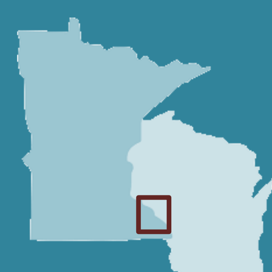
Upper Mississippi River Clean Water Act Monitoring



Minnesota-Wisconsin Pilot Evaluation Report

January 2019

Acknowledgements

The Evaluation Report was produced in collaboration with the members of the Minnesota-Wisconsin Pilot project team. This includes the following individuals:

- **Metropolitan Council Environmental Services:** Kent Johnson and Jack Barland
- **Minnesota Department of Natural Resources**: Eric Lund and Megan Moore
- **Minnesota Pollution Control Agency:** Pam Anderson, Joel Chirhart, Jordan Donatell, Mike Feist, Lee Ganske, and Dan Helwig
- **Wisconsin Department of Natural Resources:** Ron Arneson, Andy Bartels, Deanne Drake, Shawn Giblin, Kraig Hoff, John Kalas, and Brian Weigel
- **Upper Mississippi River Basin Association:** Dave Hokanson, Matt Jacobson, Kirsten Wallace, Josh Ney, Lauren Salvato, and Andrew Stephenson

The Pilot project itself was executed as a result of the shared commitment of all the participating agencies and individuals, including the membership of the UMRBA Water Quality Task Force and Water Quality Executive Committee. Additionally, Tony Olsen of USEPA's Office of Research and Development aided the project in providing a probabilistic sample site draw for fish and macroinvertebrate monitoring.

Cover Photo: The cover photo is provided courtesy of Wisconsin Department of Natural Resource (WIDNR).

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Introduction

UMR CWA Recommended Monitoring Plan

The *Upper Mississippi River Clean Water Act Recommended Monitoring Plan* is structured as a series of sampling networks designed to uniquely and comprehensively support assessment of aquatic life, fish consumption, recreation, and drinking water use attainment on the UMR ("Monitoring Plan;" UMRBA, 2014; Figure 1.1). The interagency Upper Mississippi River Basin Association (UMRBA) Water Quality Task Force developed the *Monitoring Plan* to achieve a coordinated, comprehensive Clean Water Act (CWA) monitoring approach on the Upper Mississippi River (UMR).

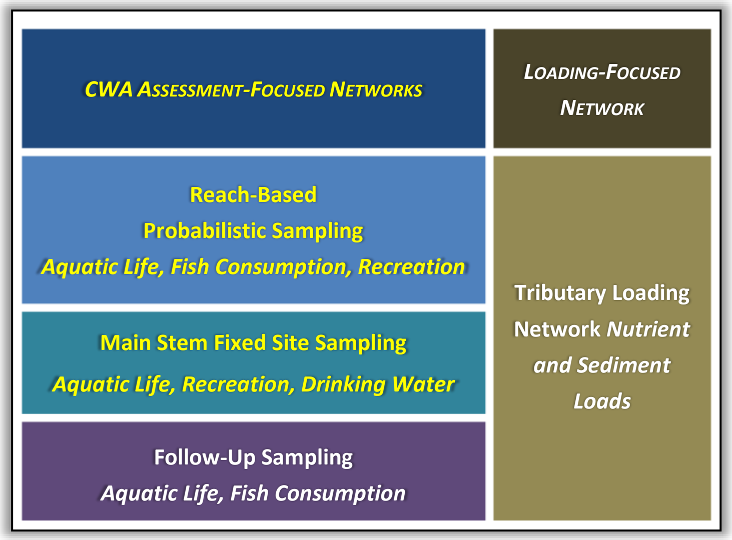

Figure 1.1: UMR CWA Recommended Monitoring Plan (Monitoring Plan) Structure of Constituent Networks and Designated Uses (the ***yellow text*** *indicates the focal area for the Minnesota-Wisconsin pilot monitoring project)*

From May 2016 to April 2017, UMR states employed a field pilot in a portion of the UMR's reaches in Minnesota and Wisconsin and focused on the implementation of the probabilistic and fixed site components of the *Monitoring Plan*.

Pilot Project Evaluation Report

This *Pilot Project Evaluation Report* evaluates the success of the pilot monitoring project ("the Pilot") from technical, logistical, budgetary, and personnel perspectives. The overall purpose of this report is to inform the UMR states regarding the feasibility and effectiveness of the *Monitoring Plan*. A companion report is available that evaluates the water quality condition based on the Pilot's sampling results (UMRBA Condition Assessment, 2019).

Discussion

Project Scope

Geographic Scope – The Pilot was employed in UMR assessment Reaches 0-3, extending from Upper St. Anthony Falls to the Root River (Table 2.1 and Figure 2.1). Sampling occurred in the river's main channel and adjacent near-shore areas throughout the run of the river, including Lake Pepin and other lake-like areas unless otherwise indicated.

Table 2.1: Geographic Extent of Pilot, UMR Assessment Reaches 0 through 3

Reach Number	**Reach Name** (Description/8-digit HUC code)	**River Miles**	**Segment Length (miles)**
0	**Assessment Reach 0** (Upper St. Anthony Falls to St. Croix River)	**854-811.5**	**42.5**
1	**Assessment Reach 1 (Rush-Vermillion)** (St. Croix River to Chippewa River/ HUC 07040001)	**811.5-763.4**	**48.1**
2	**Assessment Reach 2 (Buffalo-Whitewater)** (Chippewa River to Lock and Dam 6/ HUC 07040003)	**763.4-714.2**	**49.2**
3	**Assessment Reach 3 (La Crosse-Pine)** (Lock and Dam 6 to Root River/HUC 07040006)	**714.2-693.7**	**20.5**

Temporal Scope – Monitoring began in May 2016 and continued through April 2017, completing a typical full-year of sampling on the UMR. Fixed site monitoring of chemical and physical parameters was conducted monthly throughout pilot implementation. Probabilistic samples of biological, chemical, and physical indicators were collected from July to September 2016.

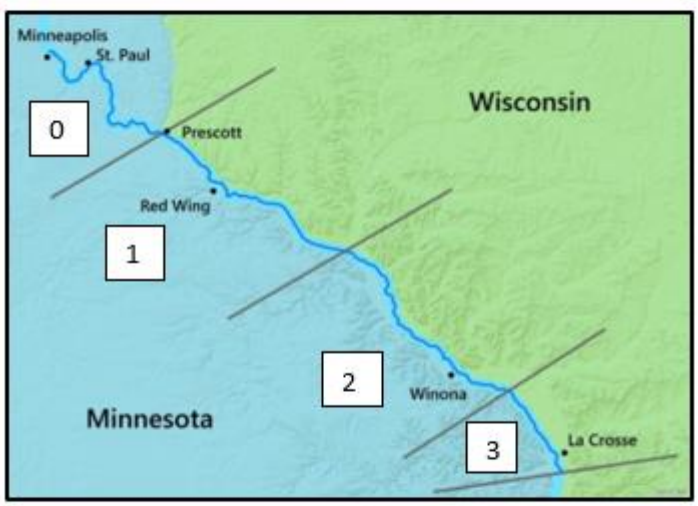

Figure 2.1: The Pilot's Geographic Extent

Parameter Scope – Most of the samples included in the *Monitoring Plan* were sampled during the Pilot. The Pilot sampling design included the fixed site and probabilistic networks, incorporating biological, physical, and chemical sampling (Table 2.2). Samples were not collected for fish tissue and probabilistic network metals. A detailed discussion of these changes follows.

