USGS
science for a changing world

Development of an Assessment Tool for Agricultural Best Management Practice Implementation in the Great Lakes Restoration Initiative Priority Watersheds—Upper East River, Tributary to Green Bay, Wisconsin

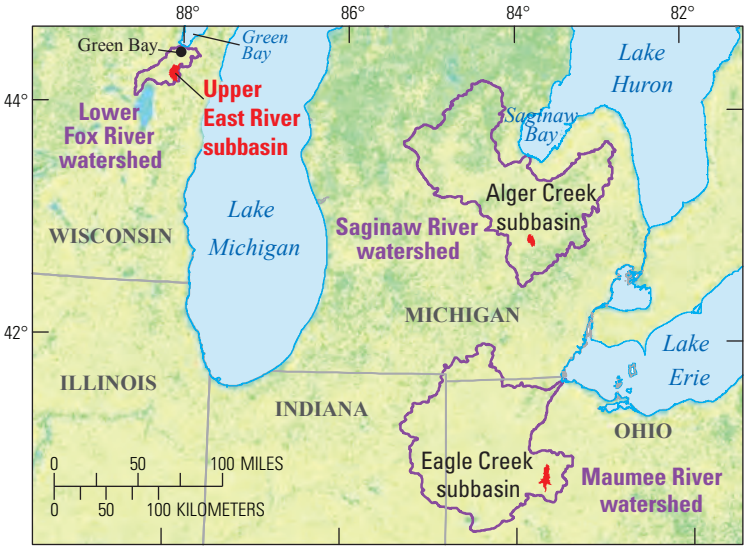
Introduction

The Great Lakes face a number of serious challenges that cause damage to water quality, habitat, ecology, and coastal health. Excess nutrients from point and nonpoint sources have a history of causing harmful algal blooms (HABs); since the late 1990s, a resurgence of HABs have forced beach closures and resulted in water quality impairments across the Great Lakes. Studies increasingly point to phosphorus (P) runoff from agricultural lands as the cause of these HABs. In 2010, the Great Lakes Restoration Initiative (GLRI) was launched to revitalize the Great Lakes. The GLRI aims to address the challenges facing the Great Lakes and provide a framework for restoration and protection. As part of this effort, the Priority Watersheds Work Group (PWWG), cochaired by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Agriculture-Natural Resources Conservation Service (USDA–NRCS), is targeting Priority Watersheds (PWs) to reduce the amount of P reaching the Great Lakes. Within the PWs, USDA–NRCS identifies small-scale subbasins with high concentrations of agriculture for coordinated nutrient reduction efforts and enhanced monitoring and modeling. The USDA–NRCS supplies financial and/or technical assistance to producers to install or implement best management practices (BMPs) to lessen the negative effects of agriculture to water quality; additional funding is provided by the GLRI through USDA–NRCS to saturate the small-scale subbasins with BMPs. The watershed modeling component, introduced in this fact sheet, assesses the effectiveness of USDA–NRCS funded BMPs, and nutrient reductions because of GLRI or other funding programs are differentiated. Modeling scenarios consider BMPs that have already been applied and those planned to be implemented across the small-scale subbasins.

Upper East River Description

One of the targeted Priority Watersheds is the Lower Fox River watershed in Wisconsin (fig. 1). Within the Lower Fox River watershed, the Upper East River basin is in east-central Wisconsin, in Brown County and the northern part of Calumet County, Wisconsin (fig. 2). The East River joins the Lower Fox River in the city of Green Bay, Wis., approximately 1.5 miles from the mouth of the Lower Fox River into Green Bay (fig. 2). Although not completely within the East River basin, the city of Green Bay, Wis., is the largest urban area in the East River basin (fig. 2).

The focus of this BMP assessment is the 45-square-mile (mi2) Upper East River subbasin (fig. 2). The land use in the subbasin is primarily agricultural, and agricultural fields in this area are dedicated to growing silage crops to support the dairy industry that is abundant in this part of the State. The grasses, corn, and pasture land uses shown in figure 3 and table 1 mostly support animal feed. Six dairies in the East River basin are considered as confined animal feeding operations (CAFOs) by the Wisconsin Department of Natural Resources, which defines a CAFO as an operation where 1,000 or more animal units are present (Wisconsin Department of Natural Resources, 2014a, 2014b, 2014c). (For a milking dairy, 715 dairy milking cows are equivalent to 1,000 animal units.) The U.S. Department of Agriculture, National Agricultural Statistics Service (2014) agricultural census of 2012 estimated 44,524 dairy cows were within Brown County, Wis., that year. With the abundance of dairy operations



Base map from U.S. National Park Service (NPS) Natural Earth physical map.

