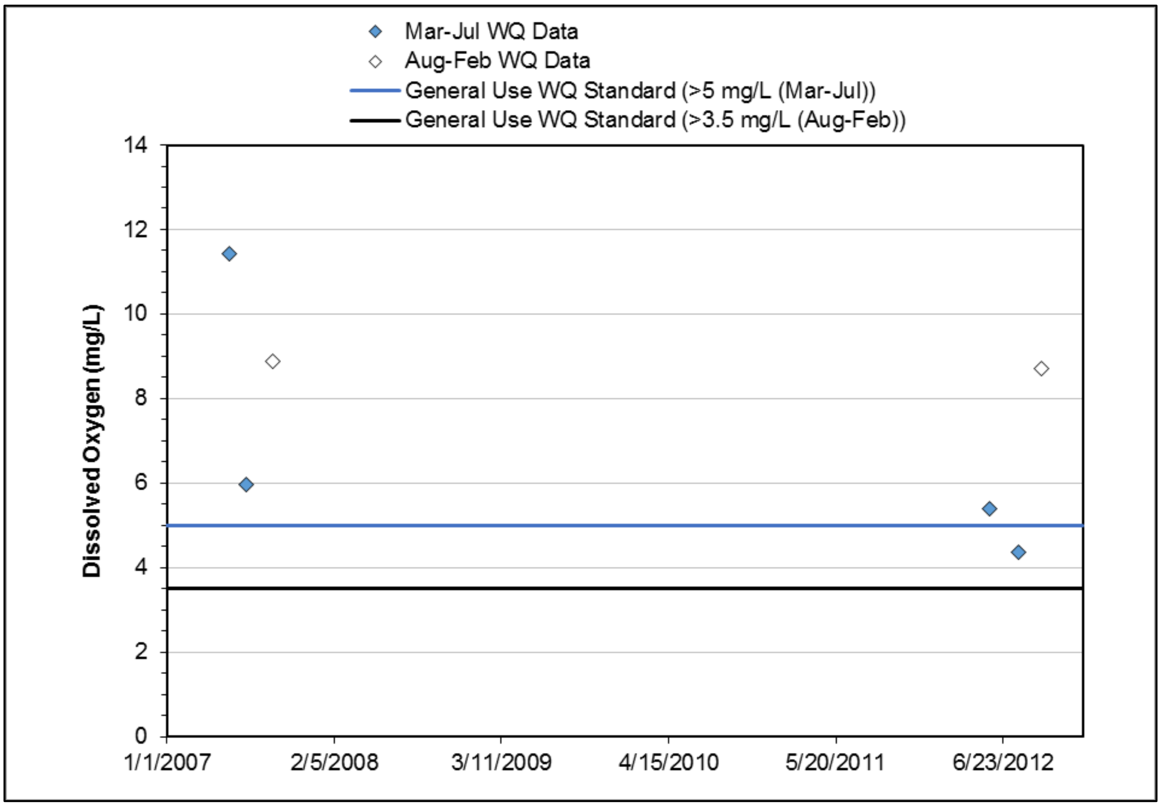


Figure 2. Dissolved oxygen water quality time series, Kaskaskia River O-35 segment.

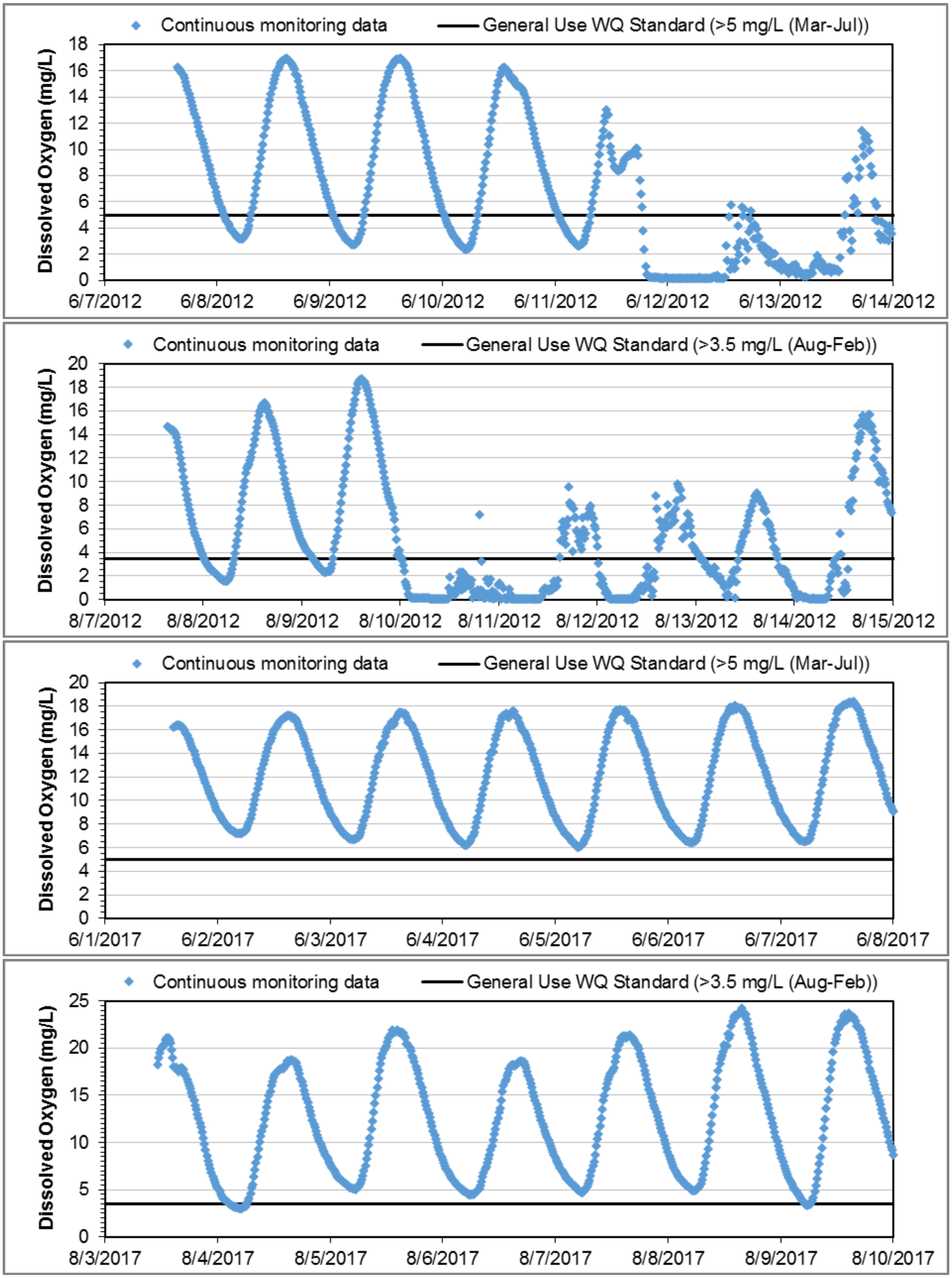


Figure 3. Continuous water quality time series for dissolved oxygen, Kaskaskia River O-35 segment.

