Memorandum

From: Hans Holmberg and Scott Bell
Date: February 13, 2014
Project: FOXRIP

To: Fox River Study Group

SUBJECT: DRAFT: Fox River Implementation Plan (FRIP) Water Quality Standards and Targets

Summary

LimnoTech reviewed the applicable water quality standards for dissolved oxygen (DO) in the Fox River and considered specific aspects of setting water quality targets in the context of the Fox River Implementation Plan (FRIP). Several of these aspects were discussed with the Illinois Environmental Protection Agency (IEPA), an active participant on the development of the FRIP. The key findings and recommendations from this review are as follows:

- Water quality modeling for the FRIP will be developed and applied to represent the critical low flow conditions for both the summer months as well as other seasons.
- For now, development of the FRIP will proceed without consideration of transient wet weather dissolved oxygen sags.
- The FRIP will be developed in consideration of both current conditions and future development conditions, which will require estimation of future low flow conditions.
- Development of the FRIP will proceed under the assumption that a feasible combination of control measures exist to meet current water quality standards. If it appears that there is no feasible alternative to achieve dissolved oxygen water quality criteria everywhere, the issue of site specific water quality criteria will be discussed with Illinois EPA.

Background

The Fox River Implementation Plan (FRIP) is being developed by the Fox River Study Group (FRSG) with the primary objective of identifying changes needed in the watershed, including pollutant reduction efforts and dam removals, to attain existing water quality standards for dissolved oxygen and reduce the impacts of excessive algal growth. The Illinois water quality standards define numeric dissolved oxygen criteria applicable to the Fox River as well as a narrative criterion for protection against excessive algal growth. Portions of the Fox River are currently included on the Illinois EPA’s list of impaired waters, also known as the 303(d) list. Impairments as a result of low dissolved oxygen and excess phosphorus are presented in Figures 1 and 2. The FRIP will rely on model simulations of watershed pollutant loadings and instream response to pollutant loads to inform the identification of actions needed to attain applicable water quality criteria and remove these impairments. This process includes the need to develop water quality targets for the FRIP based on the water quality criteria. Considerations in developing FRIP targets include:

1. What water quality criteria for dissolved oxygen and phosphorus apply to the Fox River?
2. Under what climatic, hydrologic and point source loading conditions should the models be run to simulate pollutant loadings and instream response?

3. How will results from the steady-state QUAL2K model be used to inform annual allowable phosphorus loads from the various sources?

4. How will model results be compared to the numeric targets?

This memorandum includes a presentation of the existing criteria, a summary of a discussion with Illinois EPA regarding water quality targets for the FRIP, an assessment of critical low flow values in the Fox River, and a recommended approach for establishing annual allowable phosphorus loads in the FRIP.
Figure 1. Map of Study Area with Low Dissolved Oxygen Impairments
Figure 2. Map of Study Area with Total Phosphorus Impairments
Applicable Water Quality Standards

The water quality standards and criteria applicable to the Fox River are identified in Illinois Administrative Code (IAC) Title 35, Subtitle C, Chapter I, Parts 302 and 303. The Fox River must meet the general use standards of Subpart B of Part 302. The criteria for the primary water quality concerns, dissolved oxygen and algal impairments, are included in Section 302.206 and 302.203, respectively. The applicable dissolved oxygen criteria for the Fox River are presented in the following excerpt from the IAC.

Section 302.206 Dissolved Oxygen

General use waters must maintain dissolved oxygen concentrations at or above the values contained in subsections (a), (b) and (c) of this Section.

a) General use waters at all locations must maintain sufficient dissolved oxygen concentrations to prevent offensive conditions as required in Section 302.203 of this Part. Quiescent and isolated sectors of General Use waters including but not limited to wetlands, sloughs, backwaters and waters below the thermocline in lakes and reservoirs must be maintained at sufficient dissolved oxygen concentrations to support their natural ecological functions and resident aquatic communities.

b) Except in those waters identified in Appendix D of this Part, 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 must not be less than the following:
   1) During the period of March through July,
      A) 5.0 mg/L at any time; and
      B) 6.0 mg/L as a daily mean averaged over 7 days.
   2) During the period of August through February,
      A) 3.5 mg/L at any time;
      B) 4.0 mg/L as a daily minimum averaged over 7 days; and
      C) 5.5 mg/L as a daily mean averaged over 30 days.

c) The dissolved oxygen concentration in all sectors within the main body of all streams identified in Appendix D of this Part must not be less than:
   1) During the period of March through July,
      A) 5.0 mg/L at any time; and
      B) 6.25 mg/L as a daily mean averaged over 7 days.
   2) During the period of August through February,
      A) 4.0 mg/L at any time;
      B) 4.5 mg/L as a daily minimum averaged over 7 days; and
      C) 6.0 mg/L as a daily mean averaged over 30 days.

d) Assessing attainment of dissolved oxygen mean and minimum values.
   1) Daily mean is the arithmetic mean of dissolved oxygen concentrations in 24 consecutive hours.
   2) Daily minimum is the minimum dissolved oxygen concentration in 24 consecutive hours.
   3) The measurements of dissolved oxygen used to determine attainment or lack of attainment with any of the dissolved oxygen standards in this Section must assure daily minima and daily means that represent the true daily minima and daily means.
   4) The dissolved oxygen concentrations used to determine a daily mean or daily minimum should not exceed the air-equilibrated concentration.
   5) “Daily minimum averaged over 7 days” means the arithmetic mean of daily minimum dissolved oxygen concentrations in 7 consecutive 24-hour periods.
6) “Daily mean averaged over 7 days” means the arithmetic mean of daily mean dissolved oxygen concentrations in 7 consecutive 24-hour periods.