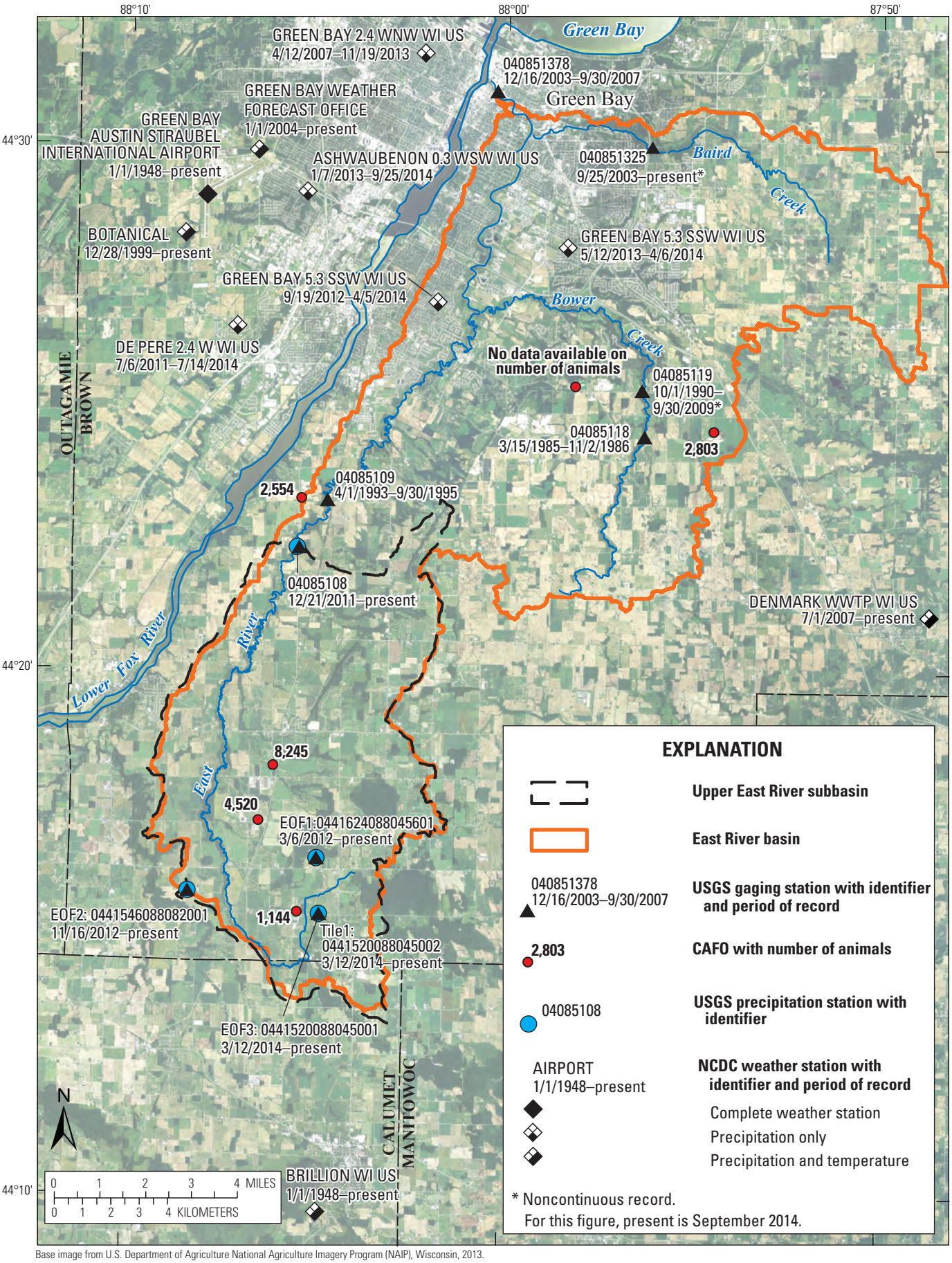
Figure 1. Priority watersheds (purple) and study subbasins of interest (red), the Great Lakes area.

through the subbasin, manure is a concern to water quality. Dairy manure typically contains high levels of nutrients, especially phosphorus. Storage of manure can be problematic for many producers because quantity can easily overwhelm storage capacity. As a disposal method, many dairy operations apply manure to agricultural fields as a soil amendment and fertilizer. Timing and method of manure application can have drastic effects on the nutrient concentration in surface runoff.

