Wisconsin Department of Natural Resources
Office of the Great Lakes
2015 Areas of Concern Grant

Grant Title: St. Louis River Nemadji Projects and Sediment Data Tool

Duration: April 1, 2015 through June 30, 2017

Project Title	Location	Year 1	Year 2	Project Cost	Budget categories	Project duration	Proposal Starts on Page #	Budget Table Page #
Project 1 of 3: Nemadji River Watershed Habitat Assessment using Lidar Data (Remedial Action Plan Project 9-13)	St. Louis River AOC	$100,000	$95,000	$195,000	Contractual - Private contractor(s)	8/1/15 through 6/30/17	2	8
Project 2 of 3: Addressing excess sedimentation impairments in the Nemadji River Basin (Remedial Action Plan Project 6-5)	St. Louis River AOC	$98,905	$35,281	$134,186	Contractual - Private contractor(s); staff salaries, fringe, travel, supplies, indirect	8/1/15 through 6/30/17	10	18
Project 3 of 3: Contaminated Sediment Data ETL Tool Development	St. Louis River AOC	$73,125	$69,870	$142,995	Contractual - Private contractor; supplies	4/1/15 through 6/30/17	20	23
Total		**$272,030**	**$200,151**	**$472,181**				

WDNR Office of the Great Lakes AOC Non-Competitive Grant 2015/16 (Project 1 of 3)

Project Title:	Nemadji River Watershed Habitat Assessment using Lidar Data (Remedial Action Plan Project 9-13)
Project Applicant:	WDNR
Organization name:	Office of the Great Lakes, Wisconsin Department of Natural Resources
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Project Manager:	Molly Wick
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DUNS Number:	NA

Person responsible for reporting: Molly Wick

Project Location: Nemadji River Watershed, St. Louis River Area of Concern

Problem Statement:
This is a two-part project that consists of (A) collecting lidar (Light Detection and Ranging) data, and (B) conducting a GIS-based cumulative watershed stressor and habitat assessment in the Nemadji River watershed. The Nemadji watershed is a tributary to the St. Louis River estuary and located in the St. Louis River Area of Concern. Figure 1 shows the location of the Nemadji River watershed. The Nemadji watershed was identified as a target area for habitat restoration under the Loss of Fish and Wildlife Habitat beneficial use impairment (BUI 9). In addition to 1,700 acres of aquatic habitat restoration and other approaches, the BUI 9 Removal Strategy includes:

- *Protect and rehabilitate additional aquatic or hydrologically connected habitat throughout the AOC watersheds to maintain healthy fish and wildlife populations. Completion of the Management actions at prioritized sites listed in Table 11 and shown on Figure 11 will result in achievement of this criterion.*

This strategy recognizes the vital chemical, biological, and physical connection between the landscape, tributaries, and the St. Louis River estuary itself. This project, aimed at habitats hydrologically connected to the St. Louis River estuary, is Project 9-13 in the 2013 Remedial Action Plan (RAP) Update, Table 11, "Nemadji River watershed - Conduct habitat assessment and evaluation to determine priority locations for conifer restoration, land protection, and AIS control."

The entire Nemadji watershed was included within the St. Louis River Area of Concern due to long-term issues related to excessive sediment. Anthropogenic influences are difficult to distinguish from natural geological influences in this sediment-rich system, but a history of forest clearing and land conversion to agriculture in the early 1900's altered the system's hydrology and exacerbated natural sediment issues. These issues have improved over time with re-conversion back to forests and logging best management practices. The Nemadji Basin Plan

established a goal of less than 40% open lands in subwatersheds (~10 sq mile size). Recent studies have shown that although open lands constitute a much smaller portion of the watershed than in the early 20th century, open lands are increasing in subwatersheds in the Nemadji Basin (WDNR, 2014). Because legacy land use has resulted in degraded habitats in the watershed, our approach will be to identify priority habitat restoration sites based on a range of landscape stressor attributes at a watershed scale. This will be done in GIS using a high-resolution digital elevation model derived from lidar along with other available data. Instead of just looking at habitat needs, we will identify areas where habitat needs overlap with potential for slowing the flow and/or increased storage, which will help reduce cumulative impacts and improve habitat downstream as well.

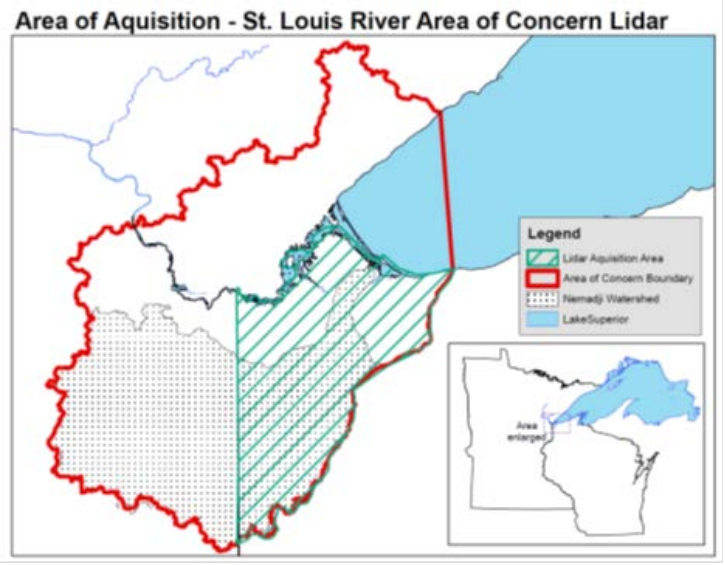

Figure 1: The proposed lidar acquisition area is 308 sq. miles within the St. Louis River Area of Concern.

Project Summary:

A) Lidar Data Collection

Airborne lidar uses light in the form of a pulsed laser to measure the distance from a plane flying over to the surface of the Earth. Lidar generates precise three-dimensional information about the shape of the surface of Earth. The resulting data can used for a very wide range of purposes including but not limited to mapping drainage networks, land uses, road crossings, culverts, erosional features, floodplains, canopy density, biomass, archaeological features, among many other things. For example, biomass estimations based on lidar data can be used to help farmers plan their fields and determine where and how much fertilizer is necessary. In the Duluth area, lidar data is being used to assess the changes in the landscape caused by a 500-year storm and plan climate change adaptation. We will collect lidar data for the Wisconsin portion of the St. Louis River Area of Concern in order to complete coverage for the Area of Concern. We will use the lidar data to identify and prioritize ecological restoration sites in the Nemadji watershed. The collection of lidar data for this project will also allow many other applications, because the dataset will be made publicly available.