*Table 2.2: Pilot parameters (where **X** indicates components sampled in the Pilot, shaded indicates components not sampled in either the Pilot or full plan, shaded X indicates components to be sampled in full plan, but not sampled in the Pilot)*

Indicator Group	Indicators	**Probabilistic Monitoring** (15 sites per reach, 60 sites in pilot area)	**Mainstem Fixed Network** (20 sites UMR-wide, 4 sites in pilot area)	**Tributary Loading Network** (34 sites UMR-wide, 8 sites in pilot area)
Biological Communities	Fish	**X**		
	Vegetation	**X** (100 sites per reach)		
	Macroinvertebrates	**X**		
Fish Tissue	Mercury (Hg)	X		
	PCBs	X		
Field	Water Temperature	**X**	**X**	X
	DO (conc.& sat)	**X**	**X**	X
	pH	**X**	**X**	X
	Conductivity	**X**	**X**	X
	Turbidity	**X**	X	X
	Secchi Depth	**X**	X	
Nutrients	NO3+NO2	**X**	**X**	X
	TN	**X**	**X**	X
	NHx	**X**	**X**	X
	TP	**X**	**X**	X
	DP	**X**	**X**	X
	Chlorophyll a	**X**	**X**	X
Bacteria	*Escherichia coli*	**X**	**X** (April-October)	
Algal Toxins	Microcystin		X	
	Cylindrospermopsin		X	
Miscellaneous	BOD	**X**	**X**	
	Chloride	**X**	**X**	
	Sulfate	**X**	**X**	
	TSS	**X**	**X**	X
	TOC		**X**	
	Hardness (Ca & Mg)	**X**	**X**	X
	Alkalinity	**X**	**X**	
	Fluoride*		X	
Metals (total)	Aluminum (Al)	X	**X**	
	Calcium (Ca)	X	**X**	
	Cadmium (Cd)	X	**X**	
	Chromium (Cr)	X	**X**	
	Copper (Cu)	X	**X**	
	Iron (Fe)	X	**X**	
	Lead (Pb)	X	**X**	
	Magnesium (Mg)	X	**X**	
	Potassium (K)	X	**X**	
	Sodium (Na)	X	**X**	
	Zinc (Zn)	X	**X**	
Other	Arsenic (As)	X	**X**	
	Mercury (Hg)	X	**X**	
	Selenium (Se)	X	**X**	
Organics	VOCs, Pesticides, Other*		X	
	Phenols*		X	
Physical Habitat and Characteristics	Substrate	**X**		
	Depth	**X**		
	Velocity	**X**		
	Discharge**		**X**	X

*Only sampled at fixed sites in proximity to a drinking water intake. **From existing gages near sampling sites, where available

Modifications to Pilot

The Pilot project team made a number of modifications from the *Monitoring Plan*. Limited staff and funding required certain changes to the scope that would likely be feasible under a fully funded program. In other situations, changes were made to improve feasibility and effectiveness. These changes warrant further deliberation and potential revisions to the *Monitoring Plan.* The changes are indicated in bold text in the following pages.

Chemistry Monitoring – **Metals were sampled at fixed sites, but not sampled at probabilistic sites.** This reduced overall cost of the project without losing any material information, given that there is limited potential benefit of probabilistic sampling for metals. An August 2014 review of existing sampling data indicated a limited likelihood of metals exceeding existing water quality standards and beyond previously identified mercury impairments. Fixed site sampling was maintained to create a baseline dataset and identify any new metals exceedances. This sampling will be used to evaluate the most beneficial extent of metals sampling in future monitoring plan implementation. The Pilot assessed total metals but not dissolved metals.

No monitoring was conducted for drinking water use-only analyses (e.g., volatile organic chemicals, synthetic organic chemicals, phenols, and fluoride) because there are no public water supply intakes in the pilot area. This is unique to Reaches 0-3. There are public water supply intakes in most other reaches of the UMR (Reaches 7-13).

The *Monitoring Plan* recommended sampling for either for dissolved organic carbon (DOC) or total organic carbon (TOC). **The Pilot project team elected to monitor for TOC.** This was due to TOC being a potential corollary to biological oxygen demand (BOD) and chemical oxygen demand (COD). **Turbidity was also dropped as a parameter for the Pilot** given that both Minnesota and Wisconsin no longer utilize turbidity as a parameter in their respective CWA assessments.

Biological Monitoring – The Pilot project team **utilized an artificial substrate sampling approach for macroinvertebrates**. This method is different than the Environmental Monitoring and Assessment Program–Great Rivers Ecosystem (EMAP-GRE) kick-sampling approach described in the *Monitoring Plan*. The artificial sampling approach requires the use of a multimetric index instead of the EMAP Great River Macroinvertebrate Index (GRMIn) or modified *Ad Hoc* GRMIn – i.e., Wisconsin Large River Index of Biotic Integrity ("Large River IBI;" Weigel and Dimick, 2011). The artificial substrate method was selected because of sampling logistics, safety, and consistency with long term monitoring data already available in this section of the river – e.g., Metropolitan Council macroinvertebrate monitoring. Pending conclusions of an ongoing macroinvertebrate comparison study and evaluation of the Pilot, EMAP-GRE methods may be included in future *Monitoring Plan* implementation.

Physical Habitat and Characteristics – Extensive site information was collected during both fish and macroinvertebrate monitoring and a more limited dataset was collected alongside submersed aquatic vegetation (SAV) monitoring. **This information was added to the physical habitat and characteristic data**. Data collected is specified in each of the indicator group monitoring instructions found in the *Field Operations Manual* (UMRBA, 2016a).

Fish Tissue Monitoring – **Fish tissue sampling was <u>not</u> conducted as part of the Pilot** for several reasons, including reducing costs and fish take. While an alternative method was proposed to minimize the number of fish taken, it was not ultimately advanced. More detailed information about the proposed method is discussed in the *Field Operations Manual* (Appendix E). In addition, data were not compatible with existing fish consumption advisories. A more detailed discussion about the relationship between existing advisories and the *Monitoring Plan* is available in the Provisional UMR CWA Assessment Methodology report ("Provisional Methodology;" UMRBA, 2016b).

Algal Toxins – **Algal toxins were not sampled e.g., microcystin and cylindrospermopsin.** The Pilot project team determined that this monitoring would not be particularly effective or helpful given the sporadic and variable occurrence of these toxins. UMRBA convened a harmful algal bloom (HAB) work group in 2016 to explore the issues of HABs on the UMR.