U.S. Department of the Interior
U.S. Geological Survey

ISSN 2327-6932 (online)
http://dx.doi.org/10.3133/fs20153065

Fact Sheet 2015–3065
November 2015



Base image from U.S. Department of Agriculture National Agriculture Imagery Program (NAIP), Wisconsin, 2013.

Figure 2. Locations of U.S. Geological Survey (USGS) gaging stations, confined animal feeding operations (CAFOs), and National Climatic Data Center (NCDC) weather stations in the East River basin and Upper East River subbasin, Wisconsin.

Table 1. Land use for the East River basin and Upper East subbasin, Wisconsin (from U.S. Department of Agriculture, National Agricultural Statistics Service, 2013).

Land use	East River Basin land use (percent)	Upper East subbasin land use (percent)
Corn	22	29
Grass/pasture	21	22
Alfalfa	16	21
Developed/low intensity	10	3
Deciduous forest	7	7
Developed/open space	6	3
Soybeans	4	3
Winter wheat	3	4
Developed/med intensity	3	<1
Woody wetlands	3	4
Developed/high intensity	1	<1
Other Hay/nonalfalfa	1	2
Oats	1	1
Barren	1	<1
Other	<1	<1

Best Management Practices

Producers within the Upper East River subbasin have received extensive funding through the GLRI and existing authorities provided to USDA–NRCS by the Farm Bill to implement BMPs to improve the water quality of agricultural runoff. Common BMPs are listed in table 2. Nutrient management plans (NMPs) prescribe the amount, timing, locations, and methodology of manure or fertilizer application to minimize nutrient runoff. The NMPs are extensively used in the dairy industry and are required for CAFOs (Wisconsin Department of Natural Resources, 2014c); NMPs are the second most highly implemented practice in the Upper East River subbasin.

Conservation crop rotation is the most widely used BMP in the Upper East River subbasin. Many fields operate on a 6-year rotation; the first 3 years are usually corn silage followed by 3 years of alfalfa or hay. Years in corn typically see a commercial fertilizer application of nitrogen and phosphorus at planting, and a fall application of manure. Fertilizer and manure are directly incorporated into the fields. Hay or alfalfa is chopped approximately every 6 to 8 weeks during the growing season.

Photo by Matt Komiskey, USGS.

Table 2. Most contracted best management practices (BMPs) through the U.S. Department of Agriculture-Natural Resources Conservation Service Farm Bill conservation programs in the Upper East River subbasin, Wisconsin (in alphabetical order from the National Conservation Planning Database, David Butler, U.S. Department of Agriculture-Natural Resources Conservation Service, written commun., 2015).

Best management practice
Apply nutrients less than 30 days before planting.
Conservation cover.
Conservation crop rotation.
Cover crop.
Critical area planting.
Filter strip.
Grassed waterway.
Heavy use area protection.
Nutrient management.
Residue management, mulch till.
Residue management, no-till/strip till.
Residue management, reduced till.
Residue management, no-till.
Upland wildlife habitat management.
Water and sediment control basin.

There are a small amount of cash crops, typically corn for grain (not differentiated from corn silage on fig. 3) or soybeans, grown in the Upper East River subbasin that covers about 5 percent of the land area. Cash crops or cover crops can be rotated 1 year into the nonhay or nonalfalfa years of a dairy rotation. Cover crops, the third most implemented BMP in this area, can include winter wheat, clover, radishes, oats, and others. Other widely used BMPs include grassed waterways, filter strips, and residue management such as reduced tillage or no-till.

Monitoring Data

The U.S. Geological Survey (USGS) installed three edge-of-field (EOF) sites to monitor nutrient loads in surface runoff where BMPs have been or will be implemented within the Upper East River subbasin (fig. 2). EOF1 (0441624088045601) and EOF2 (0441546088082001) have crude waterways where the slopes of two fields drain to each gaging station; data collected at these sites are to evaluate USDA–NRCS-designed grassed waterways. EOF3 (0441520088045001) has an accompanying subsurface-tile drain monitoring station (0441520088045002). EOF3 was established to evaluate cover crops as a BMP. At the EOF sites, individual event loads are calculated through the monitoring process; daily and annual nutrient loadings are computed with the Graphical Constituent Loading Analysis System (GCLAS; Koltun and others, 2006).