B) Analysis: Cumulative Watershed Stressors and Habitat Assessment

This project is designed to identify priority habitat restoration based on a range of landscape stressor attributes at a watershed scale. In order to guide this process, a project planning committee, which will consist of AOC staff and agency resource managers, will convene to provide technical advising for the project. The project planning committee will use expert knowledge to identify specific habitat types and/or species of concern (e.g. Species of Greatest Conservation Need) that will guide the assessment analysis process. The habitat assessment will be designed to identify habitat restoration for those specific habitat types of interest or species of

concern. A cumulative watershed stressor assessment will identify priority in-stream aquatic habitat for restoration, and a watershed-wide habitat assessment will identify priority hydrologically connected habitats for restoration and preservation.

The analysis portion of this project will start with compilation of necessary available datasets. Several additional datasets will then be derived from lidar data or other existing datasets, and are listed under Project Deliverables below. One of the layers to be derived will be a map of existing ditch networks. Many ditches were installed in the watershed during the early 1900's for agriculture and still exist today, although agriculture in the watershed has waned. These ditches effectively increase peak flows and drain wetlands. Ditch networks can be mapped using aerial photos, but this method does not identify forested wetlands which are very prevalent in the highly forested Nemadji watershed. The lidar-derived high-resolution surface model will allow accurate mapping of these historical ditches.

This project will build off of previous work that was done as part of a functional wetland assessment for Douglas County. The work included cataloging attributes of present-day and historical wetlands in order to identify potentially restorable wetlands. This component of the project is important because restoration of natural wetlands has potential to slow runoff and reduce peak flows, as well as provide habitat for many Species of Greatest Conservation Need. The previous work was completed in the Wisconsin portion of the Nemadji watershed, but not in the Minnesota portion. The same analysis, using available corollary datasets, will be completed for the Minnesota portion of the watershed as a component of this project to facilitate complete coverage of the functional wetland assessment for the watershed, which will then be used to help prioritize areas for habitat protection and restoration.

Once existing and derived layers have been compiled, the data layers will be overlaid in order to identify watershed-wide potential habitat restoration and protection sites based on site attributes and on the habitat types and/or species of concern identified by the project planning committee. This process is targeted at hydrologically-connected habitats.

Next, we will identify priority in-stream restoration sites based on cumulative stressors along the stream network. The bare earth model generated from high resolution lidar data will allow us to produce a map showing the amount of area that drains into a given point (known as flow accumulation). Additional layers will then be used to weight the flow accumulation based on landscape attributes. This can be used to identify, for example, the amount of open lands upstream of any given point along the Nemadji. This cumulative type of assessment is more representative of a natural stream system, which responds to the characteristics of the landscape upstream from any given point. These weighted accumulations will then be compiled into a stressor analysis for the stream, which will show the cumulative stressors at any given point on the stream. This type of analysis is not possible without an accurate stream network and flow accumulation layer derived from a high-resolution lidar-derived bare earth model.

Lastly, the watershed-wide habitat assessment and the cumulative stressor assessment will be overlaid and evaluated in order to identify priority sites for habitat restoration/protection which will reduce stressor impacts to the Nemadji River, and improve hydrologically connected and aquatic habitats in the Nemadji River watershed.

Current Status:
Currently lidar is available within a one-mile swath along the southern coast of Lake Superior in Douglas, Bayfield and Ashland counties, and within the city limits of Superior, Wisconsin. Lidar data is also available state-wide in Minnesota, so it is available in the portion of the Nemadji watershed that is in Minnesota. A large portion of the Nemadji watershed (roughly 40%) does not have any lidar coverage. Figure 1 shows the extent of proposed coverage. The collection of this area would facilitate full coverage for the Nemadji River watershed and the St. Louis River Area of Concern.

Previous studies have mapped open lands using photointerpretation of Landsat data within subwatersheds delineated from topographic maps. Using lidar-based methods, we will map open lands significantly more accurately. Open lands will be mapped based on canopy density derived from lidar point clouds, or the "cloud" of points returned to the detector for each laser pulse that hits the surface. This method is less subjective, more consistent, and more accurate than using Landsat data, because it is based on canopy density thresholds instead of manual interpretation and delineation of landsat imagery.

Collaboration and Partnerships:
Many natural resource managers have expressed the need for high resolution lidar for the Lake Superior Basin. Some of the additional uses of lidar data in the AOC and in the region include mapping fish passage barriers, wetland mapping, floodplain mapping, slow the flow efforts, and forestry planning.

The collection of lidar for the Lake Superior Basin in Douglas County was included in a recent proposal by the Wisconsin Coastal Management Program for USGS 3D Elevation Program funding in part due to the need for complete lidar coverage for the St. Louis Area of Concern. The proposal also included coverage in Manitowoc and Bayfield Counties and was submitted in December, 2014. If this proposal is funding, project costs for this proposal may be reduced.

A project planning committee that will be formed to advise this project will include stakeholders, resource managers and experts from many partnering agencies. Potential partners include Lake Superior Research Institute, University of Wisconsin – Superior, Douglas County, West Wisconsin Land Trust, EPA Midcontinent Ecology Division, US Fish and Wildlife Service, NOAA, USGS, Wisconsin Sea Grant, Minnesota DNR, Minnesota Pollution Control Agency, and Minnesota Board of Soil and Water Resources.

Results of the habitat assessment will be made publicly available through a partnership with Douglas County. Douglas County Land Records Department has an online GIS portal which will allow public access to the data produced. The results of the habitat assessment will also be included in the workshops planned to educate forest and land managers as part of a complementary proposal, *Addressing excess sedimentation impairments in the Nemadji River Basin (BUI 6)*. These workshops will occur in Spring, 2017.

Project Goals:
A) Collect lidar data for the Wisconsin portion of the St. Louis River Area of Concern in order to complete coverage for the St. Louis River AOC.

B) Use lidar data along with other available datasets listed below to identify priority habitat restoration sites in the Nemadji watershed based on watershed-wide attributes, a cumulative stressor analysis, and priority habitat types and/or Species of Greatest Conservation Need.

Project Deliverables:

Note that some project deliverables may be adapted based on project planning committee recommendations.

