Fox River Watershed Investigation – Stratton Dam to the Illinois River: Water Quality Issues and Data Report to the Fox River Study Group, Inc.

Executive Summary

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Study Background

The Illinois Environmental Protection Agency (IEPA) in their *Illinois Water Quality Report 2000* (IEPA, 2000) listed parts of the Fox River in McHenry and Kane Counties and part of Little Indian Creek as impaired. In the 2002 IEPA report (IEPA, 2002), the entire length of the Fox River in Illinois is listed as impaired, as well as Nippersink, Poplar, Blackberry, and Somonauk Creeks, and part of Little Indian Creek. The IEPA has included the Fox River and these tributaries on their list of impaired waters commonly called the 303(d) list (IEPA, 2003). The IEPA uses a detailed, stepwise method to develop this list, 303(d) and their rational and methodology are described in *Illinois 2002 Section 303(d) List* (IEPA, 2003).

Concerns about the surface water quality in the watershed led to the formation of the Fox River Study Group, Inc. (FRSG) in 2001. Initially the FRSG developed a plan to collect additional water chemistry data to augment the ambient monitoring by the IEPA and used in IEPA's use assessment of water quality. With encouragement from the IEPA, the FRSG expanded its initiative to a watershed plan that centers on development of models of the watershed to help investigate water quality issues and develop feasible watershed management plans. Models provide linkages between observed constituents in the water and their sources. Well-calibrated models can be used to evaluate potential management scenarios to assess their probable impact, thus serving as tools to evaluate alternative actions. At the request of the FRSG, the Illinois State Water Survey (ISWS) proposed a multiphase plan of study with the ultimate objective of developing watershed computer models and a long-term monitoring and modeling plan. Phase I of the project, reported herein, was to assemble and evaluate available data in preparation for model development. Phase II will focus on customizing models of watershed to address identified water quality issues. Subsequent phases will involve intensive data collection for model calibration and validation, and implementation of long-term monitoring and model updates. The current study is limited to the Fox River watershed below Stratton Dam to the confluence with the Illinois River. Ultimately the study area must be expanded to include the upper portion of the watershed, including Wisconsin, in a collaborative watershed plan between agencies in both Illinois and Wisconsin. Fundamental to all phases of the project is information dissemination and communication with stakeholders.

This report presents the results of phase I of the project, which was funded by the IEPA. The report is only one of the products of phase I. The Fox River Watershed Investigation Web

site (http://ilrdss.sws.uiuc.edu/fox), accessed through the Illinois Rivers Decision Support System Web site, was developed and serves as a portal to other products, including a database of publications reporting water quality data for the Fox River watershed; a project bibliography; geographically referenced geographic information system (GIS) datasets and metadata with online mapping tools; a water chemistry database, FoxDB, with an interface for viewing and loading data; and an electronic version of the full report.

The Watershed

The Fox River drains 938 square miles in Wisconsin and 1720 square miles in Illinois. The river and the land in the watershed are used for agriculture, industry, recreation, residences, and urban development. The river currently supports multiple water uses, including aquatic life, fish consumption, swimming, recreation, and public water supply. In addition, the river and its tributaries receive and assimilate various pollution sources such as storm water, and permitted discharges from municipal and industrial facilities.

The Fox River watershed, one of the most populous watersheds in Illinois, is home to about 11 percent of the state's population. The Illinois part of the watershed had an average population density of 588 persons per square mile in 2000. Lake, Kane, and McHenry Counties all rank among the top ten Illinois counties in population. The population in the watershed is expected to increase dramatically by year 2020, ~30 percent over the 2000 totals, with much of the growth in McHenry and Kane Counties. Along with population increases in past years, land use in the watershed has changed. Between about 1992 and 2000, urban areas increased to cover an additional 3 percent of the total watershed while agricultural use declined. This change is concentrated in certain high-growth areas. Population growth and increases in urban land cover are occurring along the Fox River corridor and several tributaries between southern McHenry County and northern Kendall County. Poplar Creek and Waubansee Creek watersheds experienced the largest percent conversion to urban land cover between 1992 and 2000.

