Upper Mississippi River Restoration
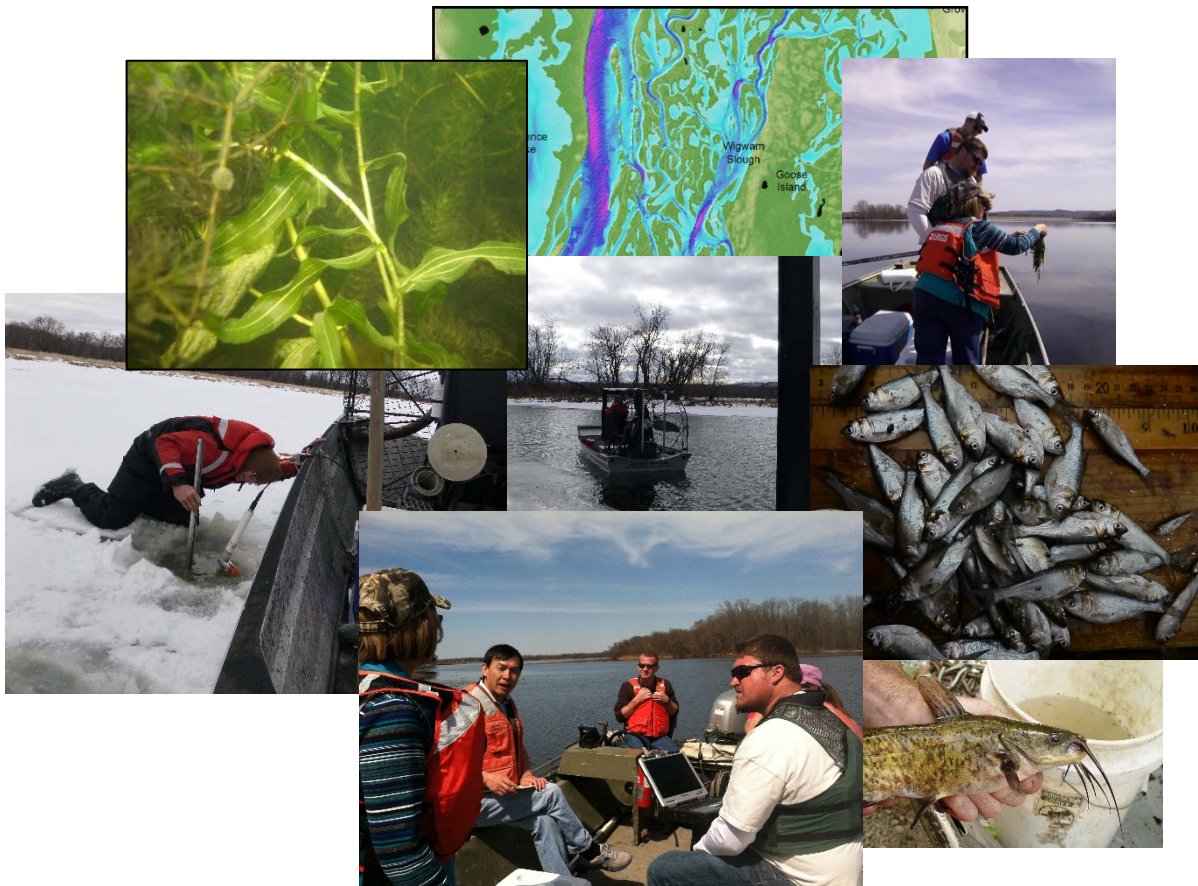Leading · Innovating · Partnering

Long Term Resource Monitoring
FY18 SOW

Enhancing Restoration and Advancing Knowledge of the Upper Mississippi River

Addressing the
FY2015–2025 UMRR Strategic Plan

The Upper Mississippi River Restoration (UMRR) Program for the Upper Mississippi River System (UMRS) is first comprehensive program for ecosystem restoration, scientific research, and monitoring on a large river system in the Nation and the world. The UMRS is one of this Nation's unique natural resources. The ecosystem provides habitat to a wide array of fish and wildlife species distributed among a complex assortment of flowing channels, floodplain lakes, backwaters, wetlands, and floodplain forests. With an ecosystem as diverse and complex as the UMRS, many of its processes and their interrelationships are not well known. One way to help understand this multifaceted system is through environmental monitoring. The UMRR Long Term Resource Monitoring (LTRM) data provides the scientific foundation required for sound management actions, effective river restoration projects, and informed environmental policy decisions for the UMRS.