A) Lidar Data

The data collection requirements and deliverables are the same as the USGS Lidar Base Specification Version 1.0 requirements. The LiDAR will be acquired according to USGS Quality Level 2 (QL2) standards. The nominal pulse spacing will be planned for 0.7 meters resulting in a nominal pulse density of 2.0 meters. The vertical accuracy will meet or exceed 9.25 centimeter RSMEz in non-vegetated terrain. Grid deliverables will have a cell size of 3m or smaller. The area to be acquired is shown in Figure 1. The total area to be acquired is 308 square miles. All deliverables will be placed in the public domain. Deliverables include:

a. Classified point cloud, .LAS
b. Breaklines, Shapefile
c. 1' Contours, Shapefile
d. Bare earth Digital Elevation Model (DEM), Grid
e. NSSDA/FEMA accuracy Report, PDF
f. FGDC compliant metadata, .xml format

B) Cumulative Watershed Stressors and Habitat Assessment

a. Geodatabase and Grid of high-resolution Nemadji River Network based on lidar bare earth model. High resolution is defined as <3m cell size.
b. Geodatabase and grid of existing ditch networks in the Area of Concern based on lidar bare earth model and imagery interpretation.
c. Open Space Analysis including:
    i. Grid of canopy density based on lidar point cloud analysis within the Nemadji watershed.
    ii. Grid of open space based on canopy density analysis within the Nemadji watershed.
d. Completion of the Functional Wetland Assessment (FWA) in the Minnesota portion of the watershed, including:
    i. Compile datasets needed for the FWA including existing wetlands data, land use/cover, land ownership, public lands, and any others identified by the planning committee as useful.
    ii. Convert/Refine existing wetlands data to National Wetlands Inventory
    iii. Interpret/Classify Landscape position, Landform, Water flow path, and Waterbody Type (LLWW) for each wetland based on Tiner, 2011.
    iv. Assign wetlands to categories of ecological function based on characteristics defined using both NWI and LLWW codes. Wetland functions to be assessed will be determined by the project planning committee.

v. Spatial modelling using SSURGO soils and derived surface layers (below) to identify areas with hydric soils and areas that have potential for spring and summer ponding and flooding.
vi. Identify potentially restorable wetlands using a predetermined image-interpretation-based method based on available datasets, the above analyses, and discussion with the project planning committee.
vii. The final deliverables for the FWA for the Minnesota portion of the Nemadji watershed include the following:
    i. Geodatabase containing all wetlands and their functional attributes (NWI and LLWW).
    ii. Geodatabase containing potentially restorable wetlands.

e. The following landscape and stream geomorphic characteristic grids will be derived from lidar bare earth model:
    i. Landscape slope
    ii. Aspect
    iii. Watershed position
    iv. Stream slope
    v. Stream sinuosity
    vi. Valley confinement
    vii. Stream Power Index
f. Compilation of the additional relevant existing datasets described for analyses below (includes land use, wetlands, soils, surficial geology, bedrock geology, roads and road density, and any others identified by the project planning committee).
g. Habitat Analysis: Overlay of derived and public datasets (including wetlands, ecological type, soils, geomorphology, landscape and stream geomorphic characteristics) in order to identify watershed-wide habitat restoration potential based on priority habitat types and/or Species of Greatest Conservation Need.
h. Watershed Stressor Analysis: This analysis includes overlaying the following grids to identify cumulative stressors along the stream network: ditch networks, road and road density, wetlands, soils, surficial geology, bedrock geology, landscape and stream geomorhpic characteristics. The deliverables for this analysis include:
    i. Grid and map depicting cumulative watershed stressors along the stream network
    ii. Grid and map depicting priority restoration areas based on watershed stressor analysis.
i. Priority Restoration & Protection Assessment: Overlay of watershed stressors and habitat analysis to identify highest priority areas for restoration and protection. The deliverable for this analysis is a grid and map of Priority Restoration and Protection areas.
j. Final Report with recommendations of priority restoration/protection areas to resource managers, maps and spatial layers (i.e. grids) described above.
k. Conduct pre- and/or post- analysis site visit as needed to verify remote data, photo interpretation, and classification.

l. Attend meetings and & presentation of final analysis to resource managers and AOC coordinators.

Project Coordination, Activities and Timeline:
The WDNR will contract this project out in two parts: lidar acquisition, and GIS analysis. Lidar will be contracted and collected in year one in fall 2015, during leaf-off. Data quality assurance and quality control will then follow, with data delivery to the WDNR by June, 2016. The cumulative watershed stressors and habitat assessment will be conducted using the data deliverables of lidar collection in year two.

Year 1:
- November 2015 – Acquire lidar
- November 2015 – May 2016 – Data Processing and QAQC.

Year 2:
- July 2016 to February 2017 – Watershed Stressor and Habitat Assessment
- March 2017 – Delivery of Watershed Stressor & Habitat Assessment.
- April/May 2017 - Results of Watershed Stressor & Habitat Assessment will be presented at workshops that are part of a complementary proposal, *Addressing excess sedimentation impairments in the Nemadji River Basin*.

Budget

Year 1 - August 1, 2015 – June 30, 2016

Staff salaries	$ 0
Travel	$ 0
Equipment	$ 0
Supplies	$ 0
Contractual	$ 100,000
Other	$ 0
August 1, 2015 – June 30, 2016 TOTAL	**$ 100,000**

Year 2 – July 1, 2016 – March 30, 2017

Staff salaries	$ 0
Travel	$
Software/hardware	$
Supplies	$
Contractual	$ 95,000
Other	$ 0
July 1, 2016 - March 30, 2017 TOTAL	**$ 95,000**
2-Year Project TOTAL	**$ 195,000**

Additional budget detail:
Contractual: Year 1 Contractual is for lidar acquisition for the AOC, and Year 2 Contractual is for the cumulative watershed stressors and habitat assessment analysis.

References

Minnesota Pollution Control Agency (MPCA) and Wisconsin Department of Natural Resources (WDNR). 1992. The St. Louis River System Remedial Action Plan. Stage One. April 1992.

Minnesota Pollution Control Agency (MPCA). 2009. St. Louis River Area of Concern Delisting Targets. Wq-iw1-25. December 2009.

Minnesota Pollution Control Agency (MPCA). St. Louis River Area of Concern Implementation Framework: Roadmap to Delisting (Remedial Action Plan Update), By LimnoTech. St. Paul, Minnesota. July 15, 2013. (http://www.pca.state.mn.us/index.php/view-document.html?gid=19677)

St. Louis River Citizen's Action Committee (SLRCAC). 2002. Lower St. Louis River Habitat Plan. May 2002.

St. Louis River Alliance (SLRA). 2011. Lower St. Louis River Habitat Plan, Appendix 9, Strategies Implementation Planning Worksheets. SLRA Habitat Work Group. January 2011.