Further review of available data was conducted to determine the cause of impairment:

- **Point Sources:** There are no point sources contributing to the impaired segment. All point sources are located upstream of the impaired segment and discharge into unimpaired segments based on available data. Point sources are not likely contributing to the O-35 low dissolved oxygen impairment.

- **Eutrophication:** Dissolved oxygen data was paired with phosphorus and chlorophyll-a data to determine if eutrophication is contributing to low dissolved oxygen conditions. Data older than 10 years were included in the analysis based on the assumption that conditions have not changed along the segment. Phosphorus versus dissolved oxygen data collected from 2002–2012 does not indicate a strong correlation (Figure 4). Chlorophyll-*a* and dissolved oxygen data collected from 2002–2007 show a weak correlation, however, chlorophyll-*a* values are very low and do not indicate eutrophic conditions (Figure 5).

- **Physical Properties:** There is only one monitoring station on the segment with relevant data, and that station represents the upper part of the stream segment referred to as Kaskaskia Ditch. Kaskaskia Ditch is small and highly ditched and channelized based on review of air photos.

Although the impairment has been verified, a strong link to a pollutant is not present. Additional data could be collected to further evaluate the cause and extent of impairment.

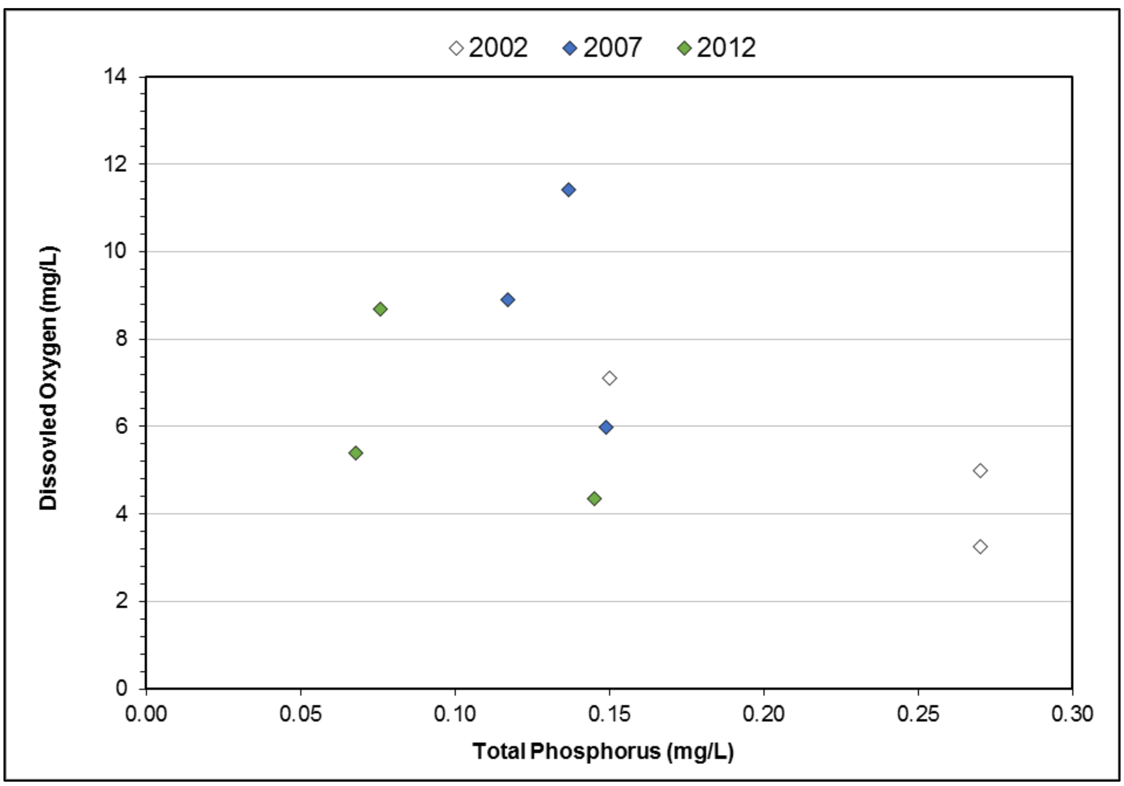


Figure 4. Total phosphorus versus dissolved oxygen, 2002–2012, Kaskaskia River O-35 segment.