Assessment Tool Development

A Soil and Water Assessment Tool (SWAT) model is in development for simulating the effects of GLRI-funded and non-GLRI funded BMPs on nutrient loadings in the Upper East

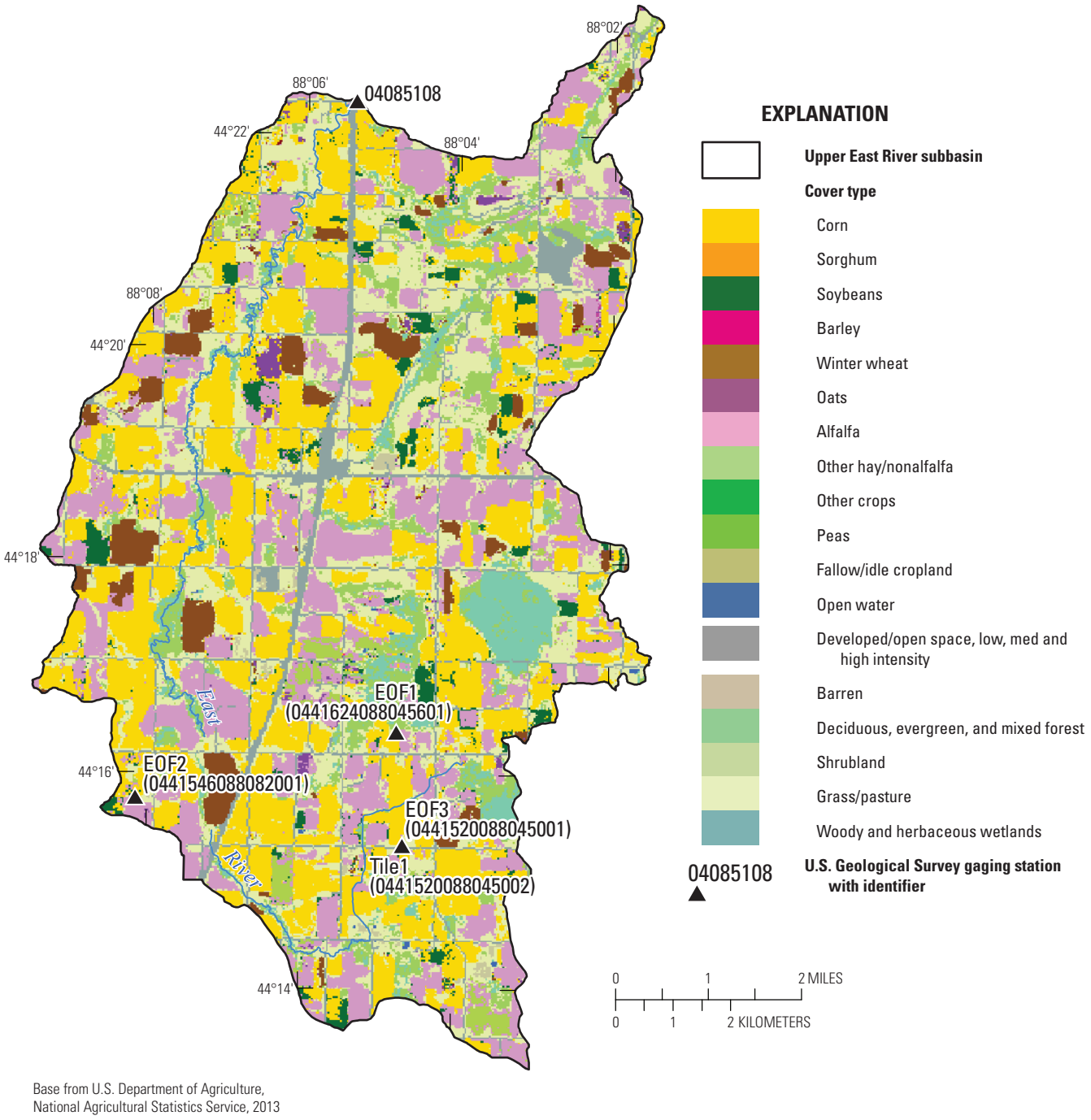


Figure 3. U.S. Geological Survey gaging station and land use in the Upper East River subbasin, Wisconsin.