The value of UMRR LTRM's long term data set continues to grow. It serves as a foundation for the restoration of the UMRS by revealing patterns and trends, establishing benchmarks of the current state for comparison to future conditions, serving as an early warning of change, supporting planning and management through the identification of key issues and trends, and evaluating the effectiveness of restoration and management actions on the UMRS.

Table of Contents

<p align="center">**FY18 UMRR LTRM (Base Monitoring) Scope of Work**</p>

This Scope of Work (SOW) describes tasks in support of the US Army Corps of Engineers' Upper Mississippi River Restoration (UMRR) Program Long Term Resource Monitoring (LTRM) element, authorized by Congress in the 1986 Water Resources Development Act and reauthorized in the 1999 Water Resources Development Act, to be performed by the USGS-Upper Midwest Environmental Sciences Center (UMESC) in La Crosse, Wisconsin, and six state-operated field stations (Illinois, Iowa, Minnesota, Missouri, and Wisconsin). This long term monitoring directly supports Upper Mississippi River System (UMRS) understanding, critical for successful UMRS restoration by the UMRR. This SOW complements those work items in the UMRR Science in Support of Restoration and Management FY18 SOW.

A comprehensive monitoring program consists of environmental monitoring, research, systemic data acquisition, modeling, and information delivery in an effort to provide a solid scientific foundation upon which resource managers and policy makers base management actions and develop environmental policy.

Aquatic Vegetation Component

The objective of the UMRR LTRM Aquatic Vegetation Component is to collect quantitative data on the distribution and abundance of aquatic vegetation in the Upper Mississippi River System (UMRS) and to conduct research related to aquatic vegetation for the purpose of understanding its status, trends, ecological functions, and responses to disturbances and UMRR restoration activities. Aquatic vegetation in the UMRS is desirable because of its many values, most notably as food for migratory waterfowl (Korschgen et al. 1988) and habitat for fish. Monitoring data are collected within three LTRM study reaches in the UMRS (Pools 4, 8, and 13 on the Upper Mississippi River). Data entry, quality assurance, data summaries, standard analyses, data serving, and report preparation occur under standardized protocols.

Methods

For monitoring aquatic vegetation, sampling will be conducted following the LTRM aquatic vegetation standard sampling protocol (Yin et al. 2000). A total of 1,350 sites will be surveyed, including 450 in Pool 4, 450 in Pool 8, and 450 in Pool 13 (Table 1). The presence/absence and abundance of aquatic plant species at each site will be measured and recorded. Pool-wide estimates of abundance and percent frequency of occurrence will be derived by pooling data over all strata.

Products and Milestones

Tracking number	Products		Staff		Milestones
2018A1	Complete data entry and QA/QC of 2017 data; 1250 observations.				
	a. Data entry completed and submission of data to USGS		Lund, Drake, Bales		30 November 2017
	b. Data loaded on level 2 browsers		Schlifer		15 December 2017

	c. QA/QC scripts run and data corrections sent to Field Stations		Sauer, Schlifer	28 December 2017
	d. Field Station QA/QC with corrections to USGS		Lund, Drake, Bales	15 January 2018
	e. Corrections made and data moved to public Web Browser		Yin, Sauer, Schlifer, Caucutt	30 January 2018
2018A2	Web-based: Creating surface distribution maps for aquatic plant species in Pools 4, 8, and 13; 2016 data		Yin, Rogala, Schlifer	31 July 2018
2018A3	Wisconsin DNR annual summary report 2015 that combines current year observations from LTRM with previous years' data, for the fish, aquatic vegetation, and water quality components.		Drake, Bartels, Hoff, Kalas	30 Sept 2018
2018A4	Complete aquatic vegetation sampling for Pools 4, 8, and 13 (Table 1)		Yin, Lund, Drake, Hupfeld	31 August 2018
2018A5	Pool 4 Graphical summary and maps of aquatic vegetation current status and long-term trends.		Lund	30 Dec. 2017
2018A6	Pool 8 Graphical summary and maps of aquatic vegetation current status and long-term trends.		Drake, Weeks	30 Dec. 2017
Intended for distribution				
LTRM Technical Report: Ecological Assessment of High Quality UMRS Floodplain Forests (2007APE12; Chick, Guyon, Battaglia) (With author for revision)				
LTRM completion report: FY05-07 data--Analysis and support of aquatic vegetation sampling data in Pools 6, 9, 18, and 19 (2008APE4a; Yin) (With author for revision)				
Manuscript: Have the recent increases in aquatic vegetation in Pools 5 and 8 been the result of water level management drawdowns, HREPs, or natural fluctuations? (2009APE1a; Yin) (With author for revision)				
Manuscript: A statistical model of species occupancy using the LTRM aquatic vegetation data (2013A7; Yin) (With author for revision)				

