Lower Sheboygan River AOC Benthic Habitat Mapping and Improvement Study

Quality Assurance Project Plan

EPA Grant Funding Source:
Grant #: GL-00E00876

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Prepared: Patrick S. Forsythe
Date: 8/31/2011
Revision #: 3

Approvals: **Date:**

T. Kevin O'Donnell — 9/19/11
T. Kevin O'Donnell, EPA Project Officer

9/16/11
Louis Blume, EPA Great Lakes National Program Office

Donalea Dinsmore — 9/19/11
Donalea Dinsmore, WDNR Quality Assurance Coordinator

9/22/11
Patrick S. Forsythe, University of Wisconsin - Green Bay

* Subject to update of QAPP after collection and review of fall survey data.

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Donalea Dinsmore, WDNR Quality Assurance Coordinator	
_____	_____

Distribution List

Individuals Assigned
Patrick S. Forsythe, University of Wisconsin – Green Bay Assistant Professor
Donalea Dinsmore, Wisconsin DNR Great Lakes Funding and Quality Assurance Coordinator
Travis Motl, Wisconsin DNR Fisheries Management Biologist for the Southeast Region
Stacy Hron, Wisconsin DNR Sheboygan Area of Concern Coordinator and Manager
Victor C. Pappas, Wisconsin DNR Sheboygan River Basin Supervisor

Executive Summary
The Lower Sheboygan River was designated an Area of Concern in 1985 by the Environmental Protection Agency. While there is substantial motivation to delist this area, quantitative data on the physical and biotic characteristics of the Lower Sheboygan River are not currently available, limiting our ability to implement, evaluate, monitor and predict future changes in the biological community. The main goals of this project are to estimate the quantity, quality and distribution of benthic habitat used by resident and migratory fish/invertebrates that are often linked to growth, survival and successful reproduction.

A. Project Organization and Management

Individual(s) Assigned	Responsible for:
Patrick Forsythe, UWGB Assistant Professor	• Oversight of project including hiring of personnel, data management and reporting on project status to the WIDNR and EPA
Chris Firkus, UWGB Graduate Research Assistant	• Organization of field activities, data collection and analysis, archiving and producing maps of Sheboygan River substrates.
UWGB Undergraduate Research Assistant	• Field and logistical support including some data analysis

Problem Definition/Background
The Sheboygan River meanders through eastern Wisconsin for over 70 miles before flowing into Lake Michigan at the city of Sheboygan. Unfortunately, high levels of pollution from the dumping of industrial waste have led to substantial degradation in fish and wildlife habitat, and severe declines in the health and numerical abundance of aquatic animal populations. As a result, the Lower Sheboygan River (14 miles of river from Sheboygan Falls to the Harbor) was

designated an Area of Concern in 1985 by the Environmental Protection Agency. In 1989, a Remedial Action Plan was drafted with the goal of defining impairments to the Sheboygan River so that management actions such as the restoration of fish habitat could be successfully implemented. Unfortunately, quantitative data on the physical and biotic characteristics of the Lower Sheboygan River are not currently available. Thus, our ability to appropriately select, successfully implement, evaluate, monitor and predict future changes in the biological community including fish and invertebrates in response to management activities remains limited. To address a portion of this uncertainty, we propose to conduct a detailed inventory of the Sheboygan River benthic aquatic habitat using side scan sonar.

Project Objectives

The primary objectives of this project are to 1) estimate the quantity and quality of benthic habitat likely used by resident and migratory fishes, and 2) merge quantitative estimates of substrate type with detailed aerial maps showing its approximate distribution. Our project will place specific emphasis on the Upper (Sheboygan Falls Dam downstream four miles to the Waelderhaus Dam in Kohler) and Middle River (Waelderhaus Dam to the former Chicago & Northwestern railroad bridge) sections. Data from this project, coupled with recent/ongoing surveys of the fish and invertebrate community, as well as Multi-dimensional Surface Water Modeling conducted by the USGS, will serve to help guide species-specific habitat improvement projects that have the greatest probability of increasing fish growth, survival and successful reproduction (i.e., important parameters required for delisting the AOC). Predicting changes in the biological community in response to all AOC related projects, particularly bank stabilization and sediment load reduction, will also be facilitated with this habitat data.