River subwatershed. This model is to help demonstrate the potential benefits BMPs have to reducing nutrient loading from agricultural fields. The SWAT model is an empirically based model that simulates hydrology and water quality on a daily time step (Neitsch and others, 2011). Site-specific BMP information has been received from the USDA–NRCS National Conservation Practice Database from applied practices 2004 to 2014, and planned practices from the present (2015) until 2018 through a Memorandum of Understanding (MOU) and coordination with USDA–NRCS. USDA–NRCS field-level staff are supplying additional information on best management practices, including: timing of operations, type and amounts of fertilizer or manure applied, and harvest dates and yields. These data are for setup and calibration of the model. Fertilizer application rates for the model were based on conversations with local USDA–NRCS staff. Soils within the Upper East River subbasin are somewhat poorly to poorly drained (Soil Survey Staff, Natural Resources Conservation Service, U.S. Department of Agriculture, 2014), and an unknown amount of the subbasin contains tile drains. Tile drainage usage is being estimated based on land use, soil type, and land slope. Model input parameters are detailed in table 3.

The SWAT model calibration for hydrology and water quality constituents (sediment, phosphorous, and nitrogen) is to two gaging stations on the East River (04085108 and 040851378). The period of record at both sites brings the calibration period to approximately 6.5 years (table 3). Validation is being performed at the now out-of-service gaging station: East River at Midway Road near De Pere, Wis. (04085109),

Table 3. Soil and Water Assessment Tool Modeling Parameters for the Upper East River subbasin and East River basin, Wisconsin.

[HUC, hydrologic unit code; ID, identification number and name; mi², square mile; SWAT, soil and water assessment tool; CAFO, confined animal feeding operation; USGS, U.S. Geological Survey]

Parameter	Item/data source
HUC 10 ID	0403020403 East River basin
HUC 12 ID	040802040301 Upper East River subbasin
East River basin	144.9 mi² (92,736 acres)
Upper East River basin	45 mi² (28,821 acres)
Landuse	Constructed from site-specific management data provided U.S. Department of Agriculture-Natural Resources Conservation Service combined with common land unit field boundaries and the U.S. Department of Agriculture, National Agricultural Statistics Service (2013). (http://nassgeodata.gmu.edu/CropScape/).
Soils	Soil Survey Geographic (SSURGO) database (Soil Survey Staff, Natural Resources Conservation Service, U.S. Department of Agriculture, 2014). (http://datagateway.nrcs.usda.gov/).
Weather	National Climatic Data Center for precipitation and temperature (http://www.ncdc.noaa.gov). All other weather data were simulated by the Soil and Water Assessment Tool built-in weather generator from averages from the nearby station at the Green Bay Austin Straubel Airport including wind speed, solar radiation, and relative humidity and missing values for temperature and precipitation.
Gages used for hydrology calibration and period of record available	USGS Water Data (http://waterdata.usgs.gov/nwis). East River at Cnty Trunk Highway ZZ near Greenleaf, WI (USGS 04085108): December 2011—September 2014. East River at Monroe Street at Green Bay, WI (USGS 040851378): December 2003–September 2007. Bower Creek at County Trunk Highway MM near De Pere, WI (USGS 04085119): October 2006–September 2009. Baird Creek at Superior Road at Green Bay, WI (040851325): September 2003–September 2007: October 2009–September 2014
Gage used for hydrology validation and period of record available	East River at Midway Road near De Pere, WI (04085109), April 1993–September 1995. Bower Creek at County Trnk Highway MM near De Pere, WI (04085119): October 1990–March 1995; April 1996–June 1997
Gages used for water quality calibration and period of record	East River at County Trunk Highway ZZ near Greenleaf, WI (04085108), daily sampling, February 2012–September 2014. East River at Monroe Street at Green Bay, WI (040851378), daily sampling, December 2003–September 2007.
Gage used for water quality validation and period of record	East River at Midway Road near De Pere, WI (04085109), sporadic sampling, April 1993–September 1995.
Number of CAFOs	Wisconsin Department of Natural Resources (http://dnr.wi.gov/topic/AgBusiness/data/CAFO/) HUC10: 6 HUC12: 3

Photo by Matt Komiskey, USGS.

approximately 2 miles downstream from 04085108. This gaging station was operated from April 1993 to September 1995 and has approximately 2.5 years of daily hydrology data. A total of 26 water quality grab samples were collected at this site over that period. Grab sample data are being converted to daily loads by using the Load Estimator (LOADEST) program (http://water.usgs.gov/software/loadest/), which requires concentration data and time-series streamflow data. Additional model calibration and validation details for other sites are listed in table 3. Site-specific, intensive agricultural management practices derived from the USDA-NRCS National Conservation Practice Database are being simulated within the Upper East River subbasin of the larger East River basin model.