7) “Daily mean averaged over 30 days” means the arithmetic mean of daily mean dissolved oxygen concentrations in 30 consecutive 24-hour periods.

There is one segment of the Fox River that is listed in Appendix D of Section 302 for enhanced dissolved oxygen protection as identified in Section 302.206(c):

**302. Appendix D Stream Segments for Enhanced Dissolved Oxygen Protection**

<table>
<thead>
<tr>
<th>BASIN NAME: Illinois</th>
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</thead>
<tbody>
<tr>
<td>Segment Name: Fox River</td>
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<tr>
<td>Segment No.: 270</td>
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<table>
<thead>
<tr>
<th>End Points</th>
<th>Latitude</th>
<th>Longitude</th>
<th>COUNTY</th>
</tr>
</thead>
<tbody>
<tr>
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<td>41.6177003859476</td>
<td>-88.5558384703467</td>
<td>KENDALL</td>
</tr>
<tr>
<td>end</td>
<td>41.7665361019038</td>
<td>-88.3100243828453</td>
<td>KANE</td>
</tr>
</tbody>
</table>

The dissolved oxygen criteria apply at all times other than at critical low flows, those less than the 7Q10, as defined in Section 302.103.

### Section 302.103 Stream Flows

“Except as otherwise provided in this Chapter, the water quality standards in this Part shall apply at all times except during periods when flows are less than the average minimum seven day low flow which occurs once in ten years.”

The water quality standards applicable to algal growth are found in Section 302.203 and are presented below.

### Section 302.203 Offensive Conditions

Waters of the State shall be free from sludge or bottom deposits, floating debris, visible oil, odor, plant or algal growth, color or turbidity of other than natural origin. The allowed mixing provisions of Section 302.102 shall not be used to comply with the provisions of this Section.

The U.S. EPA has mandated that States develop numeric nutrient criteria, in part to address algal growth issues. The IEPA is currently working through this process with consultation by U.S. EPA. For the purposes of the FRIP, required reductions in phosphorus loads will be assessed to meet dissolved oxygen criteria, but numeric targets for ambient phosphorus or chlorophyll-a concentrations are not anticipated.

The applicable dissolved oxygen criteria are presented on a map of the study in Figure 3 and also presented in Figures 4 and 5 in profile along the river from the upstream boundary of the study area at Stratton Dam to the downstream boundary of the study area at the confluence with the Illinois River.
Figure 3. Map of Study Area with Applicable Dissolved Oxygen Criteria
Figure 4. Longitudinal Profile of Dissolved Oxygen Criteria Applicable March through July

Figure 5. Longitudinal Profile of Dissolved Oxygen Criteria Applicable August through February
Water Quality Target Discussion with Illinois EPA

Members of the FRSG and LimnoTech participated in a conference call with Illinois EPA on January 30, 2014 to discuss considerations in setting water quality targets for the FRIP. A summary of the outcomes of the discussion is presented below.

1) Seasonal-based annual load targets – Is Illinois EPA amenable to doing a seasonally-varied evaluation, considering changes in low-flows and temperatures, to define the annual load targets?
   • Illinois EPA stated that the most important goal is to achieve the water quality criteria for dissolved oxygen.
   • Illinois EPA will accept a seasonal analysis to develop seasonal load limits and then transform them into annual load limits, as long as the water quality standards are met.
   • Based on this discussion, the FRIP will be developed based on a seasonal evaluation for achieving water quality targets and will establish associated annual load targets and/or reductions for each major source category.

2) Wet weather dissolved oxygen effects – Is Illinois EPA expecting the FRIP to consider possible wet weather dissolved oxygen sags?
   • Illinois EPA did not provide an answer on this, but said that they would need to consider the question further.
   • Based on this discussion, the development of the FRIP will proceed without consideration of transient wet weather dissolved oxygen sags at this time. However, follow up with Illinois EPA to confirm their expectations on this issue is needed.

3) Future planning conditions – How should the FRIP account for probable changes in low flow?
   • This question initiated a discussion of adaptive management, including future monitoring to see how water quality is changing as a result of actions taken under the plan.
   • Members of the FRSG agreed with the need for adaptive management and Illinois EPA said that it was part of the FRSG’s original proposal.
   • Illinois EPA did not express an opinion about what planning horizon to use in the FRIP nor did they express a preference as to how possible hydrologic changes in the future should be represented. There was a consensus that sensitivity analyses demonstrating how required implementation actions might vary as a function of assumed low-flow values would be worthwhile.
   • Based on this discussion, the FRIP will be developed as planned in evaluating future loading and control scenarios.