Index Sites – The full *Monitoring Plan* includes a network of "index sites" on the lower reaches of major UMR tributaries. Index sites provide comparison data for calibrating biological indices, identifying stressors, and setting attainable thresholds for chemical, physical, and biological parameters. **The Pilot project team determined that index site monitoring would not be part of the Pilot** to minimize cost and complexity and the purpose and value of the index sites were outside the Pilot's scope. The Pilot project team recognized that ongoing monitoring is unknown and determined that the investment in calibration data was not warranted.

Follow-Up Sampling – **Follow-up sampling and monitoring for secondary indicators (e.g., sediment chemistry) were not included in the Pilot**. The Pilot project team determined that each state/sampling entity would determine its need to conduct follow up and secondary indicator monitoring. This reduced the complexity and costs of the Pilot, while also providing flexibility to the states.

Tributary Loading Network – **The tributary loading network was not sampled as part of the Pilot** to reduce the complexity and costs. The existence of states' loading measurement networks and the emergence of United States Geological Survey (USGS) continuous monitoring stations may limit the need for an additional, separate loading network. Rather, the tributary loading network locations identified in the *Monitoring Plan* have been shared with USGS and others in hopes of encouraging load monitoring at these sites.

Tools Developed in Support of the Pilot

A number of tools were developed to improve the implementation of the Pilot and should be considered for inclusion in the *Monitoring Plan*.

Field Operations Manual – The *Monitoring Plan* alone did not provide the detail necessary for sampling to be executed in a consistent manner by all implementing partners, and the *Field Operations Manual* was created to promote consistent sampling. The *Field Operations Manual* was finalized in July 2016 and will likely need to be revised to support any future monitoring program in light of lessons learned during the Pilot.

Online Water Quality Viewer – An online Pilot Project Water Quality Viewer was created to provide spatial information in an easily viewable format, including sampling site locations, transects and reach boundaries. This viewer proved to be valuable in the desktop reconnaissance phase of the project, including for reviewing probabilistic sites and establishing biological sampling transects. And, it has continued to be a valuable reference throughout the Pilot implementation. While the viewer has been primarily used to provide geographic information, it is possible to connect the viewer to results stored in accessible databases such as via the Water Quality Portal, a data clearinghouse managed by a cooperation of federal agencies. Should implementation of the *Monitoring Plan* continue elsewhere on the UMR, the viewer should be expanded to support similar monitoring.

Chemistry Methods Comparison – The Metropolitan Council Environmental Services laboratory (MCES), the Minnesota Department of Health laboratory (MDH), and Wisconsin State Laboratory of Hygiene (WSLH) developed a comparison table of methods to assist water chemistry monitoring and quality control processes. This compilation was integrated into the *Field Operations Manual*.

Chemistry Data Sharing Spreadsheet – A data spreadsheet was developed to facilitate sharing among agencies and to facilitate data analysis. This spreadsheet was populated by the sampling agencies in collaboration with UMRBA staff.

Water Quality SharePoint Site – During the pilot implementation, a UMR Water Quality SharePoint site facilitated the distribution of working documents (e.g., *Field Operations Manual*) and provided links to tools i.e., the Online Water Quality Viewer and water quality data. However, it is not clear that this provided a fully successful shared workspace. Usage was limited and login problems arose. Different methods of providing a work group space (e.g., via UMRBA website) should be explored for any future monitoring implementation.

Sampling Implementation

The Pilot project team followed the procedures outlined in the *Field Operations Manual* with some modifications as a result of high discharge and water levels throughout the 2016 sampling season. Separate field crews collected samples for chemistry, fish, macroinvertebrate, and vegetation. Additional explanation on field sampling conditions can be referenced in the *UMRBA Condition Assessment.*

Chemistry Sampling – Chemistry sampling at both fixed and probabilistic sites was completed as scheduled and was not substantially impacted by high flows. However, there may be impacts to the water chemistry results due to high discharge.

Metropolitan Council staff collecting chemistry data

Fish Sampling – Fish assemblage sampling was completed at all probabilistic sample sites. However, the high flow conditions had multiple impacts on fish sampling, including 1) increased water depth made it more difficult to detect fish near the substrate, 2) increased velocity made precise boat control more difficult, and 3) shorelines that would have been exposed were inundated. Sampling occurred in areas that would not typically be underwater. Sampling crews created artificial edges (e.g., trees) when access to the “true” shoreline was prevented. Additionally, Minnesota slightly delayed its sampling with the intent of waiting for more typical flow conditions. The majority of Minnesota’s sampling was done in mid- to late-September, while Wisconsin’s samples were collected primarily in July and August. Despite these issues, comparisons indicate that Pilot results are largely consistent with those from 2004-2006 EMAP-GRE monitoring (UMRBA Condition Assessment, 2019).

Field crews were challenged with the requirement to collect fish samples at two sites per day, particularly when large numbers of fish were caught. The crews experienced fatigue and safety issues. There would be cost implications to consider by reducing fish sampling from two to one site per day.

Macroinvertebrate Sampling – Macroinvertebrate sampling was also impacted by high discharge conditions. Only about 50 percent (32 of 60) of the macroinvertebrate samplers were recovered during the Pilot monitoring. High flows likely contributed to the low recovery rate by the potential movement of samplers or submerged floats due to snags lodged in ropes. However, there was enough data available to conduct an assessment that incorporates macroinvertebrate scores.

Vegetation Sampling – About 97 percent of vegetation sites (493 of 510) were successfully sampled during the Pilot. Sixteen of the seventeen non-sampled sites occurred too close to a navigation dam. On average, 99 sites were sampled in each assessment reach. The target was 100 sites sampled per reach. The primary impact of high discharge on vegetation sampling is that a large proportion of sites were located on steep substrates adjacent to shoreline. This would cause the maximum depth of SAV to be unusually high and potentially bias the submersed macrophyte index (SMI) score upwards. However, data analysis indicates Pilot results are largely consistent with the Long Term Resource Monitoring (UMRR LTRM). The vegetation monitoring team produced its own "Doability Report" for the Pilot that provides additional details on monitoring implementation (Drake and Lund, 2016).

Quality Control

Standardized field collection methods for chemistry, fish, macroinvertebrate, and vegetation are described in the *Field Operations Manual*. The use of standard field methodology was a central mechanism to ensure consistency in results. Each state/sampling agency conducted their own internal quality assurance/quality control (QA/QC) reviews of the data at various stages in the process, including field, laboratory, and office. All data were reviewed and deemed suitable for analysis. Spilt sampling was conducted for chemistry monitoring and replicate sampling was completed for chemistry, fish, and macroinvertebrate indicators.