Consequences of this population growth are greater demand on the Fox River for public water supply, and stormwater and effluent assimilation. A 1997 study of streams in northeastern Illinois (Dreher, 1997) showed that nearly all streams in urban/suburban watersheds (population density > 300 persons/square mile) exhibited signs of considerable impairment of fish communities. Without proper planning, water quality and biological integrity may decline in the Fox River and its tributaries.

Review of Previous Water Quality Studies

Numerous studies of water quality in the Fox River watershed have been conducted over the years. Studies vary in terms of constituents considered, geographic area, and time span, although most have focused on the mainstem of the Fox River. Nutrient concentrations (nitrogen and phosphorus) have been evaluated in several studies. Nitrate nitrogen levels typically have not exceeded the public water and food-processing standard of 10 milligrams per liter (mg/L), but total N has been at levels that suggest high nutrient enrichment. There are no in-stream standards for P, but levels generally have been above recommended levels for total phosphorus. Dissolved

oxygen is one of the most fundamental indicators of the health of aquatic ecosystems. Past and recent studies of the diurnal variation in dissolved oxygen have shown violations of the Illinois Pollution Control Board (IPCB) standard with wide variations attributed to high algal growth. Low dissolved oxygen consistently has been identified as a problem in the Fox River, typically during low-flow conditions in the summer and fall. High pH levels are another consequence of high algal biomass. Siltation and high suspended solids concentrations have been investigated because of habitat degradation associated with deposition of materials in the river channel. The largest sediment deposits are in impounded areas upstream of dams, but free-flowing areas of the main channel of the Fox River remain relatively free from sediment accumulation. There have been occasional violations of IPCB criteria for various major and trace elements. Fecal coliform counts vary widely, with several orders of magnitude difference suggesting pathogen-related parameters are greatly affected by a variety of sources and conditions. Pesticides and synthetic organic compounds have been detected in water, sediment, and fish tissue.

The latest IEPA assessment of the Fox River watershed (IEPA, 2003) lists leading sources of impairment identified by the IEPA as organic enrichments and low dissolved oxygen, followed by pH. These factors may be related to the biological productivity, fueled by nutrient loading. Siltation, suspended solids and nutrients, also are listed as possible impairment issues, along with flow alteration (documented site-specific knowledge of unnatural flow alterations, such as dams and water withdrawals) and habitat alteration (other than flow, such as documented channel alteration). Pathogens are listed as the source of impairment for tributaries (Nippersink, Poplar, Blackberry, and Somonauk Creeks); however, no confidence level is given for these assessments, possibly due to the inadequacy of data for evaluating compliance with standards. Habitat alteration is listed as the source of impairment for Little Indian Creek. Polychlorinated biphenyls (PCBs) found in fish tissue are listed as a source of impairment along the mainstem of the Fox River. PCBs accumulate in the food chain and are an indicator of past, not current activities, and are not linked to present inputs to the system.

Phase I Evaluation of Water Chemistry Data, 1998-2002

In order to take advantage of all water chemistry data collected in the watershed and, in particular, data collected by the FRSG, water chemistry data were compiled in a single database. The database created, FoxDB, includes water chemistry, sediment chemistry, and flow data collected at 190 different sites in the Fox River watershed, 88 sites located on the Fox River, and 102 sites on tributaries. Only 60 sites were sampled at least once during the last five years: 38 sites on the Fox River and 22 sites on tributaries. The primary sources of data for this time period are IEPA, United States Geological Survey (USGS), FRSG, Fox River Water Reclamation District (FRWRD), Fox Metro Water Reclamation District (FMWRD), and the Max McGraw Wildlife Foundation (Santucci and Gephard, 2003).