Tiner, R. W., 2005. Assessing cumulative loss of wetland functions in the Nanticoke River Watershed using enhanced National Wetlands Inventory data. Wetlands, Vol. 25, No. 2.

Wisconsin Department of Natural Resources (WDNR). 2014. Comparative Analysis of Open Lands in Sub-watersheds in the Wisconsin Portion of the Nemadji River Basin.

WDNR Office of the Great Lakes AOC Non-Competitive Grant 2015/16 (Project 2 of 3)

Project Title:	Addressing excess sedimentation impairments in the Nemadji River Basin (Remedial Action Plan Project 6-5)
Project Applicant:	WDNR
Organization name:	Office of the Great Lakes, Wisconsin Department of Natural Resources
Street/Mailing address:	101 S. Webster St. Madison, WI 53707
Project Manager:	Molly Wick
Phone number:	715-395-6911
Email address:	**molly.wick@wisconsin.gov**
DUNS Number:	NA

Person responsible for reporting: Molly Wick
Project Location: St. Louis River Area of Concern

Problem Statement

The goal of this 2-year project is to assess excess sedimentation impairments in the Nemadji River basin and coordinate implementation planning about the Nemadji Basin Plan. The Nemadji watershed (shown in Figure 1) was included in the St. Louis River Area of Concern (SLRAOC) because of concerns about accelerated erosion and sedimentation due to land use practices dating back to the mid-1800's. The St. Louis River AOC is impaired for excessive loading of sediment and nutrients (Beneficial Use Impairment 6). The goals of the project will be met through collection of biological, water quality, and sediment data, Hydrological Simulation Program-Fortran (HSPF) modelling, and development of workshops to encourage land use planning and "slow the flow" management practices in the Nemadji Watershed.

The Removal Target for the Nemadji watershed under the excessive loading of sediment and nutrients beneficial use impairment (BUI) states (from the SLRAOC Remedial Action Plan 2013 Update):

- *Watershed management objectives for the Nemadji River watershed, as established by the Nemadji Basin Plan (NRCS, 1998), have been adopted and progress towards implementing the objectives is being made.* (MPCA, 2013)

The Nemadji Basin Plan established a goal of less than 40% open lands (young forests, agriculture, and urban) in subwatersheds. This goal was adopted by the 2013 RAP as part of the removal strategy for BUI 6. Recent studies have shown that although open lands constitute a much smaller portion of the watershed than in the early 20th century, open lands are increasing in most subwatersheds in the Nemadji Basin (WDNR, 2009). This could be because forests planted after logging in the late 1800's and early 1900's have matured and are once again ready to be logged. Although forestry practices have improved since then, about 20% of all subwatersheds are not meeting the <40% target, and an increase in open space has been observed in those watersheds between 2002 and 2014. The target is clearly not being met. However, the naturally

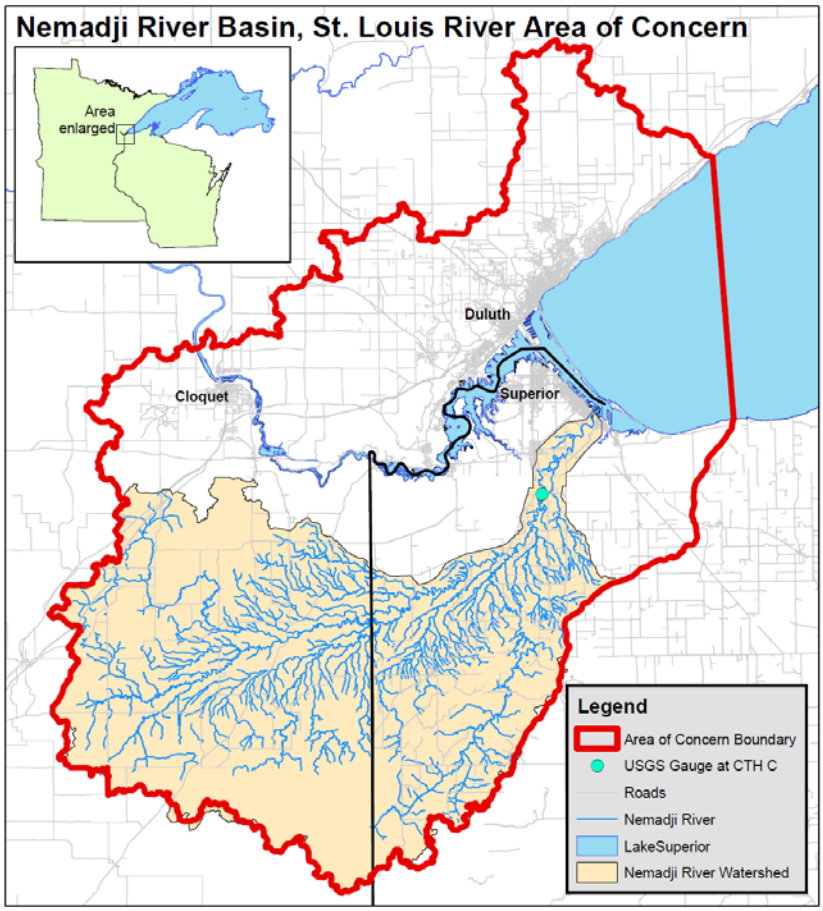

Figure 1: Map of Nemadji River Watershed in the St. Louis River Area of Concern.

high sedimentation rates in the river are difficult to distinguish from anthropogenic influences to sedimentation. This proposal is geared towards accurately assessing the impairment in the watershed and identifying if additional actions in the basin are needed to meet the intent of the BUI 6 Removal Target.

Current Status

The Nemadji watershed is part of the St. Louis River AOC because of accelerated erosion and sedimentation in the watershed due to land use practices dating back to the mid-1800's. The Nemadji Basin is also prone to high sediment loads due to its natural geologic setting. The lower third of the basin is situated in extremely clay-rich glaciolacustrine soils that are prone to erosion and mass wasting. The upper third of the basin is situated in interbedded glacial tills and beach and outwash sands and gravels. A drop in water level of glacial Lake Duluth (present day Lake Superior) after the last glaciation 11,000 years ago resulted in the carving of a deep river valley with steep, erodible clay banks. Abundant perched wetlands exist in the basin's uplands due to the clay-rich soils.