Fisheries Component

The objective of the UMRR LTRM Fisheries Component is to collect quantitative data on the distribution and abundance of fish species and communities in the UMRS and to conduct research related to fishes for the purpose of understanding resource status and trends, ecological functions, and response to disturbances and UMRR restoration activities. The UMRS is probably the most biologically productive and economically important large floodplain river system in the United States (Patrick 1998; U.S. Geological Survey 1999), and fish are one of the most important goods and services the UMRS provides to humans (Carlander 1954). Fishes within the UMRS are the subject of commercial and recreational fisheries, both of which contribute substantially to local economies (Fremling et al. 1989). Scientists and fishery managers also recognize fish communities as an integrative index for a complex set of physical and biological conditions on the UMRS.

Data are collected within six LTRM study reaches in the UMRS (Pools 4, 8, 13, and 26 and Open River Reach on the Upper Mississippi River and La Grange Pool on the Illinois River). Data entry, quality assurance, data summaries, standard analyses, data serving, and report preparation occur under standardized protocols (Ratcliff et al. 2014).

Methods

For monitoring fish, sampling will be conducted following the LTRM study plan and standard protocols (Ratcliff et al. 2014) as modified from Ickes and Burkhardt 2002. Species abundance, size structure, and community composition and structure will be measured over time. Between 250 and 400 samples will be collected in each study area (Table 1). Sample allocation will be based on a stratified random design, where strata include contiguous backwaters, main channel borders, main channel wingdams, impounded areas, and secondary channel borders. Tailwaters in the impounded reaches and tributary mouths in the Open River will be sampled under a fixed site design. Sampling effort will be allocated independently and equally across 3 sampling periods (June 15–July 31; August 1–September 15; September 16–October 31) to minimize risks of annual data loss during flood periods and to characterize seasonal patterns in abundance and habitat use. Pool-wide estimates of abundance will be derived by pooling data over all strata.

Products and Milestones

Tracking number	Products	Staff	Milestones
2018B1	Complete data entry, QA/QC of 2017 fish data; ~1,590 observations		
	a. Data entry completed and submission of data to USGS	DeLain, Bartels, Bowler, Ratcliff, Gittinger, West, Solomon, Maxson	31 January 2018
	b. Data loaded on level 2 browsers; QA/QC scripts run and data corrections sent to Field Stations	Ickes, Schlifer	15 February 2018
	c. Field Station QA/QC with corrections to USGS	DeLain, Bartels, Bowler, Ratcliff, Gittinger, West, Solomon, Maxson	15 March 2018
	d. Corrections made and data moved to public Web Browser	Ickes, Sauer, and Schlifer	30 March 2018
2018B2	Update Graphical Browser with 2017 data on Public	Ickes, Sauer, DeLain,	31 May 2018

		Bartels, Bowler, Ratcliff, Gittinger, West, Solomon, Maxson, Schlifer	
	Web Server.		
2018B3	Complete fisheries sampling for Pools 4, 8, 13, 26, the Open River Reach, and La Grange Pool (Table 1)	Ickes, DeLain, Bartels, Bowler, Ratcliff, Gittinger, West, Solomon, Maxson	31 October 2018
2018B4	Summary Letter: Floodplain fisheries sampling	West, Sobotka	31 October 2018
2018B5	IDNR Fisheries Management State Report: Fisheries Monitoring in Pool 13, Upper Mississippi River, 2017	Bowler	30 June 2018
2018B6	Sample collection, database increment, Summary letter on Asian carp age and growth: collection of cleithral bones	Solomon, Maxson, Casper	31 January 2018
2018B8(D)	Database increment: Stratified random day electrofishing samples collected in Pools 9–11	Bowler	30 Sept 2018
2018B9(D)	Database increment: Stratified random day electrofishing samples collected in Pools 16–18	Bowler	30 Sept 2018
2018B10	Database increment: Open River Chevron Dike monitoring	West, Sobotka	31 Oct 2018
2018B11	Database increment: Evaluating the Fish Community in a rare Backwater Habitat in the Middle Mississippi River 2018	West	30 Sept 2018
Intended for distribution			