These data generally support the IEPA's findings of low dissolved oxygen levels, high pH on the mainstem of the Fox River and the potential for fecal coliform levels exceeding standards, high nutrient levels, and siltation. However, assessment of impairments is not the intent of the analyses, rather the data were examined primarily from the viewpoint of model selection, specifically investigating seasonal effects, flow regime effects, longitudinal variations

along the river, as well as to identify monitoring gaps. The following observations are made on the basis of the available data for the Fox River mainstem.

- Most measurements (94% of all data) exceed the U.S. Environmental Protection Agency (USEPA) recommended criterion of 2.18 mg/L as N for total nitrogen (USEPA, 2000). Total nitrogen levels tend to remain constant with spring concentrations slightly higher, but the form (ammonia, nitrate, or organic) varies seasonally. Nitrate nitrogen forms tend to be highest in the winter and spring, while organic and Kjeldahl nitrogen are higher in the summer. Ammonia nitrogen levels may exceed standards near Algonquin in McHenry County and in Ottawa, typically in the summer during low flows. Reported measurements of nitrate nitrogen are below the public water supply standard of 10 mg/L.

- Phosphorus concentrations at most stations exceed the USEPA recommended criterion for streams of 0.076 mg/L for total phosphorus. The highest concentrations are associated with summer low-flow conditions, although total loading during high flows is greater. Total phosphorus increases steadily from the Wisconsin border to Yorkville, where the trend reverses and total phosphorus levels decline toward Ottawa.

- Dissolved oxygen levels less than the standard occur from Johnsburg to Oswego, typically in impounded areas upstream of dams during summer low-flow conditions.

- Measurements of pH have exceeded the IEPA standard of 9 from Algonquin to South Elgin and from Montgomery to Ottawa. Levels of pH do not follow strong trends except that they tend to decrease with increasing flow.

- Suspended solids levels tend to be highest between April and August. Both concentrations and loads increase with flow, although the trend has a seasonal component. There are no water quality standards for suspended solids.

- Fecal coliform counts exhibited at almost all stations downstream of Johnsburg indicate a high likelihood of noncompliance with the water quality standards.

- Data are insufficient to detect trends in algae mass with respect to seasons or flow regime, but measurements at stations monitored since 2001 by the FRSG show concentrations far exceeding USEPA guidance for eutrophic conditions.

Data Gaps in Water Chemistry Monitoring

The adequacy of sampling data can *only* be judged in terms of the goals of the study or the questions to be answered. Data collection programs conducted by the IEPA and USEPA and have been designed primarily to generate long-term datasets that document ambient conditions. Samples collected several times per year give a snapshot of the water chemistry, but when collected systematically over a long period of time, sample results can document general trends. Data collected by the FRSG also provide a snapshot of the water chemistry, and have the added enhancement that they are collected on the same day at points along the Fox River and are

collected more frequently, providing a more complete spatial and seasonal dataset. In contrast, data for the Max McGraw Wildlife Foundation study were collected over a short period of time and do not provide insight to seasonal or flow regime effects, but capture diurnal variations in concentration levels.

Data requirements for modeling depend upon the requirements and expectations of the models, such as the level of detail needed to assist resource managers with decision-making for developing feasible watershed management plans. In general, insufficient data are available to customize model rate coefficients for the Fox River watershed, and intensive data collections will be needed for model calibration and verification once models are selected and output specifications are determined.

There are some basic water chemistry data gaps. While models are being developed, some additional monitoring could be conducted that would provide data useful for definition of background conditions, regardless of model specifications. In terms of providing background information on ambient water quality conditions, there are some clear water chemistry data gaps.

- The central part of the watershed, primarily in Kane County, has been monitored extensively, but the presence of dams and the associated impoundments introduce discontinuities and limit the ability to interpret water quality conditions much above or below the monitoring site.

- Between Yorkville and Ottawa, there are no active monitoring sites.

- The sampling of tributaries (Poplar and Somonauk Creeks) is, for the most part, limited to locations near their confluence with the Fox River. This provides some information on loading from the watershed, but no detail of conditions upstream.