Chemistry Split Sampling – Water chemistry spilt sampling was conducted on three occasions during the Pilot: November 17, 2015, February 16, 2016, and October 3, 2016. This was particularly important in light of some variation in methods among the three laboratories conducting chemistry analyses for the Pilot: MCES, MDH, and WSLH. Each laboratory's analytical methods were recorded in a summary spreadsheet, which was appended to the *Field Operations Manual* and chemistry data-sharing worksheet.

For a majority of the parameters, there was concurrence among the results from the three labs in the split sampling as all the agencies used U.S. Environmental Protection Agency (USEPA) approved methods. However, for a subset of parameters – including aluminum, arsenic, *E. coli*, mercury, and total nitrogen – there was variation that could be meaningful in an assessment or regulatory context. In all these cases, there was at least one methodological difference among the analyses conducted by the labs. Of note, variation in total phosphorus results appeared to be reduced appreciably when the MDH lab changed its analytical method subsequent to the first round of split sampling.

In addition to inter-lab spilt sampling, limited intra-lab replicate analysis was performed to examine the degree of intra-lab variability in results. Some intra-lab variation was observed for chlorophyll-a, *E. coli*, and mercury, though the predominant explanation for variation in Pilot results appears to be inter-lab variability rather than intra-lab differences.

Replicate Sampling: Chemistry, Fish, and Macroinvertebrates – Replicate sampling was also incorporated into the sampling approach for the chemistry, fish, and macroinvertebrate indicator groups. Ten percent of samples were replicates, equating to two probabilistic sample sites per reach and one chemistry replicate sample at each fixed site. Replicate probabilistic sites were selected in the order of the site identification assigned during the random site draw by USEPA. Note that vegetation monitoring did not resample due to the large number of samples collected for this indicator group. However, vegetation results were evaluated using UMRR LTRM's data review process to identify data entry and formatting errors.

A review of replicate sampling for water chemistry did not show significant variation between original and replicate results. A review of replicate scores for fish indicated similar outcomes at seven of the eight locations where replicates were collected (Table 2.3). The only site where a significant difference was detected was at site UMR15-0362. Discrepancies appeared to be driven by underlying differences in the metrics for exotic, detritivore, native, and darter species.

For macroinvertebrates, the loss of a substantial number of samplers meant that only two replicate samples were recovered from the eight planned samples (two per reach). No conclusive statements can be made with regard to replicate results for macroinvertebrate monitoring.

Table 2.3: Fish Sampling Replicate Comparisons

Probabilistic Site Number	UMR Assessment Reach (and River Mile)	Sample Type	Date	GRFIn Score
UMR15-0361	0 (RM 842.5)	Original	9/23/16	57.04
		Replicate	9/27/16	44.20
UMR15-0362	0 (RM 835)	Original	9/20/16	70.71
		Replicate	9/28/16	32.31
UMR15-0303	1 (RM 786.5)	Original	8/9/16	57.52
		Replicate	10/4/16	59.53
UMR15-0301	1 (RM 771)	Original	9/13/16	82.56
		Replicate	10/3/16	78.64
UMR15-0062	2 (RM 754)	Original	7/15/16	65.74
		Replicate	9/1/16	51.54
UMR15-0061	2 (RM 718)	Original	7/18/16	56.49
		Replicate	8/22/16	68.68
UMR15-0242	3 (RM 709.5)	Original	7/29/16	72.45
		Replicate	8/30/16	74.86
UMR15-0241	3 (RM 702)	Original	7/19/16	75.90
		Replicate	8/8/16	71.24

Fish Vouchers – Vouchers, in the form of a photograph (Wisconsin) or as a preserved specimen (Minnesota), were retained as a reference for every species encountered during sampling. In Minnesota, voucher samples were sent to the Bell Museum for review and processing. Both vouchering methods worked well and are acceptable approaches for future implementation, given that the selected method and results are well documented. Each approach has its own advantages and disadvantages. For example, photography may take more time in the field while collecting specimens adds additional laboratory costs and time for managing voucher samples.

Data Flow, Availability, and Compilation

In general, each state utilized its typical data recording and reporting systems with the results made available to all participants. New data sharing tools were developed specific to the Pilot.

Chemistry – Water chemistry data consisted of both field measurements collected from on-site instruments– e.g., water temperature, pH, conductivity and samples for laboratory analysis. All three participating agencies submitted field recorded information with samples for analysis to their respective laboratories (Figure 2.2). Then, laboratory samples analyses were processed and all data (field and lab-produced) were compiled into each agency's respective water quality database.

For Minnesota and Wisconsin, this information is also loaded into USEPA's Water Quality Exchange database (WQX) and is available online at the Water Quality Portal. During the Pilot, data were obtained both directly from sampling agencies and via the Water Quality Portal.

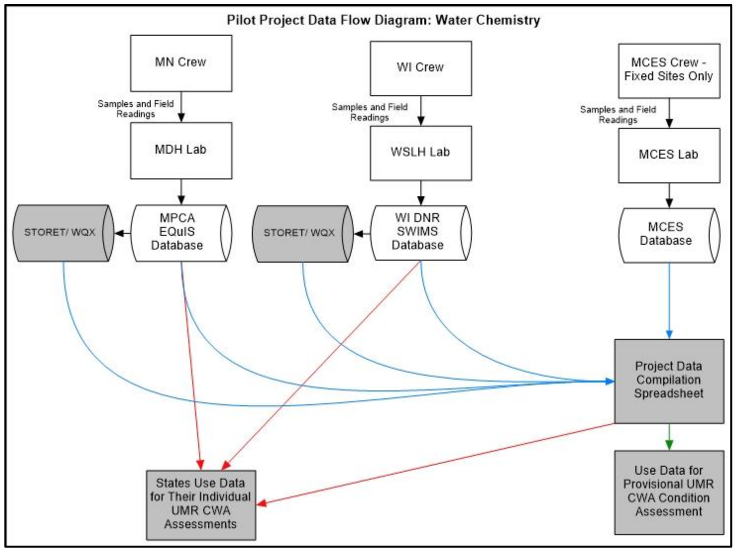

Figure 2.2: Water Chemistry Data Flow

UMRBA staff created a flat file spreadsheet to facilitate data sharing and worked in coordination with agency staff to populate this spreadsheet using chemistry data (including split and replicate sample results) received from the sampling agencies and queried from the Water Quality Portal. Though not all data became available at the same time, the spreadsheet allowed all implementing agencies to access each other's data in a standardized format and to develop the *UMRBA Condition Assessment*.

Fish – Fish assemblage characteristics used to calculate the Great River Fish Index (GRFIn) as well as accompanying water quality, habitat, and site characteristic data were recorded in the field by the Minnesota Pollution Control Agency (MPCA) and WIDNR crews (Figure 2.3). Both agencies used paper and electronic data capture methods and performed internal data entry, formatting, and review. MPCA and WIDNR exchanged their complete datasets. Subsequently, GRFIn scores were calculated by WIDNR staff and shared with MPCA and UMRBA. The GRFIn scores are available for use by each agency and are incorporated into the *UMRBA Condition Assessment*.