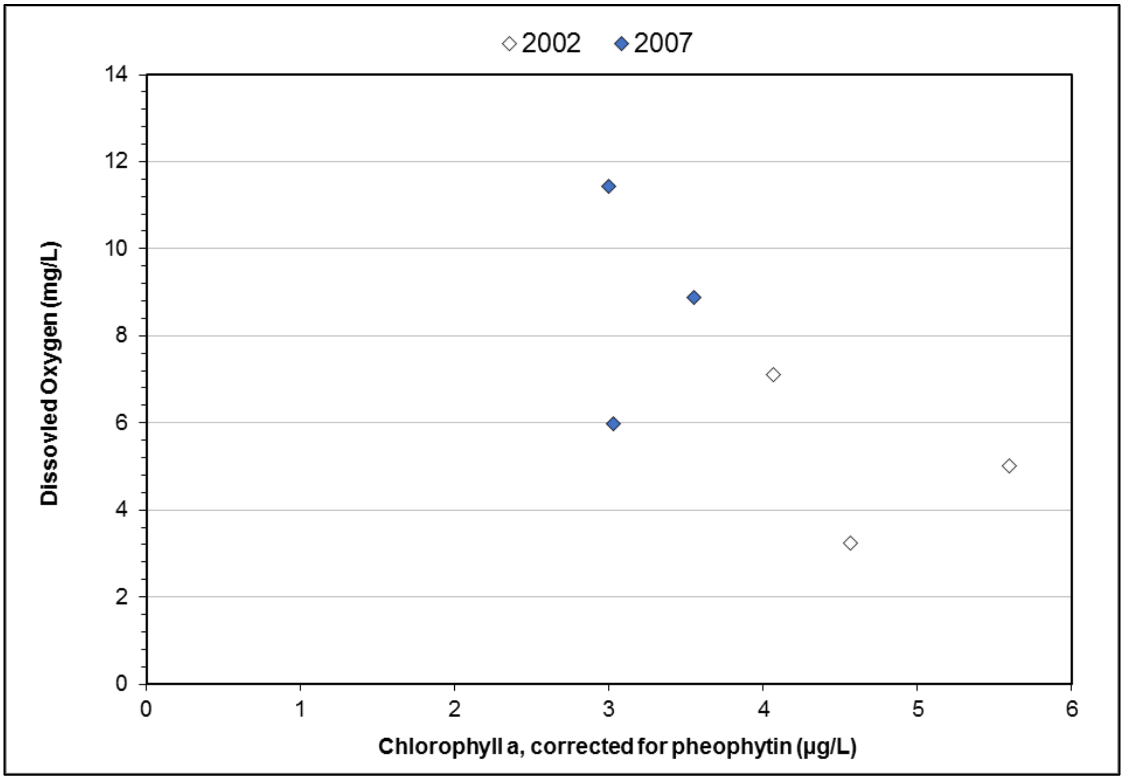


Figure 5. Chlorophyll-a versus dissolved oxygen, 2002–2007, Kaskaskia River O-35 segment.

4.2 Lake Fork (OW-01, OW-02)

Lake Fork is listed impaired for aquatic life due to low dissolved oxygen and elevated levels of chloride along two segments: OW-01 and OW-02. There is one Illinois EPA sampling site located on segment OW-01 (sampling site OW-01) and one Illinois EPA sampling site located one mile upstream of segment OW-02 (sampling site OW-03). There are no data available for OW-02; however, data collected at OW-01 were used by Illinois EPA to assess and determine impairment in OW-02. The proximity of station OW-01 to segment OW-02 enables assessment of these adjoining segments with equal weight. Aquatic life use assessments can be made within approximately 10 miles upstream and downstream from the sample site for wadable streams and 25 miles for unwadable streams (IEPA 2016).

Six chloride and dissolved oxygen samples were collected on OW-01 between 2007 and 2012, and 3 samples were collected on OW-03 in 2007 (Table 7, Figure 6 and Figure 7). One exceedance of the general use water quality standard for chloride was observed in August 2012 at OW-01, with an additional sample close to the standard during the following month. The one chloride exceedance confirms aquatic life use impairment on segments OW-01 and OW-02. Chloride concentrations do not exceed the standard upstream of the impaired segments at OW-03. The timing of chloride sample collection is important to fully understand the sources and pathways of chloride movement in the watershed. Currently, all available data were collected between May through September; there are no available winter data. Additional sampling should be completed during spring melt and winter months to determine pollutant sources.

Multiple violations of the general use standard for dissolved oxygen were observed at OW-01 in August of 2012 and 2017 (Figure 8), and the dissolved oxygen impairments on segments OW-01 and OW-02 are confirmed. No violations of the standard were observed upstream of the impaired segments at OW-03; therefore, point sources are not likely contributing to any impairment along OW-02. Available phosphorus data were evaluated to determine if eutrophication was contributing to low dissolved oxygen conditions; however, no correlation was found between phosphorus and dissolved oxygen (Figure 9).

Table 7. Data summary, Lake Fork OW-01 and OW-02 segments

Sample Site	No. of samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV (standard deviation/ average)	Number of exceedances of general use water quality standard (500 mg/L)
Chloride						
OW-01	6	36	256	876	1.37	1
OW-03 (upstream of OW-02)	3	29	53	91	0.63	0
Sample Site	**No. of samples**	**Minimum (mg/L)**	**Average (mg/L)**	**Maximum (mg/L)**	**CV (standard deviation/ average)**	**Number of exceedances of general use water quality standard (>5 mg/L (Mar-Jul) and >3.5 mg/L (Aug-Feb))**
Dissolved Oxygen						
OW-01	6	4.6	7.5	13.6	0.44	1
OW-03 (upstream of OW-02)	3	7.2	9.1	10.2	0.18	0