Completion report: LTRM Fisheries Component collection of six darter species from 1989–2004. (2006B13; Ridings) (under revision)

LTRM Completion report, compilation of 3 years of sampling: Fisheries (2009R1Fish; Chick et al.) (under revision)

LTRM Fact Sheet: Tree map tool for visualizing fish data, with example of native versus non-native fish biomass (2013B16) (under revision)

Water Quality Component

The objective of the UMRR LTRM's water quality component is to conduct monitoring and research to obtain basic limnological information required to (1) increase understanding of the ecological structure and functioning of the UMRS, (2) document the status and trends of ecological conditions in the UMRS, and (3) contribute to the evaluation of management alternatives and actions in the UMRS. The water quality component focuses on a subset of limnological variables related to habitat quality and ecosystem function that includes physicochemical features, suspended sediment, and major plant nutrients known to be significant to aquatic habitat in this system.

Data are collected within six LTRM study reaches in the UMRS (Pools 4, 8, 13, 26, and Open River Reach on the Upper Mississippi River and La Grange Pool on the Illinois River). Data entry, quality assurance, data summaries, standard analyses, data serving, and report preparation occur under standardized protocols (Soballe and Fischer 2004).

Methods

For monitoring water quality, limnological variables (physicochemical characteristics, suspended solids, chlorophyll a, phytoplankton [archived], and major plant nutrients) will be monitored at both stratified random sites (SRS) and at fixed sampling sites (FSS) according to LTRM protocols.

Fixed site sampling
Fixed site sampling will be conducted as in FY2006 except for modifications made in 2010 for Pools 4 and 8 (Table 1).

Stratified random sampling
Stratified random sampling will be conducted at full effort levels (same as FY2000) for fall, winter, spring, and summer episodes (Table 1).

In situ data collection
For both FSS and SRS in situ data will be collected on physicochemical characteristics per the standard protocols (Soballe and Fischer 2004).

Laboratory analyses
Samples for chemical analysis (nitrogen (total N, nitrate/nitrite N, ammonia N), phosphorus (Total P, SRP), and silica) will be collected at all fixed sites and at approximately 35% of all stratified random sampling locations as specified in the sampling design. Samples for flourometric chlorophyll and suspended solids (total and volatile) will be collected at all SRS and Fixed sites Sampling and laboratory analyses will be performed following LTRM protocols (Soballe and Fischer 2004) and Standard Methods (American Public Health Association 1992).