Land use changes in the past two centuries have resulted in hydrologic alterations and accelerated erosion rates. The forested watershed was logged extensively for the dominant white and red pine in the mid- to late-1800's and early 1900's. After much of the watershed was logged, land was subsequently drained and converted to agriculture. In the 1950's, agriculture accounted for 50% of the land use in the basin. Increased water yields during peak agriculture resulted in incision and entrenchment of Nemadji and its tributaries, and disconnection from the floodplain. Riedel et al. (2001) found evidence of channel incision and associated increase in water yield correlated with timber harvesting, extensive forest fires, and large-scale agriculture. Several of the upstream tributaries studied were still actively incising and have yet to create a stable morphology since historic land use changes. Since the mid-1900s, many lands have been converted back to forests. Today, the watershed is approximately 69% forested 18% agriculture, and 11% wetlands and lakes.

Sedimentation issues related to historic land use changes are very difficult to distinguish from normal processes in this naturally sediment-rich system, and an increase in precipitation event intensity due to a changing climate compounds the problem further. Significant data gaps prevent a complete understanding of the basin's impairments. We do not have a record of sediment loading before or during peak land use change, and there is limited sediment loading data available for the system today. The Nemadji Basin Plan estimated the average annual sediment load at the mouth of the Nemadji to be 131,000 tons per year based on data from the early 1970's.

Project Goals:

Assessment goals:

- Verify the status of the sediment loading impairment in the Nemadji River, and verify that progress has been made towards reducing erosion and sedimentation in the Nemadji River Basin by filling major data gaps:
    - Collect biological and water quality data to assess the biological integrity of the system, specifically in downstream reaches, and identify any impacts of the present sedimentation rates on biota in the system.
    - Collect suspended sediment concentration data in order to calibrate existing TSS data and calculate a modern sediment load to determine if sediment loading has improved since the last sediment load was calculated based on 1970's data. (Nemadji Basin Plan - NRCS, 1998).
    - Develop HSPF modeling scenarios to help distinguish anthropogenic impacts from natural sedimentation in the Nemadji River basin and show changes in sediment loading before, during, and since peak logging and agriculture.

Implementation Planning Goals:

- Develop and implement a strategy to promote a watershed-based land use-planning approach to stormwater runoff management. This strategy will include implementation of the Nemadji Basin Plan through coordination of workshops, meetings for stakeholders, and facilitation of a local watershed group. Note that this action meets the intent of the Removal Target for Excessive Loading of the Sediment and Nutrient BUI, as it involves implementation strategies of the Nemadji Basin Plan.

Project Summary:

To help show if historic land use change has had an impact on biota in the system, we will collect biological and water quality monitoring data on the Lower Nemadji. The Nemadji River is listed as impaired for turbidity according to section 303d of the EPA's Clean Water Act in Wisconsin and Minnesota. Previous data collected by the WDNR upstream from CTH C suggest that the Nemadji hosts healthy biological communities. Based on indices of biological integrity (IBIs), all the sites sampled previously had good or excellent fish and macroinvertebrate communities, with the exception of a site on Crawford Creek, which is downstream of a site contaminated with creosote, PAHs and dioxins (Roesler, 2014).

While assessments upstream of CTH C in Wisconsin suggest that the river hosts healthy biological communities, there are very limited data in downstream reaches. The lower reaches might be expected to be most degraded due to the cumulative impacts upstream and the urban influence of the city of Superior, Wisconsin, which is located at the mouth of the Nemadji. We

will collect macroinvertebrate, fish, and water quality data in those downstream reaches to calculate IBIs and determine if biota in the Nemadji River are impaired. Water quality data will be collected to identify potential stressors for biota impairments.

In order to compare modern sediment loads to historic sediment loads in the Nemadji prior to the implementation of the Nemadji Basin Plan, we will collect suspended sediment concentration (SSC) and bedload data at CTH C. The Nemadji Basin Plan previously estimated the average annual sediment load at the mouth of the Nemadji to be 131,000 tons per year based on data from the early 1970's. That estimate relied on the assumption that bedload contributes 3% to the total load, based on limited bedload data also collected in the 1970's for the Red Clay Project using methods not well-suited for the grain size present in the Nemadji (Rose 1980). The Minnesota Pollution Control Agency has collected Total Suspended Sediment (TSS) data at the Nemadji CTH C site since 2009 through the Watershed Pollutant Load Monitoring Network. This dataset includes about 25 samples per year during rain events for six years. Studies of sediment loading by the USGS based on the Knife River in Duluth and other Minnesota streams has shown that load estimates based on TSS data significantly underestimate sediment loads (Ellison et al., 2014). Therefore we will collect SSC data along with modern bedload data (using methods better-suited for the Nemadji River than previously used) in order to calibrate the existing TSS data and estimate an accurate modern sediment load.

Hydrological Simulation Program-Fortran (HSPF) modelling is proposed to help show how the Nemadji Basin has responded to historic land use change. The Minnesota Pollution Control Agency (MPCA) has funded TetraTech to construct a HSPF model for the entire Nemadji Basin. Their process includes three stages: constructing the model, populating the model, and running scenarios. Sediment and water quality data collected will be used to build the model. This project will fund scenario development to investigate sediment loading under pre-settlement conditions, during peak logging and peak agriculture land use, and as present-day sediment loading.

The Removal Target for Excessive Loading of Sediment and Nutrients also includes supporting implementation of the Nemadji Basin Plan. One of the recommendations of the Nemadji Basin Plan was to organize a watershed group to help oversee implementation of other Nemadji Basin Plan recommendations. We propose a two-pronged implementation planning effort which will include coordination of a local stakeholders group and coordination of a local watershed citizens group. Work with the stakeholder group will focus on education about the recommendations of the Nemadji Basin Plan including best management practices for slowing the flow. Work with the watershed group will focus on encouraging watershed stewardship and identifying opportunities for landowners to apply best management practices on their properties.

Project Coordination:

This project consists of three parts, which would be conducted by partnering agencies. Wisconsin DNR Water Resources and Fisheries staff will collect and analyze the biota data and water quality grab samples that are proposed. The WDNR will partner with the US Geological Survey (USGS) to complete sediment monitoring. The DNR will contract with a consulting firm to use the HSPF model constructed for MPCA to model sediment loading during pre-settlement, historic, and modern times. Implementation planning efforts will be contracted by a partnering organization that will work closely with the WDNR, MPCA, MDNR, and other agencies.

Project Activities and Timeline:

Data Collection

All data will be collected during the 2015 season.