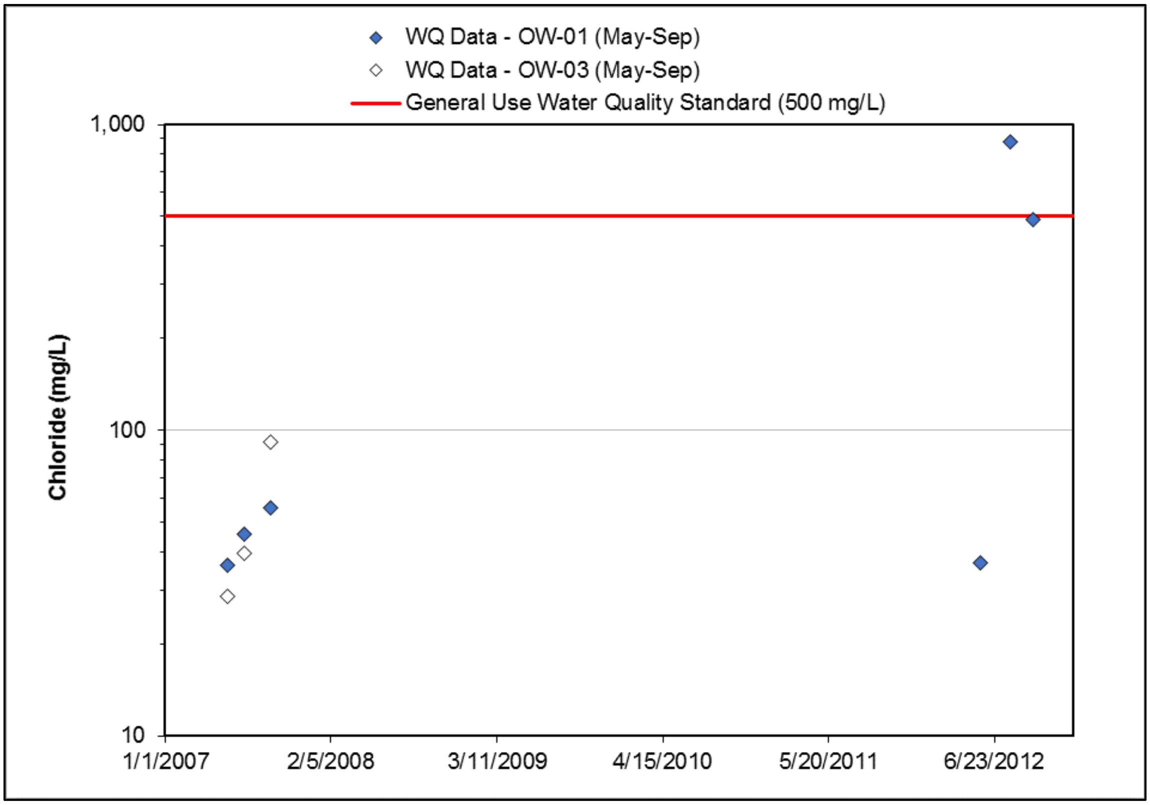


Figure 6. Chloride water quality time series, Lake Fork.

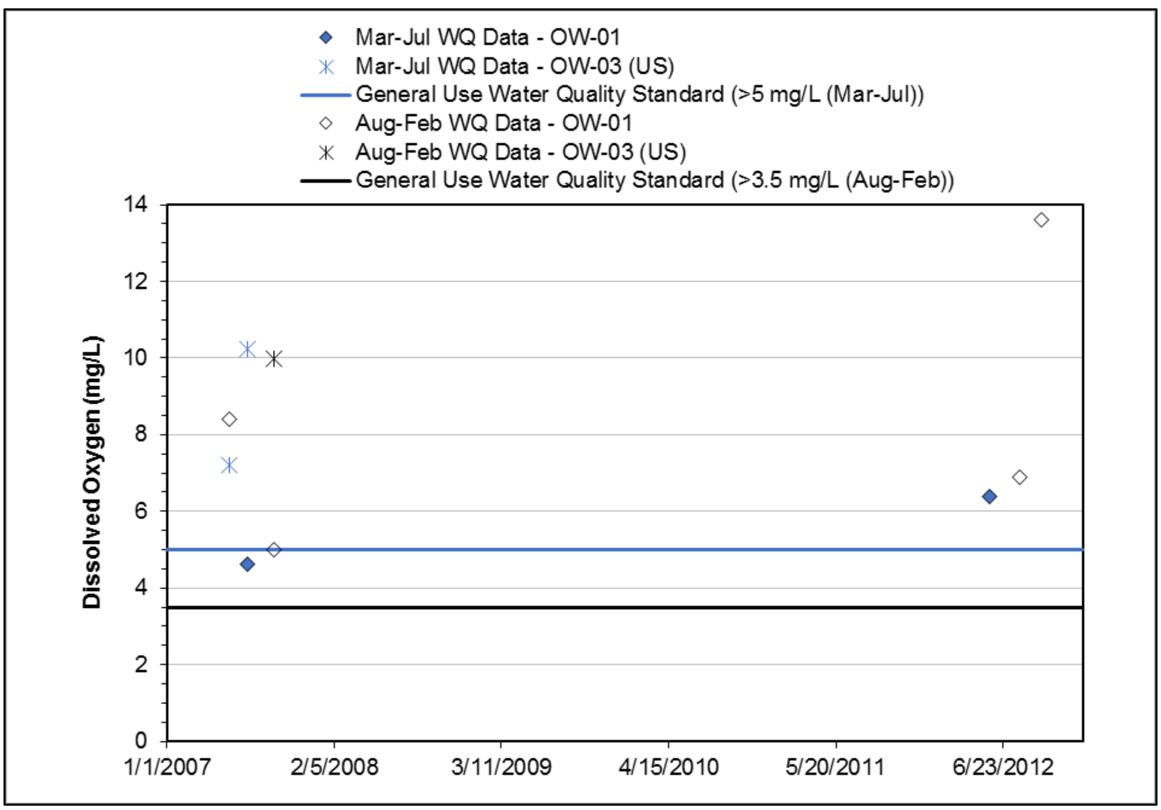


Figure 7. Dissolved oxygen water quality time series, Lake Fork.