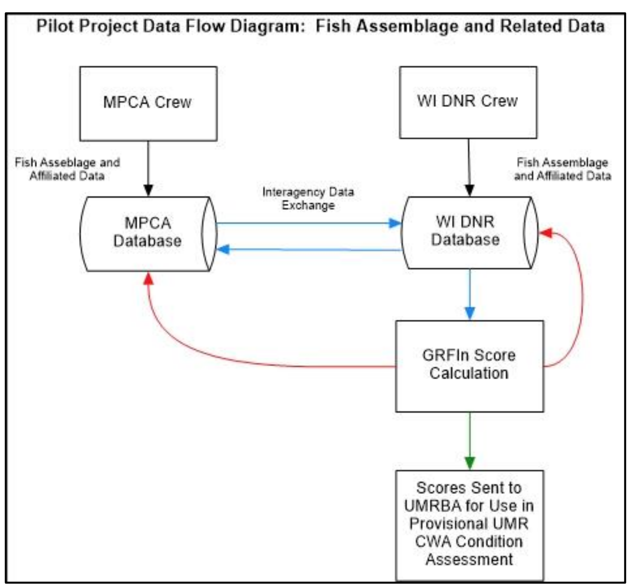

Figure 2.3: Fish Assemblage Data Flow

Macroinvertebrates – Macroinvertebrates were collected from artificial substrate samplers by MPCA and WIDNR crews. All samples were preserved and shipped to Rhithron Associates, Inc. laboratory for identification. Associated water quality, habitat, and site characteristic data were submitted to each state's individual database.

Results from Rhithron's analysis of the macroinvertebrate samples were then transmitted to MPCA (Figure 2.4). MPCA staff calculated the Large River IBI scores using these data. Data were shared with WIDNR and scores were sent to UMRBA for use in the *UMRBA Condition Assessment*.

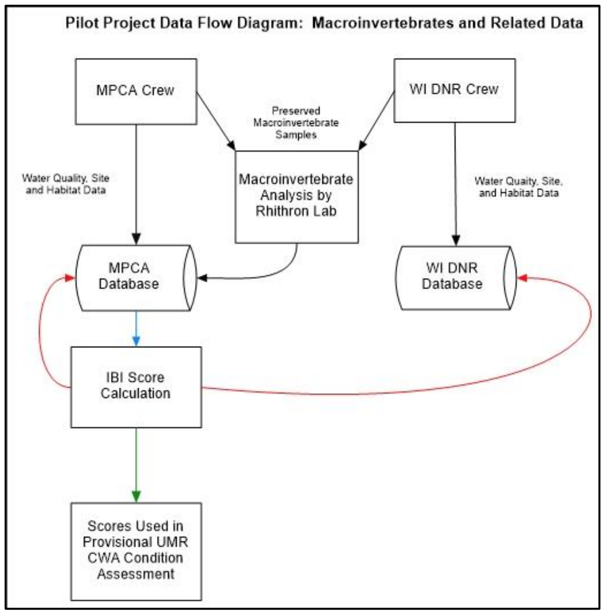

Figure 2.4: Macroinvertebrate Data Flow

Vegetation – Vegetation data were collected by Minnesota Department of Natural Resources (MNDNR) and WI DNR crews. This information, along with affiliated water quality, habitat, and site characteristic data were recorded and submitted to each state's individual database (Figure 2.5). Each state conducted QA/QC on its data and through UMRR LTRM's QA review process. MNDNR staff compiled both states' data, calculated SMI scores, and assembled a results report.

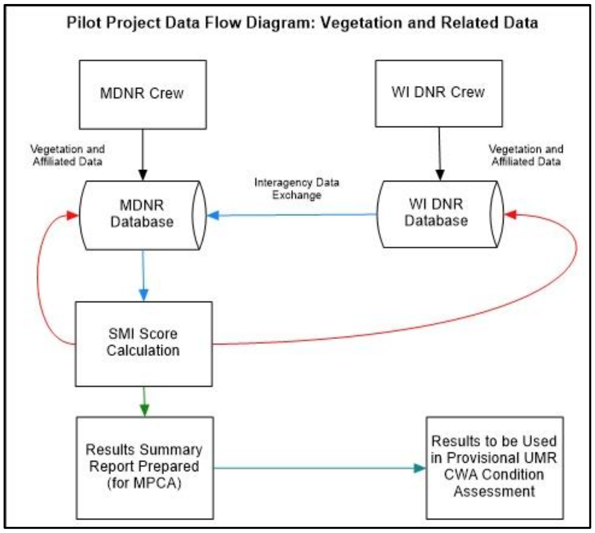

Figure 2.5: Vegetation Data Flow

Use of Data in Provisional Condition Assessment

One of the functions of the Pilot monitoring was to obtain data to test the feasibility of the *Provisional Methodology* and *Monitoring Plan* documents. The *UMRBA Condition Assessment* is a companion document to this report and provides a detailed evaluation of the effectiveness and feasibility of the *Provisional Methodology* as tested through the Pilot. Provided below are brief summary descriptions of how the datasets inform the provisional assessment methodology evaluation.

Aquatic Life Use and Recreation Use – The Pilot was largely successful in generating data for the *UMRBA Condition Assessment*. Data collected for the aquatic life use and recreation use components of the methodology were successfully obtained. Unusually high flow conditions resulted in the loss of a substantial number of macroinvertebrate samplers, reducing the robustness of the dataset. Even though reviews of fish and vegetation results indicate comparability with data from other years, results may not be representative of typical river conditions. Condition assessment outcomes need to be considered with these circumstances acknowledged.

Fish Consumption Use – Because fish tissue sample collection was dropped from the Pilot, no data were produced that could be utilized in the provisional condition assessment. The condition assessment relied on the presence or absence of fish consumption advisories in the Pilot reaches to evaluate use attainment.

Drinking Water Use – No drinking water intakes are present in the pilot sampling area, so this use was not assessed in the condition assessment. Therefore, monitoring was not conducted in the Pilot for drinking water use-only analyses – e.g., volatile organic compounds and synthetic organic chemicals.

Project Staffing and Costs

A key outcome of the Pilot is the ability to begin answering questions about the logistics of a shared CWA monitoring approach on the UMR. The Pilot was able to provide a better idea of the financial and staffing resource needs.

There are two important considerations for project staffing and expenditures. The first is that the *Recommended Monitorin*g plan envisioned monitoring and assessment over a five-year cycle where probabilistic monitoring is completed one time per cycle and fixed site monitoring is ongoing. The staffing and financial needs described below are not likely obtainable every year to support ongoing implementation. The second consideration is that the Pilot reduced or dropped certain components of the recommended plan and full plan implementation would involve additional staffing and expenditure commitments than what is reflected in the Pilot. The Pilot project staffing and cost estimates include factors that may both over- and under-estimate the costs of ongoing plan implementation.