Project/Task Description and Schedule

Year	Month	Task description	Product
2011	August	Review existing fisheries catch data and associated literature; collect aerial photos and GIS information; conduct reconnaissance boat trips of the Middle and Upper Sheboygan and calibrate side-scan sonar equipment.	
2011	September – November	Collect geo-referenced substrate data images using side-scan sonar; conduct surveys of important areas used by migratory and resident fish; and archive data using internal servers at UWGB.	Verbal report provided to Sheboygan AOC TAC.
2011	December	Convert side-scan data to files that can be manipulated with geographic information system software; begin to quantify the surface area of each substrate type in focal stream areas; and render these features of the stream discernible using mapping features in GIS.	End of year report that will include preliminary images/maps of focal stream areas. Presentation to AOC TAC if possible.
2012	January - May	Provide the WI Department of Natural	Provide maps of

		Resources with quantitative estimates of stream substrate types and detailed substrate maps of focal areas, offer recommendations for restoration activities that may increase the habitat suitability for key species, and assist in the design and implementation of fish habitat improvement projects.	focal stream areas that will include a quantitative assessment of substrate types, sizes and suitability indices for fish species.
2012	May – September	Continue to collect geo-referenced substrate data images using side-scan sonar; and archive data using internal servers at UWGB. Manipulate data files with GIS software and quantify the surface area of each substrate type. Provide the WI Department of Natural Resources with quantitative estimates of stream substrate types and detailed substrate maps, offer recommendations, assist with restoration activities, and produce a final report.	Final report that includes maps of the Sheboygan River and assessment of available fish habitat. Transfer of data/images where appropriate.

Personnel, Special Training Requirements or Certifications

Personnel at the University of Wisconsin – Green Bay involved in completing the technical aspects of this project have strong backgrounds in environmental science. Further, while they are not computer programmers, they are familiar with databases, spreadsheets, statistical packages and computer files. They also have training in statistics beyond the introductory level. The PI also has 10 years of experience in conducting this kind of research. Prior to the field-sampling season, the Project Leader will go over the SOPs, methods, and QA requirements with the graduate research assistant and undergraduate surveyors and answer any questions. All training will be documented and records will be kept in the project file. To minimize any potential health and safety risks related to field sampling conducted as part of this project, employees also need to be physically able to conduct field work under demanding conditions, be well prepared to handle contingencies or emergencies, and willing to wear safety equipment. The following are suggested requirements for all field survey personnel: a) recent CPR and first aid training, and b) completion of a satisfactory interview about health and safety aspects of the project with the Project Leader, including routine safety precautions and a discussion of actions to be taken in the event of an emergency. Graduate and undergraduate students will also refer to WDNR Manual Code 9187.91 Employees Working Alone for additional information about safety during the field work.

Documentation and Records

Project documentation will include notebooks, raw data files, final processed data (in spreadsheet files), and summary tables. All raw data collected under this project will become part of the UWGB inventory and will be treated as sensitive data. Any requests for this data can be directed to the Dr. Forsythe who will coordinate distribution. All field data sheets will be scanned and saved electronically as Portable Document Format (PDF) files. This information will be

available for review on site by the EPA Project Officer or QA Officer. A final report will be completed for the project. This report will be provided to the team responsible for preparing the Ecological Assessment Report. The report will include at a minimum an introduction, discussion of the methods used, summary of results and statistics, discussion of QA/QC, including results of QA checks and any corrective actions and other pertinent data collected. Format for the maps and metadata will be coordinated with WDNR for the final deliverables.

B. Measurement/Data Acquisition and Sample Process (Experimental Design)

Several methods are available to aquatic scientists to measure benthic environments. However, side scan sonar systems give scientists unprecedented ability to obtain high resolution images (3 cm cross-track × 20 cm along-track) of riverbeds in a short amount of time at minimal cost. Here, the process of quantifying habitat will occur in a number of steps:

1) A mosaic (compared to point estimates) of geo-referenced data will be collected from a sonar device (i.e., towfish) that emits a fan-shaped pulse perpendicular to the path of the sensor through the water towed from a surface vessel. Here, surveys will be conducted using 450 kHz frequency StarFish side scan sonar (Model 450F). The towfish will be maintained at an altitude of approximately 20% of the water depth where possible without risking bottom contact or snagging of the towfish. Survey tracks will be spaced an adequate distance apart to ensure sufficient overlap of sonar data.
2) A base layer delineating the river channel boundaries and features (e.g., points, islands, etc.) for each river and reach will be digitized manually. The "mosaic" of benthic substrate data will then be converted into files that can be manipulated with geographic information system (GIS) software. Substrates including silt, sand, gravel, cobble, boulder, bedrock and woody debris will then delineated based on textures interpreted from the data, drawn into polygons to quantify surface area of each substrate type, and then made discernible using different colors. Polygons will be saved in .SHP format and were used to create maps of substrate composition.
3) Spatially explicit models of substrate distribution will also be constructed using ArcGIS to generate a smoothed surface. Raster data for each habitat variable and sampling reach will be created using the inverse distance weighted (IDW) or loess smoothing interpolation methods. Interpolation techniques estimate the values at un-sampled locations using the distance to and values of nearby sampled points. These interpolation methods are preferred over other methods (e.g., nearest neighbor, spline, kriging, etc.) because they: (1) provided greater control over parameterization options (e.g., number of neighboring points utilized, power, incorporation of a barrier layer, etc.); and (2) have been shown to minimize error in predicting benthic surfaces at fine spatial scales in small Midwestern streams (Bolstad 2002; Kratzer et al. 2006).
4) Aerial imagery, river channel boundaries features, and substrate classifications will then be merged to provide a quantified substrate map that is edited into a larger composite image, in this case the Sheboygan River and inner Harbor. Final versions of maps will be provided in geo-referenced JPEG formats and HTML web enabled format suitable for viewing and analysis using ArcView, and other GIS software.