Products and Milestones

Tracking number	Products	Staff	Milestones
2018D1	Complete calendar year 2017 fixed-site and SRS water quality sampling	Jankowski, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka	31 December 2017
2018D2	Complete laboratory sample analysis of 2017 fixed site and SRS data; Laboratory data loaded to Oracle data base.	Yuan, Schlifer	15 March 2018
2018D3	1st Quarter of laboratory sample analysis (~12,600)	Yuan, Manier, Burdis, Kalas, Kueter, L. Gittinger, Cook, Sobotka	30 December 2018
2018D4	2nd Quarter of laboratory sample analysis (~12,600)	Yuan, Manier, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka	30 March 2018
2018D5	3rd Quarter of laboratory sample analysis (~12,600)	Yuan, Manier, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka	29 June 2018
2018D6	4th Quarter of laboratory sample analysis (~12,600)	Yuan, Manier, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka	28 September 2018
2018D7	Complete QA/QC of calendar year 2017 fixed-site and SRS data.		
	a. Data loaded on level 2 browsers; QA/QC scripts run; SAS QA/QC programs updated and sent to Field Stations with data.	Schlifer, Rogala, Jankowski	30 March 2018
	b. Field Station QA/QC; USGS QA/QC.	Jankowski, Rogala, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka	15 April 2018
	c. Corrections made and data moved to public Web Browser	Rogala, Schlifer, Jankowski	30 April 2018
2018D8	Complete FY2017 fixed site and SRS sampling for Pools 4, 8, 13, 26, Open River Reach, and La Grange Pool (Table 1)	Jankowski, Burdis, Kalas, Kueter, L. Gittinger, Kellerhals, Sobotka	30 Sept 2018
2018D9	WEB-based annual Water Quality Component Update w/ 2017 data on Server.	Rogala	30 May 2018
2018D10	Final LTRM Completion report: Evaluation of water quality data from automated sampling platforms	Soeken-Gittinger, Lubinski, Chick, Houser	30 Sept 2018
2018D11	Operational Support to the UMRR LTRM Element. Serve as in-house Field Station for USGS for consultation and support on various LTRM-wide topics	Kalas, Hoff, Bartel, Drake	30 Sept 2018
2015D12	Final report/manuscript: Developing continuous water quality monitoring methods in the UMR	Chick, Houser	1 Sept 2018
Intended for distribution			
Completion report: Examining nitrogen and phosphorus ratios N:P in the unimpounded portion of the Upper Mississippi River (2006D9; Hrabik & Crites) (under revision)			
Completion report, compilation of 3 years of sampling: Water Quality (2009R1WQ; Giblin, Burdis) (under revision)			
Manuscript: Nutrients and dissolved oxygen in the UMRS: improving our understanding of winter conditions and their implications for structure and function of the river (2014D12; Houser) (under revision)			

Land Cover/Land Use with GIS Support

Although the LTRM will not collect systemic aerial photography data, it will maintain expertise, manage existing data and infrastructure, and provide limited on-demand Geographic Information System (GIS) technical assistance to the UMRR partnership including, but not limited to:

- Aerial image interpretation of selected sites as requested
- Flight planning and acquisition of aerial imagery
- Change detection and habitat modeling
- Georeferenced aerial photo mosaics (pool wide, Habitat Rehabilitation and Enhancement Projects (HREPs), land acquisition areas)
- Georeference and create metadata for archival map/plat mosaics (Brown Survey, Mississippi River Commission data, Government Land Office data)
- Produce graphics and summary tables for partnership publications, posters, and presentations
- Conversion of ASCII coordinate data from a GPS to a spatial data set
- Conversion of GIS data layers to KMZ (Google Earth) formats for ease of viewing and sharing.
- Maintain, update, and oversee the aerial photo library of over 50,000 print and digital images.
- Maintain, update, and enhance over 20 million acres of land cover/land use and aquatic areas data spanning the late 1800s through the year 2000. This includes improving existing or developing new crosswalks for comparison of existing data sets, cropping data sets to common extents, and ensuring that all data sets are in a common coordinate system.
- Assist in the maintenance and updating of the USGS-Upper Midwest Environmental Sciences Center's (UMESC) web based geospatial data repository.
- Provide geospatial hardware and software technical support to UMESC staff and partners, as needed.
- Continue to assess advances in computer technology (hardware and software) for accurate and efficient GIS data production.
- Develop plan to implement small unmanned aerial systems technology (sUAS) in UMRS resource monitoring (training, certification, sUAS leasing options).

2018LC3: Updates on progress for land cover products

Although the primary focus of this component is to provide technical assistance and maintain existing geodatabases(i.e. including new data as it becomes available or is created such as LCU updates, KMLs, or site-specific orthoimagery; ensuring compliant with newest software), *as time allows* work may occur on the following LTRM projects. As work is accomplished for each project, it will be reported in the quarterly activities. When a project is completed, that will be announced to the partners and reported in the quarterly activities. The percentage completion for each project will be updated in each subsequent.

- Continue to update the detailed spreadsheet of all LTRM aerial photography currently housed at UMESC, including date, pool location, format (color infrared, natural color,

black-and-white), scan status (yes/no, dots per inch), interpreted status, photo scale, and extent of coverage (partial or complete). This document will be served on-line and updated as necessary. Existing analog imagery has been inventoried and the systemic sets are being scanned. The master document will be versioned (and updated periodically as scanning continues) and hosted at www.umesc.usgs.gov/data_library/photographs/photographs.html. (85% complete)

- Complete summaries detailing differences in land cover between 2000 and 2010/11 for the key pools (60% complete)

- Create a Google Earth help page to assist partners and public in using Google Earth to view and query LTRM data being served in the KMZ format. (95% complete; undergoing USGS review

- Assess automated terrain extraction software (Imagine Photogrammetry Suite) using 3"/pixel imagery or better and compare extracted elevation information to LiDAR-derived digital elevation models. This will help answer the question if using high-resolution aerial imagery can produce digital surface models on par with LiDAR elevation models.