Personnel and Time Commitment – The Pilot was implemented by a team of agency staff from Minnesota and Wisconsin who assumed different roles in execution. Each individual took on Pilot work in addition to other responsibilities; it was not a full-time job for any one individual. The project started in April 2014 with initial planning discussions and was finalized in January 2019 with final data analysis and assembly of reports (Table 2.4).

Table 2.4: The Pilot Implementation Timeline (calendar years, divided into quarters)

	2014				**2015**				**2016**				**2017**				**2018**	**2019**
UMR CWA Plan Approved																		
Scoping and Coordination																		
Fixed Site Sampling																		
Probabilistic Site Sampling																		
Data Compilation and Assessment																		
Documentation and Wrap-Up																		

Many individuals were engaged in scoping and executing the Pilot. The Pilot project team and their respective roles, times of engagement, and approximate FTE requirement were compiled to estimate total personnel costs (Table 2.5). While these personnel time estimates are a rough approximation, they do begin to provide a clearer view of the staff allocation needs to implement a shared CWA monitoring and assessment program on the UMR. The number of individuals involved and duration of time engaged would likely decline as less planning would be involved and processes would become more efficient.

Table 2.5: Personnel Commitment to the Pilot – Roles and Estimated Time

Participants		Roles							FTE Estimation		
Agency	**Name**	**Chem. Sampling**	**Fish Sampling**	**Macro. Sampling**	**SAV Sampling**	**Data Mgmt.**	**Data Analysis**	**Project Coord.**	**Duration Involved (years)**	**Est. FTE /year***	**Total FTE ^**
MCES	Jack Barland	●				●			1.0	0.1	0.1
	Kent Johnson	●						●	2.5	0.05	0.125
MN DNR	Eric Lund				●	●	●		0.5	0.1	0.05
	Megan Moore				●			●	2.5	0.05	0.125
MPCA	Pam Anderson	●						●	2.5	0.05	0.125
	Will Bouchard			●					0.5	0.1	0.05
	Joel Chirhart			●		●	●	●	2.5	0.1	0.25
	Jordan Donatell	●				●		●	1.0	0.1	0.1
	Mike Feist		●			●		●	2.5	0.1	0.25
	Lee Ganske	●							2.5	0.05	0.125
	Dan Helwig							●	1.5	0.05	0.075
	Glenn Skuta							●	1.5	0.05	0.075
WI DNR	Ron Arneson	●							2.5	0.05	0.125
	Andy Bartels		●			●	●	●	2.5	0.1	0.25
	Deanne Drake				●			●	1.5	0.1	0.15
	Jim Fischer							●	2.5	0.05	0.125
	Shawn Giblin	●		●		●	●	●	2.5	0.1	0.25
	Kraig Hoff	●							0.5	0.1	0.05
	John Kalas	●							0.5	0.1	0.05
	Brian Weigel							●	2.5	0.05	0.125
UMRBA	Dave Hokanson							●	2.5	0.15	0.375
	Matt Jacobson					●	●	●	2.5	0.15	0.375
Total											3.325

*During duration involved in project.
^Total Full Time Equivalent (FTE) over project life (approx. 2.5 years to date). Product of duration x FTE proportion when involved.

Project Costs – Project costs for the Pilot can be broadly classified as either personnel or analytical expenses. For the Pilot, existing equipment was used so no equipment costs were included. However, an ongoing monitoring program would require equipment refreshment, maintenance, and testing.

1) Estimated Personnel Costs – Personnel costs could be extrapolated based on the approximate time allocations described in the preceding section of this report. Assuming the rough estimate is accurate and average annual salary and benefits are $75,000, then estimated personnel cost for the project can be calculated as follows:

   (3.325 Total FTE) x ($75,000 per FTE) = **$249,000 estimated total project personnel cost**

2) Analytical Costs – Analytical costs are broadly defined and may include chemistry analysis, macroinvertebrate identification, and fish vouchering (Table 2.6). The analytical cost estimates were calculated by extrapolating Minnesota's costs for the entire project.

The **estimated total analytical costs for the Pilot are $174,500**

Table 2.6: Minnesota Analytical Cost Estimates and Extrapolation to Full Project

	Minnesota Estimate	Proportion of Total Project Costs	Multiplier	Estimated Project Total Analytical Cost
Chemistry Costs - Fixed Sites	$8,000 for one site	One of four fixed sites.	4	$32,000
Chemistry Costs - Probabilistic Sites	$50,000 for 30 sites (2 reaches)	Half of the total number of sites.	2	$100,000
Macroinvertebrate Identification	$13,500 for all project sites	Entirety of project sampling.	1	$13,500
Fish Vouchering	$1,700 for two reaches	Half of the total number of reaches.	2	$3,400
Vegetation Sampling	$12,800 for two reaches	Half of the total number of reaches	2	$25,600
Total	**$86,700**			**$174,500**

3) Combined Costs and Per Reach Costs – Using the above estimates of personnel and analytical cost, the estimated **overall project cost for the Pilot was approximately $424,000**. Allocating this cost over the four reaches sampled gives a **per reach cost of approximately $106,000** for the project.

4) Estimating Costs for the Entire UMR – There are numerous uncertainties and assumptions involved in estimating expenses for the entire UMR. As previously discussed, monitoring under the Pilot was reduced from the full monitoring plan so costs in other reaches could be greater. Keeping these limitations in mind, it could be stated than **an estimated cost of one full round of baseline UMR CWA monitoring per the Pilot for the entire UMR would be $1.48 million** ($106,000 per reach for 14 reaches).

Conclusions

Strengths and Successes

There are several areas that showcase the successes and strengths of the Pilot and the *Monitoring Plan*:

1) Coordinated CWA monitoring of the UMR covering biological, chemical, and physical indicators and implementation of fixed and probabilistic site monitoring was successfully completed. While the scope of monitoring was somewhat reduced from the original *Monitoring Plan* and high flows challenged sampling, data were ultimately collected across biological indicator groups (fish, macroinvertebrates, vegetation), for associated habitat characteristics, and for water chemistry at 60 probabilistic sites and four fixed sites. Coordination between different sub-groups and agencies involved was well facilitated, allowing for clear understanding of different project components, tasks, and goals. This type of coordinated, multi-indicator monitoring has long been a goal of the UMR states and the UMRBA Water Quality Task Force. The Pilot represents the first field implementation of this type of approach. While there are some portions of the *Monitoring Plan* that were not implemented, the Pilot showed that the bulk of the plan could be implemented in the field.

2) The Pilot effectively tested a collaborative and voluntary model of coordinated monitoring that relies on participating agencies providing in-kind contributions to complete monitoring, as opposed to a centrally-funded and administered program. UMRBA and its member states are continuing to pursue legislative efforts aimed at securing independent, federal funding to support coordinated future CWA monitoring on the UMR. The Pilot relied on states and participating agencies to contribute the necessary resources. While this approach has its drawbacks and it is not clear this model could be sustained in the long run, the Pilot provided a tangible test of this arrangement.