It should be noted that maps generated using side-scan sonar are considered "wide-area" classifications, and do not identify small patches of outlying substrate or individual features. For instance, an area interpreted as "gravel and cobble" may contain some sand and small boulders.

Similarly, a large area of sand (either flat or rippled) would be classified as sand, without digitizing small patches of mud or gravel in the same area. We intend to scan as much of the Sheboygan River as possible using side-scan sonar beginning at Rochester Park, Waelderhaus Dam in Kohler, and Kiwanis Park (see attached map). These river reaches are prime candidates for restoration projects because of accessibility and habitat improvements (e.g., submerged logs, gravel or boulder additions, cribbing, deflectors) would provide heterogeneous and complex physical habitat components and functional elements (resting pools, cover, foraging areas) important to resident and migratory fish and other aquatic species in the watershed.

Some areas of the Sheboygan River (e.g., riffles < 0.6 m) will likely be too shallow to scan effectively. Riffle areas are abundant in the Sheboygan River, most are likely suitable for benthic fish and the survival of embryos and larvae, and are lower priority for planned improvement projects (personal communication with Travis Motl). However, these areas could be affected (negatively or positively) by larger/future AOC activities and thus we plan to geo-reference, revisit and quantify riffle stream sections in late spring of 2012 using a single or series of transects run across the channel. Riffles are generally represented by shorter stream reaches and will be sampled at short (10- to 50-m) intervals in order to provide adequate characterization (see Daugherty et al. 2009 for more detail). Variables including stream depth, stream flow and substrate size will be recorded by hand at meter intervals along each transect. Water velocity will be measured to the nearest 0.01 m/s approximately 0.3 m above the river bottom using an electronic flow meter. Substrate at each location will be collected by hand or kicknet and substrate type will determined based on the median particle size from 5 measured rocks. Geo-referenced maps of substrate data (polygons and soothed surfaces) from transects will then be merged with maps from sonar data of the same resolution to generate obtain a composite estimate of substrate types and aerial imagery.

C. Assessment/Oversight

The responsibility for project implementation, basic data review, validation and verification lies with the PI and graduate research assistant at the University of Wisconsin – Green Bay. Corrective actions will be taken if any aspect of the sampling event differs from that planned. Under circumstances where corrective action is needed, the Project Leader will be notified and the situation researched and a decision made. Corrective actions should only be implemented after approval by the Project Leader. Corrective actions will be documented in the field log or data report at the time of decision, and will accompany all reports after analytical results are returned. The Project Leader is ultimately responsible for any corrective actions and appropriate documentation of those actions.

D. Data Validation and Usability

All mapping data, including benthic mapping data, have errors inherent in the data collection process. The challenge is to assess the accuracy of data collected for benthic habitat applications and quantify acceptable error for analyzing a given benthic community. Several studies have been published that assess the accuracy of interpolated sonar and transect based habitat data for a variety of aquatic ecosystems. As a result, the comfort level of scientists in using both types of data to predict the distribution of aquatic organisms and link fish ecology to habitat restoration has been growing (Yeung and McConnaughey 2008; Creque et al. 2010). However, because side-scan sonar is a relatively novel technology, nothing has yet been published comparing the

mapping capabilities/accuracies of both methods in a common environment, especially small streams.

Here, we intend to address both positional and thematic sources of error in our sonar benthic mapping data using standardized geo-referenced transects (1 meter intervals across the stream channel) spaced every 500 m upstream (~ 800 points). This point-based assessment is a common validation technique and will allow us to qualitatively compare observed substrate types (i.e., transects) and predictions generated from sonar. Some sampling locations will also be selected ad hoc between transects so as to be representative of the different substrata encountered. We will also compare several small reaches (< 100 m) scanned with multiple passes, as well as finer scale transects (every 5m). In doing so, maps (predictive interpolated surfaces) of the same river area generated from data collected at different times and using different approaches can be jointly modeled and statistically compared as a function of the environmental covariates (substrate in this case) while accounting for respective spatial residual processes (see cross-correlation analysis in Forsythe 2010). Specifically, we will statistically assess the magnitude of difference in location specific estimates of substrate type using hand-based transect and sonar approaches. Areas of the stream found to be statistically different (i.e., negative or positive spatial residuals) will be flagged and revisited. This comparison will provide an indication of consistent site-specific scanning errors, and whether the side-scan sonar has adequately measured the quantity/quality of substrates that comprise benthic stream habitat of the Sheboygan River.