- Assess eCognition's ability to identify and classify floodplain vegetation to the 31-class level. This software has become the standard for automated and semi-automated land cover classification. The software must be 'trained' on vegetation class signatures initially but it can use that that training and ancillary datasets to derive land cover classes from digital aerial imagery. We hope to assess is usefulness at distinguishing floodplain land cover classes for future mapping efforts. Evaluating the newest 2017 versions of Feature Analyst and eCognition to assess how well current algorithms are able to correctly identify land cover classes.

- Implement and assess high-throughput distributed processing using HTCondor. This will speed up image processing and analyses using ERDAS and eCognition. Training took place in FY17 and currently are testing image processing software.

- Assess the utility of thermal infrared aerial imagery on detecting Asian carp spawning locations within the UMRS. This camera was demo-ed for Mapping the thermal landscape of the Upper Mississippi River: A Pilot Study (see page 45 www.umesc.usgs.gov/ltrmp/documents/Sci_SOW_17_Text7April2017.pdf) in late-July. If measured temperatures correspond accurately to temps reading from in-situ loggers, the next step will be to collect test thermal imagery of potential carp spawning sites on the Illinois River.

Products and Milestones

Tracking number	Products		Staff		Milestones
2018LC1	Maintenance ArcGIS server		Hlavacek, Fox, Rohweder		September 30, 2018
2018LC2	Aerial Photo scanning (Pools 11-12; 14-22; 24-25)		Hlavacek		September 30, 2018
2018LC3	Updates on progress for land cover products listed.		Robinson		New progress reported in the quarterly activities. Percent complete updated 30 Sept 2018.

Bathymetry Component

The overall goal of the UMRR LTRM's Bathymetry Component is to complete a system-wide GIS coverage of UMRS bathymetry used to quantitatively and qualitatively assess the suitability of essential aquatic habitats. Bathymetric survey data has been combined with Lidar data to generate topobathy. This work was completed in FY17. Topobathy contains bed elevation data only, and doesn't include water depth (i.e., bathymetry) information directly.

Previously generated bathymetric coverages will be replaced with coverages derived from topobathy. Water surface elevation coverages at selected discharge conditions were developed in FY17 to complete this work. Bathymetric coverages will be generated for selected water surface elevation conditions and served as they are completed starting in FY18.

The LTRM will maintain some level of expertise to provide basic assistance with using the topobathy and bathymetry data, including, but not limited to:

- •   Deliver data in non-standard formats, such as raw point data in GIS formats or text files,
- •   Assist in developing inundation tools that use the topobathy data,
- •   Calculate summary statistics (e.g., hypsographic curves and volume) for geographical subsets of the data,
- •   Assist in spatial modeling using the topobathy and bathymetric data.

Data Management

The objective of data management for the UMRR LTRM is to provide for data collection, correction, archive, and distribution of a 90 million dollar database that consists of over 2.2 million records located in 195 tables. The 2.2 million data points currently in the system require regular maintenance and upgrading as technologies change. Also, having a publicly accessible database requires a significant level of security. This is accomplished by having the systems Certified and Accredited by a rigorous, formal process by the USGS Security team.

Methods

Data management tasks include, but are not limited to:

- Review daily logs to ensure data and system integrity and apply application updates.
- Develop and maintain field notebook applications to electronically capture data and begin the initial phase of Quality Control/Quality Assurance (QA/QC).
- Administer and maintain the Oracle LTRM database.
- Administer and maintain LTRM hardware, software, and supplies to support LTRM needs.
- Administer, maintain, and update the LTRM public and intranet data browsers to insure access to all LTRM data within USGS security policy.