3) Pilot implementation motivated the development of tools that could provide the detail and specificity needed to move the monitoring plan from concept to reality. This included the development of an online Water Quality Viewer, facilitated desktop site reconnaissance, and delineation of sampling transects. Other key products included the *Field Operations Manual* and a data sharing spreadsheet for water chemistry.

4) The Pilot demonstrated that a shared, provisional UMR CWA condition assessment that incorporates biology and water chemistry can be achieved. The Pilot included the collection of data that specifically met the requirements of the *Provisional UMR CWA Assessment Methodology (Provisional Methodology)*, which allowed a first of its kind CWA-type condition assessment of the river that bridged state lines and incorporated biological indicators. The Pilot offered a largely complete assessment of UMR conditions in a CWA context even while this initial assessment was limited by the duration and geography of the Pilot and by anomalous river conditions.

5) The Pilot project team was able to adapt and overcome obstacles, including an unusually high-water year, the departure of key group members, funding uncertainties, and changes in monitoring scope as well as other more minor challenges. The project team was able to overcome and adapt to changes seen and unforeseen in large part due to clear communication as well as understanding and acceptance of the realities of implementing a large-scale project.

Challenges and Limitations

The following appear to be areas of greatest challenges and limitations for the Pilot project and the *Monitoring Plan*:

Some components of the *Monitoring Plan* were not implemented in the Pilot. This should, in part, be considered a success of the Pilot. The Pilot identified those elements that were most challenging to implement, though dropping some of these might undermine the comprehensive nature of the plan. Some of the elements that will require consideration of their future viability in this type of monitoring.

Fish Tissue Sampling – Originally, incorporation of tissue sampling was seen as beneficial as it improved sampling collection efficiency (i.e., fish were being collected already as part of assemblage monitoring) and provided an opportunity to consistently sample species groups and size classes river-wide. However, a number of concerns were raised as the Pilot project team attempted to operationalize the tissue sampling envisioned in the *Monitoring Plan*. These concerns included cost of analysis as well as integrating and relating this data to current fish consumption advisories.

Metals Monitoring at Probabilistic Sites – The Pilot project team elected to drop metals monitoring at probabilistic sites primarily for cost reasons and in light of pre-existing data. Metals data were run through the Wisconsin and Minnesota impaired waters methodologies and found the fixed site sampling to be sufficient.

Algal Toxins – Algal toxin monitoring was not implemented as part of the Pilot because the occurrence of these toxins can be sporadic in nature and is not always amenable to a scheduled monitoring program. However, algal toxins and HABs continue to be a predominant water quality concern and technology to measure the toxins and/or surrogate parameters continues to evolve. UMR states may desire to continue reviewing the viability of monitoring for toxins and related parameters in any future implementation of the *Monitoring Plan*.

Index Sites – Index site monitoring was not implemented during the Pilot, but may need to be part of any long-term monitoring implementation in order to provide for ongoing calibration and maintenance of biological indices. However, further clarity and specificity is needed in regard to how such monitoring is carried out and how resultant data are used in calibrating indices.

Tributary Loading Network – A tributary loading network focused on nutrients and sediment was originally envisioned as part of the *Monitoring Plan*. However, it was not implemented in the Pilot. It is important to note that state and USGS' capacities in load monitoring and calculation have evolved significantly since the plan was first drafted. The utility of a separate UMR tributary loading network should be re-evaluated before it is implemented as part of any future UMR CWA monitoring.

River Conditions – Unusually high flows occurred in 2016 that may have impacted the representativeness of results. The high flows impacted the recovery rates of macroinvertebrate samplers, shifted fish and vegetation collection points, and also impacted chemistry results. The outcomes from 2016 may not be fully reflective of longer term conditions on the UMR. This particular circumstance is beyond the control of the Pilot or the *Monitoring Plan* and any monitoring approach would have been similarly impacted. However, this situation did illustrate the constraints in a single-year funded, multi-agency pilot in that options for shifting the timing of monitoring or collecting additional samples in the following season are limited and that there is not a long-term record of data with which to compare and integrate a single season's results.

Macroinvertebrate Monitoring and Assessment – Of the various indicator groups, macroinvertebrate monitoring (and assessment) faced some unique challenges:

1) Change in Methodology: The Pilot project team decided to change from the sampling method described in the *Monitoring Plan* (i.e., EMAP kick sampling) to an artificial substrate methodology. The artificial substrate methodology is more consistent with existing long-term data sets in this area of the UMR and better suited to application on a large river. However, this change in methodology requires a new biological index – the Large Rivers IBI – and a need to develop new thresholds for a condition assessment. A new condition assessment threshold was developed because of the Pilot, which may be a great success resulting from the initial methodological challenge.

2) Loss of Samplers: Nearly half of the macroinvertebrate samplers were not recovered in the Pilot. Presumably, this was caused by high flows that displaced, dislodged, or otherwise damaged the artificial samplers. It is unknown how many samples were lost due to vandalism and if this could be an issue into the future. This high rate of loss limited the rigor of the overall dual-assemblage assessment and hindered the ability to make a definitive judgement regarding what method is best to assess macroinvertebrates on the UMR. However, enough data were collected to move forward in testing the *Provisional Methodology* and to develop a new threshold value.

Technical and Institutional Complexity – The Pilot, and the *Monitoring Plan*, presented a fairly substantial level of complexity, both at the technical level and in the institutional setting. On a technical level, the plan itself calls for two separate but related monitoring networks – probabilistic and fixed sites. UMRBA's Water Quality Task Force intentionally included both of these networks in order to overcome inherent limitations in each type of monitoring approach and, in the case of fixed sites, to integrate with historic monitoring locations on the UMR. Further, the plan sought to go beyond the historic chemistry-centered assessment and fully integrate biology across multiple assemblages. The level of technical complexity was to be expected, although it did perhaps contribute to extended time for planning monitoring as participant agencies became familiar with the various plan components. The multiple and indicator groups also added to the complexity of data management and processing.

Significant institutional complexity was then overlaid onto the technical complexity. Four different state and local agencies and UMRBA were engaged. Additionally, three chemistry laboratories were involved as well as a contract laboratory for macroinvertebrate analysis. The UMR CWA Pilot has the institutional complexity comparable to large water monitoring programs such as the Ohio River Valley Water Sanitation Commission (ORSANCO), the UMMR Long Term Resource Monitoring Program (LTRM), and Chesapeake Bay Program (Figure 3.1).