Field-scale Agricultural Policy/Environmental eXtender (APEX) models (http://apex.tamu.edu/) are being developed by the University of Wisconsin-Green Bay to simulate implemented BMPs and resulting nutrient loadings at the EOF sites, and predict the effectiveness of BMPs at the field scale. Site-specific management practices, including time of operations, type and amounts of fertilizer or manure applied, and harvest dates and amounts, were provided for each EOF site by the producer with assistance from USDA-NRCS staff. These data were needed for model setup; weather data used were similar to the SWAT model input. At each EOF site, APEX models are to be calibrated to water quality loads.

These models are assessment tools to determine the effect agricultural BMPs have on reducing nutrient loads at the field and subbasin scale in the Upper East River subbasin. Initial model runs simulate current practices and differentiate between GLRI and non-GLRI funded practices. Additional model scenarios target specific BMPs, as determined with input from local and state USDA-NRCS staff at different implementation levels. Candidate BMPs for modeling in the Upper East River subbasin include those listed in table 2. Subbasin-specific information about the BMPs, including timing and quantity of fertilizer application, species of cover crops, typical crop rotation, etc., for the Upper East River subbasin is being collected at this time (2015) to help determine how to incorporate these BMPs into the SWAT model.

References Cited

Koltun, G.F., Eberle, M., Gray, J.R., and Glysson, G.D, 2006, User's manual for the Graphical Constituent Loading Analysis System (GCLAS): U.S. Geological Survey Techniques and Methods, book 4, chap. C1, 51 p. [Also available at http://pubs.usgs.gov/tm/2006/tm4C1/.]

Neitsch, S.L., Arnold, J.G., Kiniry, J.R., and Williams, J.R., 2011, Soil and Water Assessment Tool—Theoretical documentation version 2009: College Station, Texas, Texas Water Resources Institute Technical Report 406, Texas A&M University System. [Also available at http://swat.tamu.edu/media/99192/swat2009-theory.pdf.]

Soil Survey Staff, Natural Resources Conservation Service, U.S. Department of Agriculture, 2014, U.S. general Soil Survey Geographic (SSURGO) database: accessed September 16, 2014, at at http://sdmdataaccess.nrcs.usda.gov/.

U.S. Department of Agriculture, National Agricultural Statistics Service, 2013, CropScape—Cropland data layer: accessed May 6, 2014, at http://nassgeodata.gmu.edu/CropScape/.

U.S. Department of Agriculture, National Agricultural Statistics Service, 2014, 2012 Census of Agriculture—Wisconsin State and County data: Geographic Area Series, v. 1, part 49, AC–12–A–49, 580 p. [Also available at http://www.agcensus.usda.gov/.]

Wisconsin Department of Natural Resources, 2014a, DNR runoff management—CAFO permittees—Brown County: Wisconsin Department of Natural Resources, accessed April 9, 2014, at http://dnr.wi.gov/topic/AgBusiness/data/CAFO/.

Wisconsin Department of Natural Resources, 2014b, DNR runoff management—CAFO permittees—Calumet County: Wisconsin Department of Natural Resources, accessed April 30, 2014, at http://dnr.wi.gov/topic/AgBusiness/data/CAFO/.

Wisconsin Department of Natural Resources, 2014c, Frequently asked questions—Concentrated animal feeding operations WPDES permits: Wisconsin Department of Natural Resources, assessed June 17, 2015, at http://dnr.wi.gov/topic/AgBusiness/CAFO/FAQ.html.

Suggested citation:
Merriman, K.R., 2015, Development of an assessment tool for agricultural best management practice implementation in the Great Lakes Restoration Initiative priority watersheds—Upper East River, tributary to Green Bay, Wisconsin: U.S. Geological Survey Fact Sheet 2015–3065, 6 p., http://dx.doi.org/10.3133/fs20153065.

For more information contact:

Director, Illinois Water Science Center
U.S. Geological Survey
405 N. Goodwin Ave.
Urbana, IL 61801
http://il.water.usgs.gov

Author:

Katherine R. Merriman

Related reports:

http://dx.doi.org/10.3133/fs20153066/
http://dx.doi.org/10.3133/fs20153067/

ISSN 2327-6932 (online)
http://dx.doi.org/10.3133/fs20153065