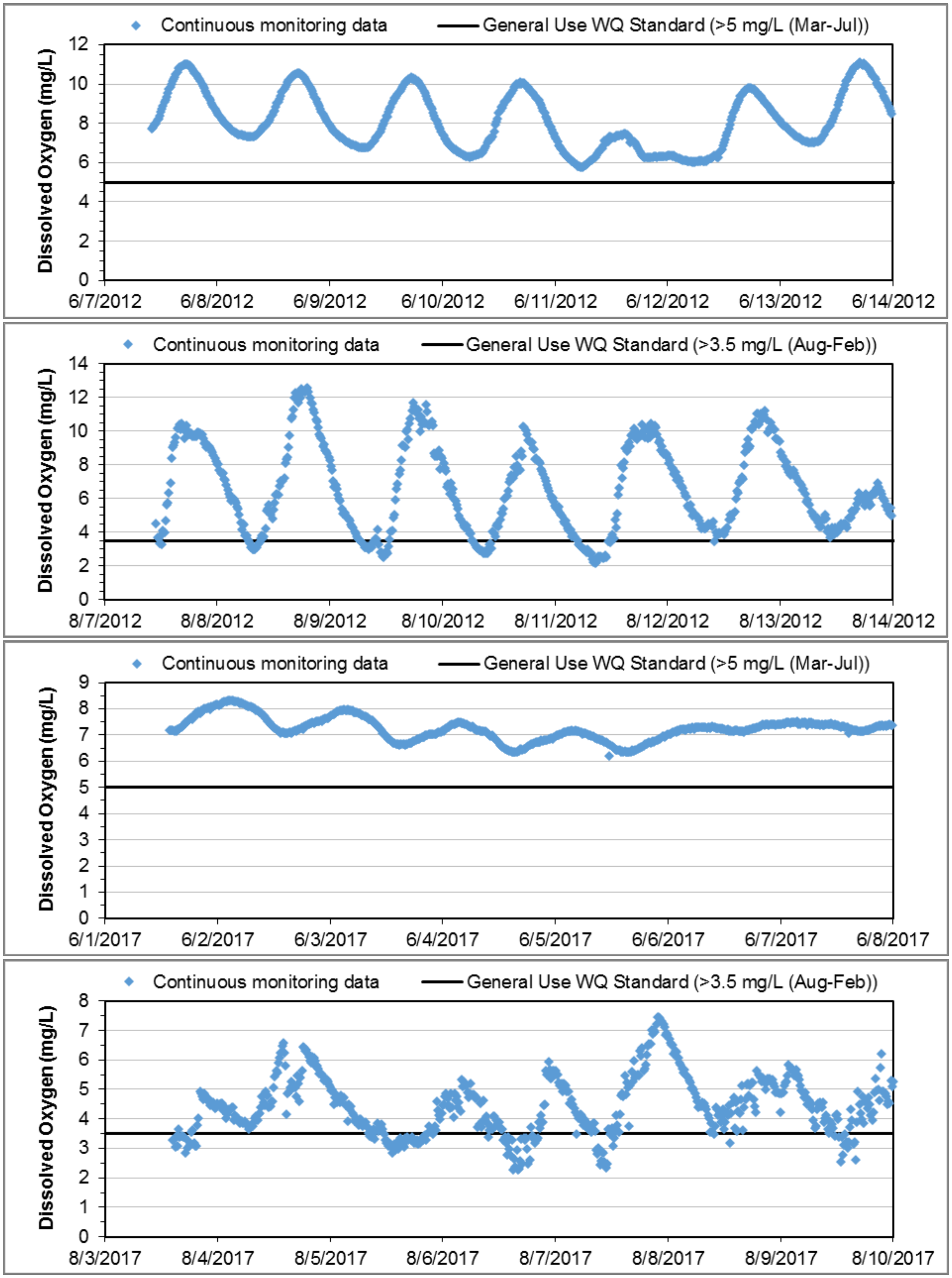


Figure 8. Continuous water quality time series for dissolved oxygen, Lake Fork OW-01 segment.

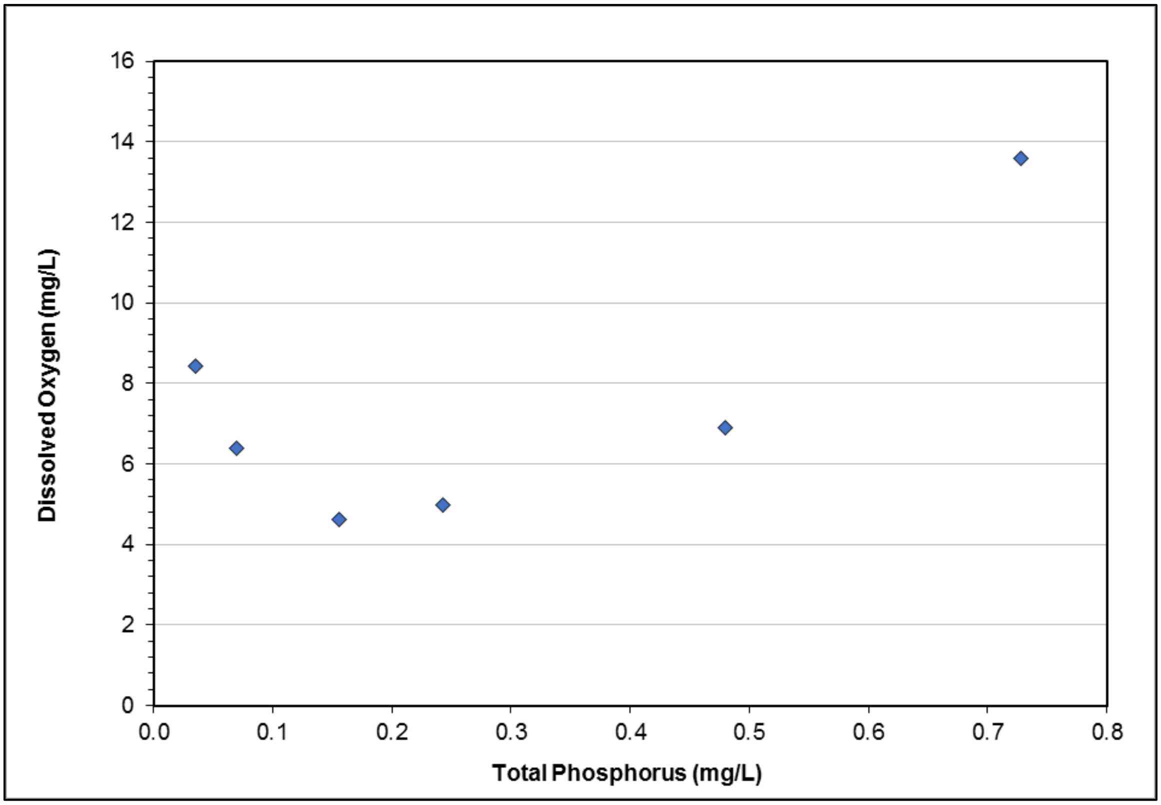


Figure 9. Total phosphorus versus dissolved oxygen, Lake Fork OW-01 segment.

5. TMDL Methods and Data Needs

The first stage of this project assesses of available data followed by evaluation of their credibility. The types of data available, their quantity and quality, and their spatial and temporal coverage relative to impaired segments or watersheds drive the approaches used for TMDL model selection and analysis. Credible data are those that meet specified levels of data quality, with acceptance criteria defined by measurement quality objectives, specifically their precision, accuracy, bias, representativeness, completeness, and reliability. The following sections describe the methods that will be used to derive TMDLs and the additional data needed to develop credible TMDLs.