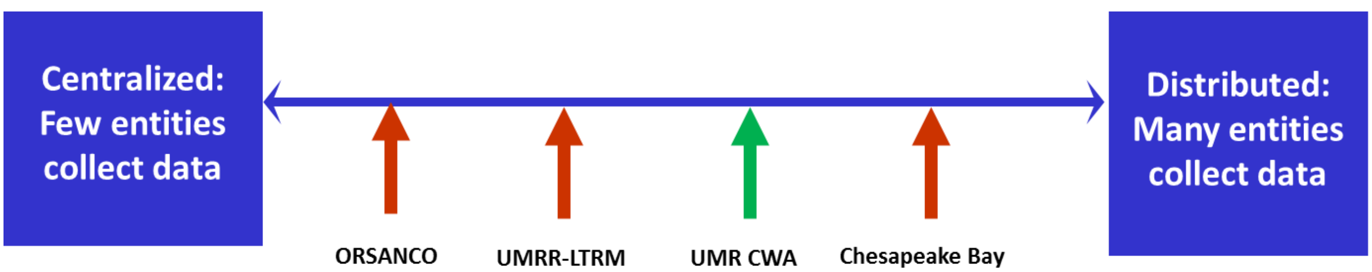

Figure 3.1: Conceptual Illustration of Monitoring Program Institutional Complexity

Inter-Laboratory Variability – Related to institutional complexity, multiple laboratories participated in chemistry analysis. Some variability was observed in the chemistry results among these labs and a number of analytical methods differences existed. While results from labs were generally consistent, these disparities may undermine the confidence in any conclusions drawn from a compiled dataset. Additionally, the varying methods of data availability and timelines made data compilation and analysis more complex. While the use of multiple labs was a practical necessity for Pilot implementation, the states may wish to reconsider this approach in any future monitoring efforts recognizing that financial limitations may dictate feasibility.

Data Flow, Management, and Analysis – Chemistry results were compiled from the three participant laboratories and accomplished via collaboration between agency and UMRBA staff. Specifics of the process varied among indicator groups. The compilation of chemistry data in some cases required reformatting before analysis and the assessment portion proved to be a significant task given the limited resources available at UMRBA and within agencies. Some of this effort was one-time only and will not need to be replicated in future monitoring, but there may remain a need for significant data analysis work in any future monitoring. An overarching data management plan was not developed during the Pilot. While this was initially envisioned as a goal associated with Pilot implementation, a more pragmatic short-term approach was adopted that deferred to the participant agencies on how to manage data internally and share for interagency use and provisional assessment development. The question of whether a more robust and explicit data management plan is needed for future monitoring should be revisited.

Inter-Operability with Results from Other Programs – While the Pilot was successful in bringing the states together on a CWA monitoring approach, outcomes were mixed in terms of the ability to integrate Pilot monitoring with data from other programs. For example, existing fixed sites and macroinvertebrate methods were consistent with pre-existing MCES data. In other instances, Pilot monitoring results were similar but different than existing sources – e.g., fish and vegetation monitoring in comparison to the UMRR LTRM program, which is the predominant source of biological data on the UMR. UMRBA staff did attempt to gather non-pilot data for a "virtual pilot" study alongside the Pilot, but data variations limited the utility of this exercise.

Sustainability of Monitoring Approach – Perhaps the overriding question emerging from the Pilot is whether this type of monitoring approach is sustainable and repeatable in the long run. The Pilot did reveal a number of challenges to sustainability that primarily relate to available resources. Funding is a primary challenge. Minnesota is the only state to have identified a potential dedicated funding source (i.e., Minnesota's Outdoor Heritage and Clean Water Legacy Funding). The funding source may be available on a longer-term basis but is dependent on the state's biennial budget. Wisconsin was able to utilize CWA Section 106 supplemental funding to execute monitoring for this Pilot, but future use of this source is not guaranteed. Illinois, Iowa, and Missouri may similarly utilize CWA Section 106 supplemental funding to support monitoring in future years. Additionally, the extent and complexity of monitoring as envisioned under the *Monitoring Plan* may not be sustainable particularly as it impacts funding and staffing needs. All of this may result in a modified monitoring approach that reduces associated costs and complexity and increases feasibility.

Overall Evaluation

The Pilot provided a successful and extensive test of the *Monitoring Plan*. This does not mean that all elements of the plan were extremely successful or even implemented in the field. But the Pilot was able to determine areas that were effective and need improvement or reconsideration as well as the necessary resources for implementation. It also resulted in the development of supporting tools that would be helpful in future monitoring efforts. Additionally, the Pilot generated a dataset compatible with the *Provisional Methodology* so that methodology could be thoroughly tested.

Recommendations for Future UMR CWA Monitoring

This project was intended to inform potential future UMR CWA coordinated monitoring. With that goal in mind the following are recommendations for any future collaborative UMR CWA monitoring by the states:

1) *Implement coordinated monitoring throughout the UMR before the close of the current 10-year monitoring plan timeframe – from 2013 to 2022*
2) *Modify the UMR CWA Recommended Monitoring Plan to improve its effectiveness and feasibility*
3) *Reassess the status and success of macroinvertebrate monitoring and assessment*
4) *Modify the vegetation monitoring approach*
5) *Explore integration of HAB-related monitoring*
6) *Revisit the need for a UMR CWA data management plan*
7) *Consider a single laboratory for chemistry analysis to eliminate disparities in results and reduce possibilities for error*
8) *Pursue opportunities to integrate the UMR CWA data with other river monitoring programs*
9) *Explore options for securing resources*
10) *Maintain and build capacity at UMRBA to support coordinated monitoring*

While the bulk of work in the Pilot, and presumably any future implementation, would fall outside of UMRBA, states have suggested that the Association's role will be in supporting planning for coordinated monitoring, maintaining tools (e.g., web viewer, field operations manual), consolidating data and information, and developing reports and provisional assessment documents. Some of the key tools and infrastructure could be maintained with a relatively modest investment. Other areas (e.g., data compilation and analysis) might still require fairly significant resource commitment during implementation, likely beyond the staff resource investment made for the Pilot, particularly in regard to geospatial applications and data management.

Acronyms Used

CWA – Clean Water Act

DOC – Dissolved Organic Carbon

EMAP-GRE – Environmental Monitoring and Assessment Program – Great Rivers Ecosystem

FTE – Full Time Equivalent

GRFIn – Great River Fish Index

GRMIn – Great River Macroinvertebrate Index

HAB – Harmful Algal Bloom

IBI – Index of Biotic Integrity

MCES – Metropolitan Council Environmental Services

MDH – Minnesota Department of Health

MNDNR – Minnesota Department of Natural Resources

MPCA – Minnesota Pollution Control Agency

QA/QC – Quality Assurance/Quality Control

SAV – Submersed Aquatic Vegetation

SMI – Submersed Macrophyte Index

SOC – Synthetic Organic Chemicals

STORET/WQX – USEPA's Storage and Retrieval data warehouse/Water Quality Exchange

TOC – Total Organic Carbon

UMR – Upper Mississippi River

UMR CWA Monitoring Plan – *Upper Mississippi River Clean Water Act Recommended Monitoring Plan*

UMRBA – Upper Mississippi River Basin Association

UMRR LTRM – Upper Mississippi River Restoration Long Term Resource Monitoring

UMRS – Upper Mississippi River

USEPA – United States Environmental Protection Agency

USGS – United States Geological Survey

VOC – Volatile Organic Compound

WIDNR – Wisconsin Department of Natural Resources

WSLH – Wisconsin State Laboratory of Hygiene

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