4) Site-specific DO – Would Illinois EPA be open to the use of site-specific water quality criteria if no feasible alternatives are identified to meet current water quality criteria? If so, what should be considered at this stage in the development of the FRIP?
analyses indicate no feasible alternatives will result in attainment of existing water quality standards?

- Illinois EPA indicated that any discussion of site-specific water quality criteria would have to involve the U.S. EPA.
- Based on this discussion, the FRIP will be developed as planned. If it appears that there is no feasible alternative to achieve dissolved oxygen water quality criteria everywhere, this issue will be raised again with Illinois EPA.

Stream Flows in the Fox River

As presented earlier in this memorandum, compliance with water quality criteria for dissolved oxygen is required to be assessed at critical low flow conditions characterized by the 7-day average low flow that is expected to occur once in ten years, or the 7Q10. The ISWS Report, Fox River Watershed Investigation: Stratton Dam to the Illinois River Phase III, Evaluation of Watershed Management Scenarios, 2013, includes an estimate of the 7Q10 value at Stratton Dam of 93 cfs. This estimate was based on the ISWS Illinois Streamflow Assessment Model (ILSAM).

LimnoTech conducted an assessment to confirm this value was representative of current conditions in the Fox River as well as assess seasonal variations in low flow. Long-term flow gauging data for two USGS stations, one at Algonquin and the other at Dayton, was obtained and examined for changes in low flow over time and across seasons. Plots of the minimum 7-day average flow for each calendar year are presented in Figures 6 and 7. These plots demonstrate the increases in 7-day average low flows over time. Therefore, LimnoTech calculated the 7Q10 value using the most recent 30 years of data. The annual 7Q10 value at Algonquin was 129 cfs and at Dayton it was 253 cfs. For comparison to the Stratton Dam 7Q10 of 93 cfs, point source and tributary flows between Algonquin and Stratton Dam applied by ISWS in the QUAL2K model were subtracted from the estimate at Algonquin, resulting in a 7Q10 value of 100 cfs at Stratton Dam. This value compares favorably to the 93 cfs estimate presented by ISWS. Therefore, LimnoTech recommends continued use of the 93 cfs value as the annual critical 7Q10 flow at the upstream boundary of the study area.

A primary outcome of the FRIP will be annual phosphorus loads allowed from each source that result in attainment of water quality standards throughout the Fox River. Application of the steady-state QUAL2K model at the annual 7Q10 will support the determination of allowable daily loads of phosphorus required to meet water quality standards at those conditions. Based on an assessment of the Algonquin flow data, the annual 7-day low flow is expected to occur 70% of the time in August, September, or October, with the highest frequency, 37% of annual low flow values, occurring in September. Under different conditions, such as higher flows, lower temperatures, or shorter daylight hours, higher phosphorus loads may occur without resulting in violations of the dissolved oxygen criteria. Extrapolating the allowable loads under critical conditions to an annual allowable load may be overly restrictive and not cost-effective. Therefore, LimnoTech will develop allowable loads under critical low-flow summer conditions, but will also consider seasonal variations in the allowable loads under conditions of varying streamflow, temperature, and daylight to inform the annual allowable load presented in the FRIP.
Figure 6. Annual 7-Day Low Flows at Algonquin

Figure 7. Annual 7-Day Low Flows at Dayton
Recommended Water Quality Targets

The primary water quality parameter of concern is dissolved oxygen. The Illinois water quality standards establish specific numeric criteria for dissolved oxygen, both on an “at any time” basis and a daily average basis. There are separate criteria for two seasonal timeframes. The QUAL2K model will be developed and applied to represent the critical conditions (7Q10, temperature and daylight) for the critical summer months as well as distinct seasons. QUAL2K will predict daily average dissolved oxygen concentrations for each segment defined in the model, as well as a minimum concentration in each segment resulting from diurnal swings related to algal photosynthesis and respiration. Model results for each model segment, for both daily average dissolved oxygen as well as daily minimum, will be compared to the applicable dissolved oxygen criterion for the given segment and season. Attainment of minimum and daily average dissolved oxygen criteria will be assessed. The model inputs will then be adjusted to reflect reduced pollutant loadings or dam removals to determine what combinations of changes result in attaining applicable dissolved oxygen criteria at all times throughout the study area.

Additional analyses will be conducted using the QUAL2K model to assess the sensitivity of the model results to changes in the 7Q10 and temperatures under future development conditions.

Continued monitoring of the Fox River will be critical to support the successful implementation of the FRIP and ultimate attainment of water quality standards. Adaptive management will rely on understanding trends in water quality in response to changes implemented as a result of the FRIP and other efforts or factors, such as climate change. Continued monitoring may also be beneficial in supporting site-specific criteria for the system, if deemed necessary.