5.1 Stream Impairments

TMDLs are proposed for segments with verified impairments and known pollutants (Table 8). A duration curve approach is suggested to evaluate the relationships between hydrology and water quality and calculate the TMDLs for chloride impairments. The Qual2K model is proposed to evaluate low dissolved oxygen Lake Fork OW-01, and additional monitoring is needed to verify impairment in Lake Fork OW-02 prior to model selection. Water quality analysis did not identify a pollutant that is causing the low dissolved oxygen impairment in O-35.

Table 8. Proposed Model Summary

Name	Segment ID	Designated Uses	TMDL Parameter(s)	Proposed Model	Proposed Pollutant
Kaskaskia River	O-35	Aquatic life	Dissolved Oxygen	Load duration curve or 4C classification	Phosphorus or non-pollutant
Lake Fork	OW-01	Aquatic life	Chloride	Load duration curve	Chloride
Lake Fork	OW-01	Aquatic life	Dissolved Oxygen	Qual2K	Biochemical oxygen demand, ammonia, total phosphorus
Lake Fork	OW-02	Aquatic life	Chloride	Load duration curve	Chloride
Lake Fork	OW-02	Aquatic life	Dissolved Oxygen	Load duration curve or 4C classification	Phosphorus or non-pollutant

a. Non-pollutant based impairment (see Section 4.1).

5.1.1 Load Duration Curve Approach

The primary benefit of duration curves in TMDL development is to provide insight regarding patterns associated with hydrology and water quality concerns. The duration curve approach is particularly applicable because water quality is often a function of stream flow. For instance, sediment concentrations typically increase with rising flows as a result of factors such as channel scour from higher velocities. Other parameters, such as chloride, may be more concentrated at low flows and more diluted by increased water volumes at higher flows. The use of duration curves in water quality assessment creates a framework that enables data to be characterized by flow conditions. The method provides a visual display of the relationship between stream flow and water quality.

Allowable pollutant loads have been determined through the use of load duration curves. Discussions of load duration curves are presented in *An Approach for Using Load Duration Curves in the Development of TMDLs* (USEPA 2007). This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points to form a curve. The data reflect a range of natural occurrences from extremely high flows to extremely low flows.

2. The flow curve is translated into a load duration (or TMDL) curve by multiplying each flow value (in cubic feet per second) by the water quality standard/target for a contaminant (mg/L), then multiplying by conversion factors to yield results in the proper unit (i.e., pounds per day). The resulting points are plotted to create a load duration curve.

3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted as points on the TMDL graph and can be compared to the water quality standard/target, or load duration curve.

4. Points plotting above the curve represent deviations from the water quality standard/target and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load. Further, it can be determined which locations contribute loads above or below the water quality standard/target.

5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards/targets.

6. The final step is to determine where reductions need to occur. Those exceedances at the right side of the graph occur during low flow conditions, and may be derived from sources such as illicit sewer connections. Exceedances on the left side of the graph occur during higher flow events, and may be derived from sources such as runoff. Using the load duration curve approach allows Illinois EPA to determine which implementation practices are most effective for reducing loads on the basis of flow regime.

Water quality duration curves are created using the same steps as those used for load duration curves except that concentrations, rather than loads, are plotted on the vertical axis. Flows are categorized into the following five hydrologic zones (U.S. EPA 2007):

- High flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows
- Moist zone: flows in the 10 to 40-percentile range, related to wet weather conditions
- Mid-range zone: flows in the 40 to 60-percentile range, median stream flow conditions
- Dry zone: flows in the 60 to 90-percentile range, related to dry weather flows
- Low flow zone: flows in the 90 to 100-percentile range, related to drought conditions

The duration curve approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 9 summarizes the general relationship between the five hydrologic zones and potentially contributing source areas (the table is not specific to any individual pollutant). For example, the table indicates that impacts from point sources are usually most pronounced during dry and low flow zones because there is less water in the stream to dilute their loads. In contrast, impacts from stormwater are most pronounced during moist and high flow zones due to increased overland flow from stormwater source areas during rainfall events.

Table 9. Relationship between duration curve zones and contributing sources

Contributing source area	Duration Curve Zone				
	High	Moist	Mid-range	Dry	Low
Point source				M	H
Livestock direct access to streams				M	H
Onsite wastewater systems	M	M-H	H	H	H
Stormwater: Impervious		H	H	H	
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	

Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low).

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act and U.S. EPA's implementing regulations. Because the approach establishes loads on the basis of a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions. An underlying premise of the duration curve approach is correlation of water quality impairments to flow conditions. The duration curve alone does not consider specific fate and transport mechanisms, which may vary depending on watershed or pollutant characteristics.

5.1.2 Qual2K

Qual2K is a steady-state water quality model that simulates eutrophication kinetics and conventional water quality parameters and is maintained by U.S. EPA. Qual2K simulates up to 15 water quality constituents in branching stream systems. A stream reach is divided into a number of computational elements, and for each computational element, a hydrologic balance in terms of stream flow (e.g., m3/s), a heat balance in terms of temperature (e.g., degrees C), and a material balance in terms of concentration (e.g., mg/l) are written. Both advective and dispersive transport processes are considered in the material balance. Mass is gained or lost from the computational element by transport processes, wastewater discharges, and withdrawals. Mass can also be gained or lost by internal processes such as release of mass from benthic sources or biological transformations.

The program simulates changes in flow conditions along the stream by computing a series of steady-state water surface profiles. The calculated stream-flow rate, velocity, cross-sectional area, and water depth serve as a basis for determining the heat and mass fluxes into and out of each computational element due to flow. Mass balance determines the concentrations of constituents at each computational element. In addition to material fluxes, major processes included in the mass balance are transformation of nutrients, algal production, benthic and carbonaceous demand, atmospheric reaeration, and the effect of these processes on the dissolved oxygen balance. The nitrogen cycle is divided into four compartments: organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. The primary internal sink of dissolved oxygen in the model is biochemical oxygen demand (BOD). The major sources of dissolved oxygen are algal photosynthesis and atmospheric reaeration.

The model is applicable to dendritic streams that are well mixed. It assumes that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (the longitudinal axis of the stream or canal). It allows for multiple waste discharges, withdrawals, tributary flows, and incremental inflow and outflow.