Macroinvertebrates:

Currently, the most downstream macroinvertebrate sample from the Nemadji River was collected at CTH W (31.2 mi above the Nemadji River mouth). Additional data is needed for sites further downstream, as these areas are the most impacted by the urban influence of the City of Superior. One standard kick sample will be collected at Finn Road, which is 19.9 miles above the mouth. Five large river Hester Dendy samples will be collected between Finn Rd and the Nemadji River mouth. Macroinvertebrate data will be used to calculate biotic indices to evaluate the health of the system and assess impairments to macroinvertebrate populations in the Lower Nemadji.

Fish:

There has been very limited fish data collected on the lower Nemadji. Management files contain boom and barge electrofishing survey data collected in August 1962 at three locations downstream from CTH C and at one location approximately one-mile upstream from CTH C in May 1952. The surveys note difficulties with electrofishing effectiveness due to fairly deep and turbid water; many fish escaped capture. In order to assess fish populations effectively, fish surveys will include both electrofishing as well as targeted fyke and gill net surveys in a variety of physical aquatic habitat types. Electrofishing surveys will be collected during a consecutive three to four-day period in July or August at five, one-mile segments along the lower Nemadji. Specific sites for fish will be determined in June 2015. Fish survey data will be used to calculate established fish biotic indices to evaluate the health of the system and assess impairments to fish populations in the Lower Nemadji.

Water Chemistry:

Currently, the most downstream water chemistry monitoring for the Nemadji River is from CTH C (11.9 mi above the Nemadji River mouth). Six monthly samples (May – October) will be collected in 2015 at three sites on the lower Nemadji River, at State Hwy 53 (0.7 miles above mouth), at Woodlawn Rd (5.4 miles above mouth), and at CTH C (11.9 miles above mouth). These samples will be analyzed for dissolved oxygen, pH, temperature, conductivity, and transparency in the field, and will be analyzed for TP, DP, TKN, NO3+NO2, NH4, TSS, turbidity, and E.coli in the lab.

Sediment:

The USGS will conduct the sediment monitoring portion of this work. SSC, TSS, and bedload data will be collected at CTH C during 10 events in 2015. This data will be used to calibrate SSC to TSS. This calibration will be used to correct the existing MPCA and WDNR TSS dataset going back to 1998 when the Nemadji Basin Plan was completed, which will then be used, along with USGS CTH C flow data, to estimate a modern sediment load on the Nemadji River. The USGS will also include an assessment of historical sediment and flow data which will be used to help interpret results. The current estimated sediment loads will be compared to those estimated in 1998 based on data from the 1970's by the Nemadji Basin Project in to identify

trends. A final report will verify improvement in sediment loading or identify further needs for sediment reduction and recommendations for the basin.

HSPF Scenario Modelling

This project dovetails with an existing HSPF modeling project in the Nemadji Basin being conducted by MPCA. Model construction is currently funded and in process. Along with existing data, the sediment and water quality data collected as a part of this project will help populate and calibrate the model. After the model is complete, scenarios can be run to investigate a range of different questions with the model. The water quality and sediment data collection described above will be used to refine and calibrate the model, which will occur in mid-2015. Scenario modelling will begin after the model is complete in Fall 2015.

The scenario development will investigate changes in sediment loading based on pre-settlement conditions, based on peak logging and peak agriculture conditions, and based on present-day conditions. Present-day conditions will be used to model modern sediment loads on the river. To model sediment loads before settlement, historic accounts from the first visitors to the region will be compiled and used to estimate land use in the watershed, and available historic data and accounts will be used to make assumptions about other necessary pre-settlement conditions such as precipitation, wetlands, soils, and others. Geomorphic and channel planform changes since pre-settlement will be investigated using the HEC-RAS model and established hydraulic metrics for the Nemadji (Magner & Brooks, 2008). To model peak sediment in the early 1900's, historic data such as Sandborn Fire Insurance maps and other historic maps, along with any available air photos will be used to determine when peak open lands occurred and estimate land use throughout the watershed at that time.

Although these scenarios will require a number of assumptions and estimations where historic data is not available, the output will provide a relative estimation of sediment loading in the past compared to now. This will allow resource managers to determine if sediment loading has been reduced since the early 1900's. A similar modelling effort was completed as part of a larger hydrogeomorphic response study for North Fish Creek near Ashland, Wisconsin. Although the watershed has some distinct differences from the Nemadji, North Fish Creek is also situated in the same red clay deposits as the Nemadji River, and can be used as a typical example of a southern Lake Superior tributary outside of the Area of Concern. Land use modelling results indicated that sediment loads during peak agricultural activity in that watershed were probably 5 times larger than pre-settlement, while modern sediment loads may be double those of pre-settlement (Fitzpatrick et al., 1999). This information gives us a "reference" area for what might be expected outside the AOC.

Implementation Planning Activities:

Implementation of the Nemadji Basin Plan is integral to the Removal Target for the Excessive Loading of Sediment and Nutrients. By conducting the implementation planning activities described below, we will implement the Watershed Organization Recommendation in the Nemadji Basin Plan, which will provide a framework and grow momentum for ongoing and future implementation of other recommendations in the Plan.

At grant award, a watershedcoordinator will be hired. The coordinator will have three main activities which are described in more detail below:

1. Develop an implementation strategy for the Nemadji Basin
2. Develop and coordinate training workshops on watershed-based land use planning tools
3. Convene and coordinate a watershed partner (stakeholder) group
4. Coordinate citizen/landowner watershed implementation activities with MN watershed partners

The coordinator will first develop an implementation strategy for the Nemadji basin. This strategy will include the activities below (coordinating a stakeholder group and watershed group) but may also include other approaches in order to promote a holistic watershed-based approach to managing runoff, reducing sediment loading, and facilitating habitat protection and restoration in the watershed.

The watershed coordinator will bring together a partner/stakeholder group which will consist of landowners, land managers, local government officials, and forest industry representatives who manage land in the watershed. The purpose of this group will be to educate stakeholders and land managers about land use planning approaches to minimize cumulative stressor impacts to streams, and to implement the Nemadji Basin Plan. Information about the history of the impairment in the Nemadji River watershed, best management practices to reduce erosion, sustainable land use planning, watershed planning tools, and potential cost-share opportunities or other project implementation funding will be provided to the group. These efforts will be coordinated with an existing Douglas County watershed-based project to "slow the flow" in Lake Superior basin watersheds in the county utilizing landscape level wetland data. Additionally, this group will provide an opportunity to share and implement the results of a corollary project for BUI 9 (Loss of Fish and Wildlife Habitat), *Nemadji River Watershed Habitat Assessment using Lidar Data*. The results of this project will identify areas that are over or nearing the open lands threshold identified in the Nemadji Basin Plan (NRCS, 1998), and will also identify areas that have high cumulative stressors and are priorities for protection or habitat restoration.