- The lack of any systematic water quality monitoring of most tributaries is a significant data gap.

- Current regular monitoring programs are not conducted with a frequency desirable for evaluating compliance with IEPA water quality standards for ammonia nitrogen, fecal coliforms, and priority pollutants (e.g., trace metals).

- Sampling for trace metals is inadequate due to current collection and analysis methods. Trace metals, such as copper, zinc, nickel, and cadmium, are present, but the lack of accurate values for trace metals is a serious limitation to assessment.

- Data showing diurnal variations that are critical to assessment of dissolved oxygen are not routinely collected.

- Current sampling programs do not address loading related to urban and agricultural runoff or combined sewer overflows. Water quality can change rapidly during runoff events, and a single sample is not representative of the mean concentration during an event.

- There is increasing awareness that a host of unmonitored chemicals used in households, industry, and agriculture enter streams and rivers. The impacts of these constituents, such as pharmaceuticals and hormones, are not yet defined. While not identified as problematic in the Fox River watershed, stakeholders should be cognizant of the potential for problems, and this may be an area for consideration in the future. The lack of monitoring data for these constituents is a data gap.

Recommendations for Interim Water Chemistry Monitoring

The following recommendations are, for the most part, made in consideration of the scope of monitoring that may be accomplished through the volunteer FRSG program.

- Conduct monitoring of the Fox River downstream of Yorkville, similar to that of the FRSG program, at former IEPA station (DT41) located on Country Road three miles south of Plano and five miles West of Yorkville (T37N R06E SW34).

- Conduct routine sampling at tributaries in order of priority: Crystal, Tyler, Ferson, Waubansee, Flint, Little Rock, Big Rock, Little Indian / Indian, and Buck Creeks following protocols similar to those of the FRSG program. Flow measurements should be made at the time of sampling for any ungaged streams.

Recommendations to Close Data Gaps in Climate and Regional Geospatial Datasets

In addition to the water chemistry data and associated rate coefficients, standard data inputs are necessary to model water quality in a watershed. These include: elevation data, stream locations, soil types and properties, land cover, stream channel geometry, flow data and climate data (precipitation and temperature). Available data are presented in Chapter 2 of this report. Below is a summary of recommendations for additional data acquisition.

- It is strongly recommended that the South Elgin gage (05551000) be reinstated as a continuous recording gage. The lack of flow data for many tributaries also will limit model capabilities, and establishing continuous recording gages is encouraged, particularly for those ungaged tributaries recommended for additional water chemistry sampling above.

- The National Hydrography Dataset (NHD) high-resolution data are nearly completed for the lower Fox River watershed, but only low-resolution data are available for the upper Fox River watershed. Cost sharing with the USGS is a viable option to finalize the high-resolution data for the entire watershed in a timely manner.

- The State Soil Geographic Database SSURGO high-resolution soils information is available for only selected counties in the Fox River watershed: Kane, McHenry, DuPage, DeKalb, and Will Counties. Other counties in the watershed should be encouraged to work with the U.S. Department of Agriculture, Natural Resources Conservation Service to develop SSURGO data.

- Precipitation data should be collected for every gaged watershed, with at least daily totals and preferably hourly data collected. Precipitation data are lacking in the lower part of the watershed.

Modeling Considerations and Recommendations for Observed Water Quality Issues

There are two aspects of water quality modeling, watershed loading and in-stream transport. Watershed loading models simulate the washoff and delivery of constituents from the land surface to the receiving stream, this process is driven by precipitation events. Receiving stream models simulate chemical interactions, mixing, and transport along the river system. These models may simulate steady low-flow conditions or changing flow conditions related to precipitation events. Results of watershed loading simulations serve as inputs to the in-stream modeling routines. Models and model resolutions chosen to represent the Fox River watershed should be selected to address issues and concerns of stakeholders, with adequate resolution and accuracy.