Hydraulically, Qual2K is limited to the simulation of time periods during which both the stream flow in river basins and input waste loads are essentially constant. Qual2K can operate as either a steady-state or a quasi-dynamic model, making it a very helpful water quality planning tool. When operated as a steady-state model, it can be used to study the impact of waste loads (magnitude, quality, and location) on instream water quality. By operating the model dynamically, the user can study the effects of diurnal variations in meteorological data on water quality (primarily dissolved oxygen and temperature) and also can study diurnal dissolved oxygen variations due to algal growth and respiration. However, the effects of dynamic forcing functions, such as headwater flows or point loads, cannot be modeled in Qual2K. A steady-state model is proposed for all impaired segments.

Qual2K is an appropriate choice for certain types of dissolved oxygen and organic enrichment TMDLs that can be implemented at a moderate level of effort. Use of the Qual2K models in TMDLs is most appropriate when (1) full vertical mixing can be assumed, and (2) water quality excursions are associated with identifiable critical flow conditions. Because these models do not simulate dynamically varying flows, their use is limited to evaluating responses to one or more specific flow conditions. The selected flow condition should reflect critical conditions, which for dissolved oxygen occurs when flows are low and the ambient air temperature is warm, typically in July or August.

5.2 Additional Data Needs

Data satisfy two key objectives for Illinois EPA, enabling the agency to make informed decisions about the resource. These objectives include developing information necessary to:

- Determine if the impaired areas are meeting applicable water quality standards for their respective designated use(s)
- Support modeling and assessment activities required to allocate pollutant loadings for all impaired areas where water quality standards are not being met

Additional data may be needed to verify impairment, understand probable sources, calculate reductions, develop calibrated water quality models, and develop effective implementation plans. Table 10 summarizes the additional data needed for each impaired segment.

Table 10. Additional data needs

Name	Segment ID	Designated Uses	TMDL Parameters	Additional Data Needs
Kaskaskia River	O-35	Aquatic life	Dissolved oxygen	Yes, to determine relationship with eutrophication
Lake Fork	OW-01	Aquatic life	Chloride	None
			Dissolved oxygen	Yes, to support Qual2K model
Lake Fork	OW-02	Aquatic life	Chloride	None
			Dissolved oxygen	Yes, to determine relationship with eutrophication
All	All	All	All	Implementation monitoring

Specific data needs include:

Determine Relationship with Eutrophication (O-35) – A series of DO measurements and chlorophyll-*a* and TP grab samples (two samples per day on three separate sampling days) should be collected from the impaired segment (site O-35) to verify impairment and to determine the role of eutrophication, if any, in the impaired segment. Sampling should occur during the warm summer months and during low flows to ensure that critical conditions are captured.

Determine Relationship with Eutrophication (OW-02) – A series of DO measurements and chlorophyll-*a* and TP grab samples (two samples per day on three separate sampling days) should be collected from the impaired segment to verify impairment and to determine the role of eutrophication, if any, in the impaired segment. Sampling should occur during the warm summer months and during low flows, and one of each paired sample should occur in the early morning to ensure that critical conditions are captured.

Support Qual2K Model Development (OW-01) – A minimum of two monitoring stations are needed on the impaired segment. Ideally, there will be two separate data collection periods, each time period lasting roughly 1 week during critical conditions (low flow, warm conditions). Although two monitoring locations are a minimum, adding more locations along the reach of interest will help determine how heterogeneous the system is and what dynamics are occurring along the reach. Monitoring stations can be located downstream of key tributaries, at road crossings, etc. as deemed necessary.

Recommended monitoring includes:

- Monitoring at two sites: 1) a new station where Lake Fork crosses E 100 N Rd, and 2) a new station where Lake Fork crosses N Co Rd 250 E:
  - Continuous dissolved oxygen, stream temperature, conductivity, and pH monitoring during warm, low flow critical conditions; monitoring should take place over approximately two weeks
  - Flow monitoring (depth and velocity) at least twice during dissolved oxygen monitoring; the number of measurements will be dependent on weather and stream conditions
  - Multiple samples of organic nitrogen, ammonia nitrogen, nitrate nitrogen, organic phosphorus, soluble reactive phosphorus, total inorganic carbon, carbonaceous biochemical oxygen demand (5-day and 20-day if possible), inorganic solids, chlorophyll-*a*, and alkalinity. Depending on the monitoring station, grab samples could be collected twice per day during the first and last days of sonde deployment or throughout the week.
  - Macrophyte and attached algae survey, survey of groundwater and tributary contributions, if any
  - Channel geometry, shade/vegetative survey, cloud cover, and channel substrate and bottom material, both upstream and downstream of the monitoring stations(s)
- A longitudinal/synoptic survey of DO concentrations along the entire reach (hand-sampling by probe on foot or from a row-boat periodically along the entire reach extent)
- Funding permitted: *in-situ* measurements of stream reaeration (via diffusion dome technique) and *in-situ* measurements of sediment oxygen demand (via chambers deployed on the streambed). Sediment bed surveys can be conducted potentially in lieu of SOD sampling (sediment total organic carbon sampling for instance could be a rough proxy for SOD if needed).
- Photo documentation of the system

Implementation Plan Development—Further in-field assessment may be needed to better determine the source of impairments in order to develop an effective TMDL implementation plan. Additional monitoring could include:

- Windshield surveys
- Streambank surveys and stream assessments for all three impaired segments and associated pollutants (phosphorus or non-pollutant for O-35 and OW-02; biochemical oxygen demand, ammonia, and phosphorus for OW-01)
- Farmer/landowner surveys
- Word of mouth and in-person conversations with local stakeholders and landowners

6. Public Participation

A public meeting was held on December 12, 2018 at the Carlyle Lake Visitor Center in Carlyle, IL to present the Stage 1 report and findings. A public notice was placed on the Illinois EPA website. There were many stakeholders present including representatives from the US Army Corps of Engineers, the Kaskaskia Watershed Association, the Original Kaskaskia Area Wilderness, Inc., and others. The public comment period closed on January 12, 2019. A comment provided by the Illinois Department of Transportation and response are below.