The watershed coordinator will work closely with the Carlton County, Minnesota, to coordinate a watershed group. The coordinator will work with the existing Carleton County coordinator to identify and coordinate implementation activities as identified in the current plans. They will jointly coordinate at least two community events per year focusing on the watershed that will encourage participation of Nemadji River watershed residents in WI and MN.

Implementation Planning Activities Timeline:
Year 1 Activities: Year one work is anticipated to occur August 1, 2015 through June 30, 2016.

- Develop and initiate implementation of a Nemadji River watershed implementation strategy.
- Convene and coordinate a watershed partner/stakeholder group consisting of stakeholders that include riparian landowners, town and county local government officials, county forestry, land and natural resource managers and interested citizens. This will include a minimum of 2-3 meetings.

- Provide 2 training workshops for watershed partner group and interested citizens on Nemadji River Basin water resource issues and how a watershed planning approach can be utilized to assist in addressing these issues.
- Identify potential cost-share opportunities and other funding for implementation of best management practices in the Nemadji watershed.
- Coordinate implementation activities with MN watershed partners.

Year 2 Activities: Year two work is anticipated to occur July 1, 2016 through June 30, 2017.

- Implement watershed-based strategy
- Continue work with watershed partner group to identify areas in watershed that provide the best opportunities for management of water runoff, stabilizing stream banks and reducing erosion through implementation of best management practices. (Minimum 2 - 3 meetings).
- Identify potential cost share and other funding opportunities for implementation of the recommendations of the watershed partner group.
- Coordinate two training workshops for public on watershed-based land use planning approach in Nemadji River watershed.
- Continue to coordinate with MN watershed partners
- Identify next steps for continuing stakeholder group and watershed group beyond this project.

Results – Outputs (deliverables) and Outcomes:

Outputs of this project include the following:

- Biotic indices based on macroinvertebrate data at six sites along the Lower Nemadji River and fish survey data downstream from the Lower Nemadji.
- Water Chemistry Data at 3 sites downstream from CTH C.
- Modern sediment load estimation based on existing and new TSS and SSC data and an updated estimate of bedload at CTC C/mouth of Nemadji.
- Modeled relative sediment loads on the Nemadji for the present day, peak sediment loading in the mid-20th century, and pre-settlement times.
- Coordination of a minimum of 4 partner/stakeholder meetings or workshops to educate land and forest managers on land use planning in order to minimize cumulative watershed stressors.
- Establishment of a watershed group to engage Wisconsin citizens in the Nemadji watershed through a minimum of 4 meetings/events.

Outcomes of this project include the following:

- Understanding of the status of the excessive loading of sediment and nutrients BUI on the Nemadji River.
- Guidance for focusing future restoration and protection efforts, if needed, on the Nemadji River based on water quality data, sediment loading data, and modeled historic sediment loads.
- An implementation plan for the watershed
- Local stakeholders and resource managers with an improved understanding of watershed principles and increased knowledge of watershed stressors.

- A multi-state citizen watershed group which will provide a framework for future stewardship work and implementation in the basin.

Collaboration and Partnerships:

Potential partners making contributions to this project include staff from the Wisconsin DNR, USGS, Lake Superior National Estuarine Research Reserve, MPCA, Minnesota DNR, Carlton County, Douglas County, Fond du Lac Band, West Wisconsin Land Trust, Minnesota Land Trust, EPA Midcontinent Ecology Division, Wisconsin and Minnesota Sea Grant, Lake Superior Coldwater Coalition.

Standard Budget

Year 1 Budget

Staff salaries	$3,204		
Fringe	$774		
Travel	$253		
Equipment	---		
Supplies	$2200		
Contractual	$91,781		
Other	---		
Sub total	$98,212		
Indirect Cost	$693		
August 1, 2015 – June 30, 2016		**TOTAL**	**$98,905**

Year 2 Budget

Staff salaries			
Travel			
Equipment			
Supplies			
Contractual	$35,281		
Other			
July 1, 2016 – June 30, 2017		**TOTAL**	**$35,281**
		PROJECT TOTAL	**$134,186**

Additional budget detail:

Staff Salaries: This includes salaries for a limited term employee to help conduct fish and macroinvertebrate surveys and water quality sampling.

Travel: Includes travel and meal costs to and from sample sites for macroinvertebrate, fish, and water chemistry monitoring.

Supplies: Supplies are included for fish surveys and include minnow traps, gill nets, mini-fyke nets, rope, anchors, stakes, dip nets, boat gas, fish collection tub/tank. DNR Fisheries owns some equipment and supplies, and those in ownership are often used in various watersheds and south shore Lake Superior tributaries; this inter-basin usage requires cleaning and disinfection. The procurement of these supplies will offset time lost to cleaning and disinfection, and allow retention of a dedicated set of equipment and supplies for the Nemadji River and other AOC work.

Contractual: Contractual work includes sediment monitoring which will be carried out by USGS, HSPF modelling, and all implementation planning efforts.

Other: Lab costs for macroinvertebrate and water chemistry analyses are included as other.

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WDNR Office of the Great Lakes AOC Non-Competitive Grant 2015/16 (Project 3 of 3)

Project Title: Contaminated Sediment Data ETL Tool Development

Project Applicant: WDNR
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Street/Mailing address: 101 S. Webster St.
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Project Manager: Kate Barrett
Phone number: 608-266-9238
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Person responsible for quarterly reporting: Kate Barrett

Project Location: Wisconsin portion of the St Louis River AOC

Problem Statement:
Partners working on the St Louis River Area of Concern (SLR AOC) have developed an MS Access database that stores sediment quality data as well as benthic invertebrate community data collected throughout the AOC by various entities. The database not only serves to consolidate data from various partners into one place, but also facilitates making these data comparable across the Area of Concern. The database is an essential component to conducting environmental assessments and identifying potential restoration opportunities with a goal of removing Beneficial Use Impairments (BUIs) and ultimately formally delisting the AOC.

The AOC partners identified adding data from new studies as a top priority for the sediment quality database to avoid a lag between collecting the data and using the data. To address this need, LimnoTech, under contract with MN PCA provided the partners with a template for translating data from new studies into a common flat-file format that would facilitate loading data into the Access Database by LimnoTech.