The temporal and spatial resolution of the model(s) must be set to appropriately simulate the conditions related to the water quality issues. Loading of selected constituents can be aggregated for a large area (e.g., an entire tributary) or distinct smaller areas (sub-watersheds). A model can be customized to provide information that represents conditions averaged over several hundred feet or several miles of the river (spatial resolution). Models can simulate conditions averaged over a year, a month, a day, or an hour (temporal resolution). Models can be calibrated for a wide range of changing flows (unsteady flow) or for a limited range such as specified low-flow conditions (steady flow). The type of calibration data needed to customize a model or models depends on the spatial and temporal resolution desired of the results. Parameters from models calibrated using data from one system can be applied to a similar system to simulate various conditions, thus extending the utility of the data collected.

Low dissolved oxygen levels, organic enrichment, pH, and algae blooms constitute water quality issues in the Fox River that are related to steady, low-flow conditions. Although the flow may be relatively stable, concentrations of these parameters change during the day and a model must be capable of simulating hourly changes. Furthermore, dissolved oxygen changes dramatically in the Fox River throughout the sequence of free-flowing areas and pooled areas, and this must be taken into consideration.

Siltation, high fecal coliform levels, and nutrient loading from the Fox River watershed are best represented by unsteady flow conditions. Models are needed to simulate the delivery of these constituents from various land uses in the watershed under a variety of flow conditions.

It is recommended that a flexible, modular framework be established for the Fox River watershed model. The model or models used should be in the public domain, well tested, and generally accepted for their reliability. The framework initially should consist of watershed loading models for major tributaries to the Fox River and a receiving stream model for the

mainstem of the Fox River. The modular framework should be such that various components, e.g., the tributary watershed models, can be refined as data become available. The USEPA's BASINS model system provides tools for integration of GIS datasets and industry standard models such as HSPF, SWAT, and QUAL2E. It is recommended that the BASINS modeling framework be selected for the Fox River watershed, in particular, the HSPF model for watershed loading from tributaries to the Fox River. A QUAL2E (or similar) model may be used to address steady, low-flow conditions and diurnal dissolved oxygen variations on the mainstem of the Fox River. An unsteady flow model, such as HSPF, for the mainstem of the Fox River could be developed to address unsteady flow issues.

Data assembled in the FoxDB and the various GIS datasets for the Fox River watershed provide a basis for setting up the model framework. It is suggested that the model framework be developed and the models calibrated to the extent possible using these data. Customized models then may be used to evaluate additional data needs and design an intensive monitoring program for model calibration. Datasets should be collected to validate the models, and an uncertainty analysis should be performed for parameters of major significance.

Information Dissemination and Stakeholder Involvement

As part of this collaborative effort to understand the watershed and protect its water resources, information dissemination and public education are important tasks. The ISWS will provide open access to all information developed by the ISWS. The Illinois Rivers Decision Support System Web site hosts the Fox River Watershed Investigation Web site. The Internet provides broad public assess to publications (publication database), data (FoxDB, which contains water chemistry and sediment chemistry sample data); and GIS mapping products for illustration of watershed features, as well as the full text of research reports. In the future, models customized for the Fox River watershed by the ISWS will be available through this portal, as will any educational or informational products developed. In addition to Internet accessibility, outreach should include meetings with stakeholders and collaboration with area water quality and engineering professionals.

Future Considerations

It is the ISWS vision that products developed through the Fox River Watershed Investigation will be a living resource for the public, researchers, engineers, planners, and policy makers. The database of water chemistry sample information should be updated routinely as monitoring continues. Models of the watershed should be in the public domain, available for use by other researchers and engineers. The monitoring program should continue, and a program of updating the FoxDB and model(s) should be established, with model results periodically compared with new data and refined. Ultimately, the study area should expand to include the entire Fox River watershed. The ISWS hopes to collaborate with the FRSG to provide sound science for watershed management and policy formation that will protect this valuable resource well into the future.

References

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