Statistical programs will also be used to identify outliers by checking for internal consistency (i.e., quality checked). Data points that depart from averages by more than two standard deviations will be investigated. Data points that are flagged as potential outliers will also be investigated for assignable cause. Adjustments can be made for causes such as a change in units or analytical method. When the cause is failure of instrumentation or a missing sample, data points can be deleted and, if necessary, replacement values will be imputed using accepted procedures.

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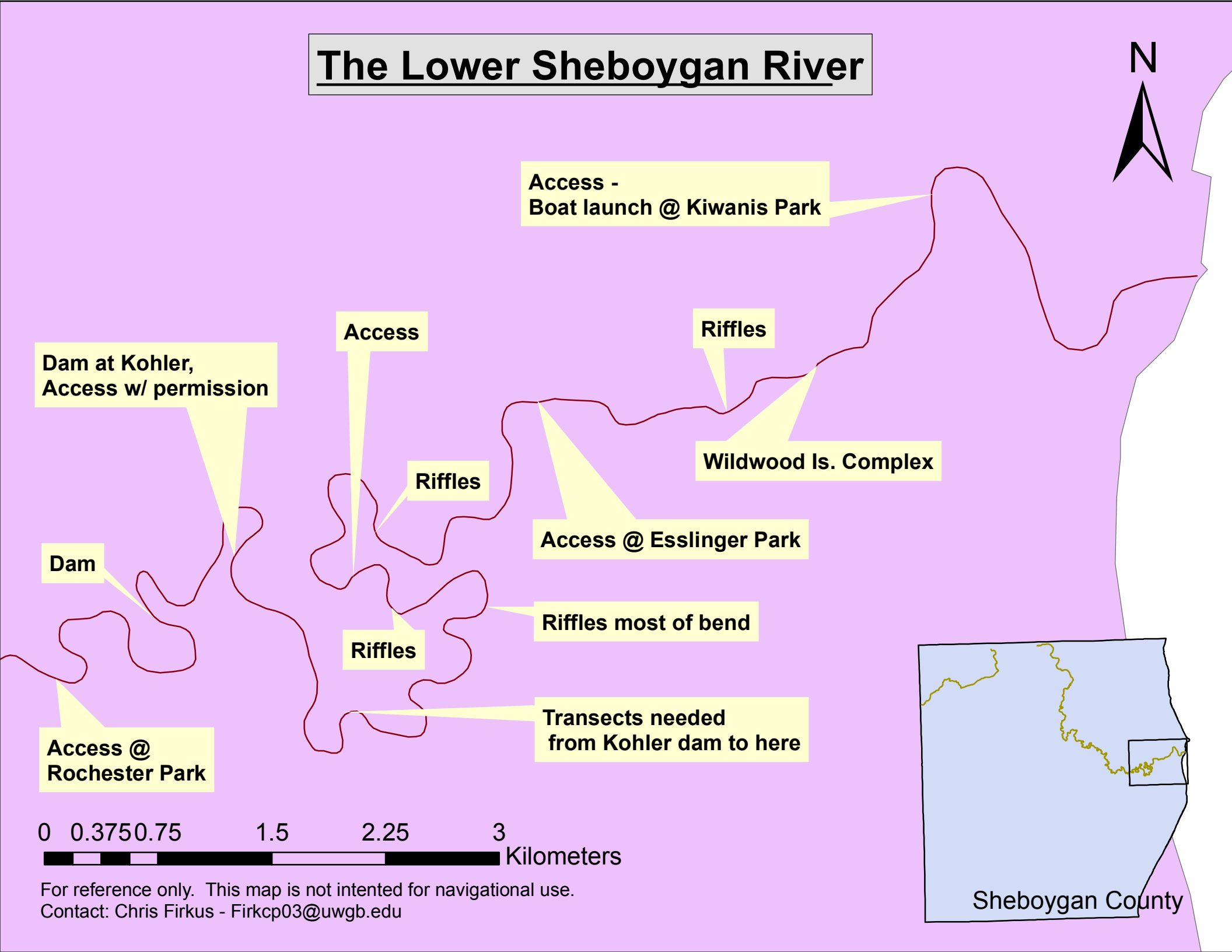
The Lower Sheboygan River



For reference only. This map is not intented for navigational use.

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