Product Description

Products and Milestones

Tracking number	Products		Staff		Milestones
2018M1	Update vegetation, fisheries, and water quality component field data entry and correction applications.		Schlifer		30 May 2018
2018M2	Load 2017 component sampling data into Database tables and make data available on Level 2 browsers for field stations to QA/QC.		Schlifer		30 June 2018

Quarterly Activities

To enhance communication with the UMRR Partnership, LTRM staff at USGS-UMESC and the six state-run field stations will track activities not explicitly listed in this current scope of work. These quarterly activity lists will document activities and accomplishments by Program partners that are not tracked in the milestone table. Activities will include such items as presentations, outreach, technical assistance, data retrieval, and consultation for LTRM Partners including state and federal agencies, NGOs, and academia. These activities demonstrate the value of LTRM data and expert scientific knowledge to clients and customers, and help to identify potential new collaborations that will benefit EMP and river managers. Activity lists will be placed on the web under the A-Team Corner page (http://www.umesc.usgs.gov/ltrmp/ateam.html). This effort addresses a need for increased communication and dissemination of information.

Products and Milestones

Tracking number	Products	Staff	Milestone
2018QR1	Submittal of quarterly activities	All LTRM staff	30 January 2018
2018QR2	Submittal of quarterly activities	All LTRM staff	13 April 2018
2018QR3	Submittal of quarterly activities	All LTRM staff	13 July 2018
2018QR4	Submittal of quarterly activities	All LTRM staff	12 October 2018

Literature Cited

American Public Health Association, American Water Works Association, and Water Environment Federation. 1992. Standard methods for the examination of water and wastewater. 18th edition, American Public Health Association, Washington, D.C. 981 pp. + 6 color plates

Carlander, H. B. 1954. A history of fish and fishing in the Upper Mississippi River. Upper Mississippi River Conservation Committee Special Publication. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

Fremling, C. R., J. L. Rasmussen, R. E. Sparks, S. P. Cobb, C. F. Bryan, and T. O. Claflin. 1989. Mississippi River fisheries: A case history. Pages 309–351 in D. P. Dodge, editor. Proceedings of the International Large River Symposium. Canadian Special Publication of Fisheries and Aquatic Sciences 106. Department

Ickes, B. S. and R. W. Burkhardt. 2002. Evaluation and proposed refinement of the sampling design for the Long Term Resource Monitoring Program's fish component. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, October 2002. LTRMP 2002-T001. 17 pp. + Appendixes A–E. CD-ROM included. (NTIS #PB2003-500042)

Ickes, B.S., Sauer, J.S., and Rogala, J.T., 2014, Monitoring rationale, strategy, issues, and methods: UMRR-EMP LTRMP Fish Component. A program report submitted to the U.S. Army Corps of Engineers' Upper Mississippi River Restoration-Environmental Management Program, Program Report LTRMP 2014–P001a, 29 p., *http://pubs.usgs.gov/mis/ltrmp2014-p001a/*

Korschgen, C. E., L. S. George, and W. L. Green. 1988. Feeding ecology of canvasbacks staging on Pool 7 of the Upper Mississippi River. Pages 237–250 in M. W. Weller, editor. Waterfowl in winter. University of Minnesota Press. Minneapolis.

Patrick, R. 1998. Rivers of the United States. Vol. IV, Part A - The Mississippi River and Tributaries North of St. Louis. Part B. The Mississippi River and Tributaries South of St. Louis. John Wiley and Sons, Inc. New York. pp. 863.U.S. Fish and Wildlife Service. 1980. Habitat Evaluation Procedure (HEP) Manual (102 ESM). U.S. Fish and Wildlife Service, Washington, DC.

Ratcliff, E.N., Gittinger, E.J., O'Hara, T.M., and Ickes, B.S., 2014, Long Term Resource Monitoring Program Procedures: Fish monitoring, 2nd edition. A program report submitted to the U.S. Army Corps of Engineers' Upper Mississippi River Restoration-Environmental Management Program, June 2014. Program Report LTRMP 2014-P001, 88 pp. including Appendixes A–G, http://pubs.usgs.gov/mis/ltrmp2014-p001

Sheaffer, W.A., Nickum, J.G., 1986. Backwater areas as nursery habitats for fishes in Pool 13 of the Upper Mississippi River. Hydrobiologia. Volume 136, Issue 1, pp. 131-139.

Soballe, D. M., and J. R. Fischer. 2004. Long Term Resource Monitoring Program Procedures: Water quality monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, March 2004. LTRMP 2004-T002-1 (Ref. 95-P002-5). 73 pp. + Appendixes A-J.