Illinois Department of Transportation comment: "…. Six chloride samples were collected between 2007 and 2012 in Lake Fork (IL_OW-01 & IL_OW-02). One sample exceeded the general water quality standard for chloride. I suggest IEPA continue to collect data to see if this exceedance was an anomaly. If a TMDL is developed for chloride, IDOT requests to be included in the TMDL calculations."

Response: IEPA will continue to monitor Lake Fork as part of their Intensive Basin Survey program which is conducted on a five-year rotation. At this time, a chloride TMDL is proposed. Illinois Department of Transportation will be included as a permitted MS4 entity if that applies; IEPA will further communicate with Illinois Department of Transportation during the Stage 3 TMDL development process.

7. References

Horsley and Witten, Inc. 1996. Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, Brunswick, and Freeport, Maine. Casco Bay Estuary Project.

IEPA (Illinois Environmental Protection Agency). 1994. Quality Assurance Project Plan. Bureau of Water, Division of Water Pollution Control. Springfield, Illinois.

IEPA (Illinois Environmental Protection Agency). 2016. Illinois Integrated Water Quality Report and Section 303(d) List, 2016. Water Resource Assessment Information and Listing of Impaired Waters. Springfield, IL.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing Biological Integrity in Running Water: a Method and its Rationale. Illinois Natural History Survey Special Publication 5. Champaign, Illinois.

NESC (National Environmental Service Center). 1992 and 1998. Summary of the Status of Onsite Wastewater Treatment Systems in the US.

Smogor, R. 2000 (draft, annotated 2006). Draft manual for Calculating Index of Biotic Integrity Scores for Streams in Illinois. Illinois Environmental Protection Agency, Bureau of Water, Division of Water Pollution Control. Springfield, Illinois.

Smogor, R. 2005 (draft). Interpreting Illinois fish-IBI Scores. Illinois Environmental Protection Agency, Bureau of Water, Division of Water Pollution Control. Springfield, Illinois.

Tetra Tech. 2004. Illinois Benthic Macroinvertebrate Collection Method Comparison and Stream Condition Index Revision, 2004.

Tetra Tech. 2018 draft. Upper Kaskaskia River Watershed Total Maximum Daily Load and Load Reduction Strategies.

USACE (U.S. Army Corps of Engineers). 2010. Historical River Morphology Study of the Kaskaskia River Headwaters to Lake Shelbyville. Technical Report 51. August 2010.

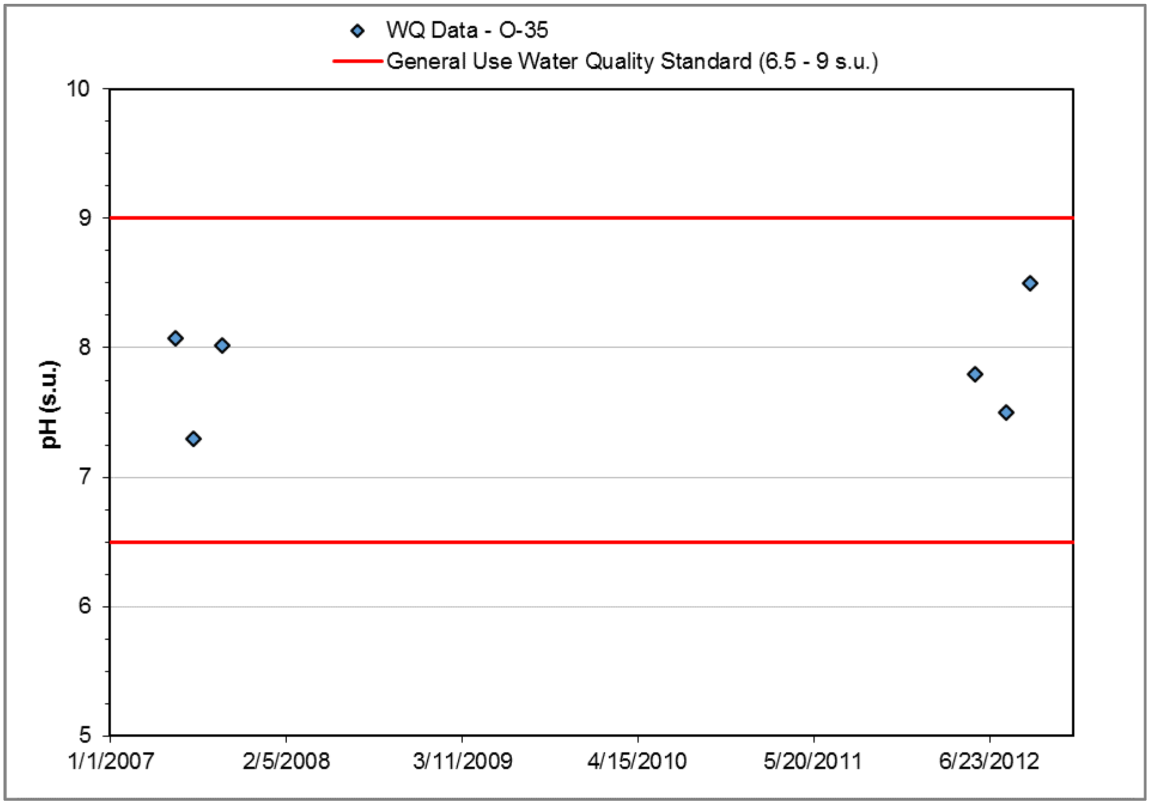
U.S. EPA (U.S. Environmental Protection Agency). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. EPA 440/4-91-001. Office of Water, Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). 2002. National Recommended Water Quality Criteria: 2002. EPA-822-R-02-047. Office of Water. Office of Science and Technology. Washington, D.C.

U.S. EPA (U.S. Environmental Protection Agency). 2007. An Approach for Using Load Duration Curves in the Development of TMDLs. EPA 841-B-07-006. U.S. Environmental Protection Agency, Washington D.C.

Appendix A – Unimpaired Stream Data Analysis

Kaskaskia River segment O-35 is listed as being impaired for aquatic life use due to pH. One IEPA sampling site was identified on the segment, O-35. No samples during 2007 and 2012 were recorded outside of the general use standard range (6.5> pH >9 s.u.). It is therefore recommended that the segment be delisted for pH and no TMDL be developed.



pH water quality time series, Kaskaskia River O-35 segment.