Prior to translation however, data are expected to be verified and validated by data custodians to ensure data integrity standards are met. These steps along with the data translation process can be very labor intensive without the proper set of tools to guide the process. Additionally, when these steps are performed manually, new errors are often introduced. WDNR will continue to work with their partners to collect sediment samples within their portion of the AOC to further understand the extent and level of contaminated sediments so there is a growing need to develop internal capacity for WDNR to conduct verification, validation and translation of WDNR data for the AOC, to ensure data may be used with confidence and in a timely manner.

Proposed Work:
We seek to hire an IT professional to conduct data verification and data validation on a backlog of studies in the SLR AOC and to transform the data from these studies into a predefined formats so they may be added to Department enterprise Oracle database (SWIMS) and the SLR AOC database (extract, transform, and load processes). The data must be qc'd (verified and validated), and then transformed from the native formats in which they are received, to a format that allows them to be loaded into SWIMS as well as into a flat file format developed for the SLR AOC database. The process is basically an extract, transform, and load (ETL). The native formats may vary depending on the original source.

Through the process of working on the backlog data, the IT professional will develop strategies and solutions for data flow processes and automated tools necessary for DNR staff to perform these steps on future data sets. This work will include developing the necessary referential tables, lookup tables, translation scripts or other automated tools, and documentation as needed, to build WDNR internal capacity. We have relied on incremental grant funding in the past to hire contractors to perform this work without the benefit of building our own capacity to perform these tasks internally. This approach is not sustainable since grant funding is becoming harder to obtain and we need to be able to use these data on a timely basis to conduct site assessments or to develop cleanup objectives for contaminated sites.

DATA VERIFICATION: the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. Data verification applies to activities in the field as well as in the laboratory and evaluates how closely planning documents and procedures were followed during data generation.

- Completeness
- Correctness
- Usability: Comparison to DQO as defined for each study to ensure compliance with method specifications and quality.
- Automated routines to check for completeness and correctness on EDD data
- Checklist for use in manual data verification

DATA VALIDATION: an analyte and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set.

Standard Data Validation Checklist:

- Standards for electronic data deliverables to be used in contracts with labs to ensure future data sets are delivered in a standardized format that support the queries noted below
- Data quality assurance checklist to be used by WDNR staff to ensure quality assurance protocols are met
- Series of MS Access queries that can be run against future datasets to translate to SLR AOC template format. The query functions will include (*not a comprehensive list*):
    - converting reporting units to standard units
    - populating fields with valid values using business rules based on template provided by MPCA contractor
    - flagging lab replicates and field duplicates with appropriate values
    - verifying that reporting limits were met
    - validating upper and lower depth values and that corresponding fields are populated correctly (check ranges, flag NULL, etc)
    - checking and flagging records with invalid NULL or Blank values
    - reformatting tables to fit flat file format provided by MPCA contractor

We propose to hire a database analyst with experience working with contaminated sediment data especially with regard to validation protocols to ensure data quality objectives are met. The contactor should have 3 or more years of experience working with MS Access 2010 and have a depth and breadth of sediment data knowledge to be able to develop the necessary extract, transform and load tools that maintain a high degree of data integrity throughout the process. Contractor should be familiar with a variety of the field's concepts, practices, and procedures to ensure data are comparable with other data maintained and shared by WDNR partners. Reliance on extensive experience and judgment to plan and accomplish goals is essential.

EXTRACT / TRANSFORM / LOAD

Identify potential sources from which we routinely extract contaminated sediment data and assist WDNR staff in developing transformation rules to convert data into format needed for existing databases (Microsoft Access and DNR-developed database – SWIMS), flat file format in MS Excel and share with external partners (i.e. St Louis River AOC Contaminated Sediment Database). Rules should incorporate verification and validation steps to ensure data are properly flagged to inform future end users and track through the data flow process.

Funding will be used to hire a Database Architect 3 level contractor, a category defined in Wisconsin Department of Administration's Vendor Management System, Fieldglass. Tasks include:

- Conduct a thorough assessment of existing data flow processes to identify areas that need to be updated using current technological solutions
- Develop strategies and solutions for data acquisitions (extractions) and data validation and verification processes
- Conduct an evaluation of field data collection devices that will improve staff data collection efforts in the field
- Develop strategies and solutions to improve data collection efforts and to transform data into required formats so they may be uploaded into existing WDNR database management systems
- Clean and transform data on a backlog of studies using industry standards such as U.S. EPA's Chemical Abstract System codes and standard reporting units, so data may be added to SLR AOC Sediment Database. Develop long term solutions for transforming data into SWIMS
- Develop internal data flow process and necessary tools so program staff are able to perform these functions on future data sets. Develop referential tables and lookup tables for compliance with enterprise system domains
- Train staff on the use of tools or software

Timetable:

We expect to bid, interview and hire contractor by April 1, 2015 after which time, he/she will begin work. Projected end of project is December 31, 2016 which assumes contractor will work 20 hours/week.

Deliverables:

- Improved data flow processes resulting from assessment of existing data flow processes
- Backlog of data from studies are successfully imported in to WDNR database management system
- Backlog of data from studies are successfully translated into the St Louis River Sediment Data flat file format
- Suite of referential tables and lookup tables on key fields identified in flat file
- Set of recommendations to improve field data collection efforts
- Automated validation routines (ex: Chemical Abstract System ids cross referenced to Chemical Codes in the data to identify non-compatible ids)
- Set of MS Access queries (or other appropriate formats) that are compatible with MS Access 2010 or higher that may be used to translate future data into flat file format
- Data Quality Assurance Checklist for Electronic Data Deliverables (EDD)
- Documentation on data flow process and User Guide for staff on the use of any tools or software used in the processes.

Collaboration with partners:

None at this time.

Requested Budget Amount: $142,995

We estimate it will take roughly 150 hours per dataset to process in to the required file formats and roughly 450 hours to develop in-house capability and tools for staff to continue these tasks on future datasets. Currently there are eight priority datasets. Budget for contractor is based on rates for a Database Architect level 3, as defined by Wisconsin Department of Administration's Vendor Management System. Budget includes estimated costs to purchase WDNR-approved ETL software.

Summary	**Costs Year 1**	**Cost Year 2**
Personnel/Salaries	0	0
Fringe Benefits	0	0
Travel	0	0
Equipment	0	0
Supplies	$3,000	0
Contract Costs		
Contractor1	$70,125	$69,870
Contractor2	0	0
Contractor3	0	0
Total	0	0
Construction Costs	0	0
Other Costs	0	0
Total Direct Charges	0	0
Indirect Charges	0	0
Total Cost/year	**$73,125**	**$69,870**
2 year TOTAL	**$142,995**	