U.S. Geological Survey (USGS). 1999. Ecological status and trends of the Upper Mississippi River System 1998. A report of the Long Term Resource Monitoring Program. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. LTRMP 99-T001. 236 pp.

Yin, Y., J. S. Winkelman, and H. A. Langrehr. 2000. Long Term Resource Monitoring Program procedures: Aquatic vegetation monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. April 2000. LTRMP 95-P002-7. 8 pp. + Appendixes A–C.

Table 1. Sampling effort within the UMRR Long Term Resource Monitoring Program element and data collected by each component.

Component	Study Area						Summary of data collected[1]
	4	8	13	26	La Grange	Open River	
Aquatic Vegetation	450 stratified random sample sites over growing season.	450 stratified random sample sites over growing season.	450 stratified random sample sites over growing season.	—[2]	—[2]	—[2]	Species, abundance, frequency, distribution, depth, substrate, detritus
Fisheries	~242 samples; 3 periods: June 15–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~262 samples; 3 periods: June 15–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~300 samples; 3 periods: June 15–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~272 samples; 3 periods: June 15–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~390 samples; 3 periods: June 15–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~247 samples; 3 periods: June 15–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	Species; catch-per-effort; length; subsample for weight, age, & diet; secchi; water depth, temperature, velocity, conductivity; vegetation density; substrate; dissolved oxygen
Water Quality	135 stratified random sites sampled in each episode (winter, spring, summer, and fall); 14 fixed sites[3]	150 stratified random sites sampled in each episode (winter, spring, summer, and fall); 19 fixed sites[3]	150 stratified random sites sampled in each episode (winter, spring, summer, and fall); 12 fixed sites[3]	121 stratified random sites sampled in each episode (winter, spring, summer, and fall); 11 fixed sites[3]	135 stratified random sites sampled in each episode (winter, spring, summer, and fall); 11 fixed sites[3]	150 stratified random sites sampled in each episode (winter, spring, summer, and fall); 9 fixed sites[3]	Suspended solids, major plant nutrients, chlorophyll a, silica, pH, secchi, temperature, dissolved oxygen, turbidity, conductivity, vegetation type & density, wave height, depth, current velocity, depth of snow/ice, substrate, phaeophytin, phytoplankton (archived),
Land Cover/Land Use	Land Cover/Land Use digital aerial photography was acquired in 2010-2011 and processed in subsequent years. Systemic land cover data for the Upper Mississippi River System is collected approximately every 10 years. To date, systemic land cover has been mapped three times through the UMRR Long Term Resource Monitoring element, in 1989, 2000, and 2010/2011.						

[1]A full list and explanation of data collected by each component is available through the UMRR LTRM data web site at http://www.umesc.usgs.gov/data_library/other/ltrmp_monitoring.html.
[2]Aquatic vegetation is not sampled in Pool 26 and La Grange because previous sampling revealed very low abundance, or in Open River due to a lack of suitable habitat.
[3]Frequency of fixed site sampling is bi-weekly in April, May, and June, and monthly in all other months, with no sampling in December and February (i.e., winter sampling in January only)

Product Definitions

Draft: A draft that has been submitted to the UMRR LTRM's USGS Science Leader or his designee which is ready for review by USGS, USACE, A-Team, or blind review, as needed. This step begins the process of formal USGS peer-review unless the Science Leader deems the product needs more work by the author(s).

Final draft: A document that the authors have edited based on review comments and has been submitted to the LTRM's USGS Science Leader or his designee.

Intended for Distribution: Indicates a final printed version or Web-based report is awaiting distribution and USGS final approval. For other products (i.e., manuscripts) this indicates submission to a journal. *Staff time is still expended at this stage of the report process.*

Summary Letter: A summary letter is a communication to Corps management and associated staff that provides quick information regarding progress on a project or product. They are often based on preliminary data and analyses, and represent interim information. Summary letters are reviewed internally by UMESC, but do not go through USGS peer review. Thus, they are not citable and should not be widely distributed. Summary letters are used only when a more complete and peer reviewed product is expected after more work on a specific project.

Leveraged Product: A product produced by LTRM staff and others outside of LTRM; may include funding from non-sources.

Donated Product: A product produced by others, without including the LTRM staff and without investment of UMRR funds.