Sediment Loading Assessment in the Nemadji River Basin
Quality Assurance Project Plan

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Distribution List

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Executive Summary

The Nemadji River was included in the St. Louis River Area of Concern due to sedimentation issues associated with the Excessive Loading of Sediment and Nutrients Beneficial Use Impairment (BUI). In order to assess the influence that sediment loading in the Lower Nemadji River has on the natural communities, U. S. Geological Survey (USGS) staff will collect suspended sediment concentration (SSC),total suspended solids (TSS),and bedload data for the Nemadji River at CTH C. Two types of samples will be collected and compared – grab and composite of a representative cross section. The SSC data along with TSS data will be used to establish a calibration curve for suspended sediment in the Nemadji River. The calibration curve along with an existing data that contains 7 years of TSS data collected at CTH C will allow USGS to calculate a modern sediment load for the Nemadji. The modern sediment load can then be compared with historical sediment loads that were calculated for the river using both combinations of SSC/cross-sectional and depth integrated composite and TSS/grab to evaluate if sediment loading in the Nemadji has changed through time.

A. Project Organization

Molly Wick, Project Coordinator, WDNR (2015)
Matt Steiger, AOC and Project Coordinator (following

- Project and QAPP coordination

Donalea Dinsmore, Quality Assurance Coordinator, WDNR

- Review and approved Quality Assurance Project Plan
- Perform project audits as necessary

Faith Fitzpatrick, Principal Investigator, USGS

- Lead scientist
- Review and analyze data
- Write final report

Joseph Schuler, Lead Hydrologic Technician, USGS

- Perform data collection in the field
- Coauthor Final Report

Scott (Nathan) Hagar, Hydrologic Technician, USGS

- Perform data collection in the field

Lucas, Hydrologic Technician, USGS

- Perform data collection in the field

Troy Rutter, Hydrologist, USGS

- Compile and calculate loads
- Coauthor final report

Project Location

The project location is the Nemadji River, with a 1,130 km^2 watershed that drains to Allouez Bay in Lake Superior. The entire Nemadji watershed was included in the St. Louis River Area of Concern due to excessive sedimentation observed in the river (See Fig. 1). The lower portion of the Nemadji watershed is situated in extremely clay-rich glaciolacustrine soils (Lake Superior Red Clay Plain) that are naturally 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. Land use changes in the past two centuries have resulted in hydrologic alterations and accelerated erosion rates in similar rivers in Wisconsin situated in the Red Clay Plain (e.g. Fitzpatrick et al 1999, Fitzpatrick and Knox 2000). The Nemadji watershed was logged extensively in the late 1800's and early 1900's, and 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). 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.

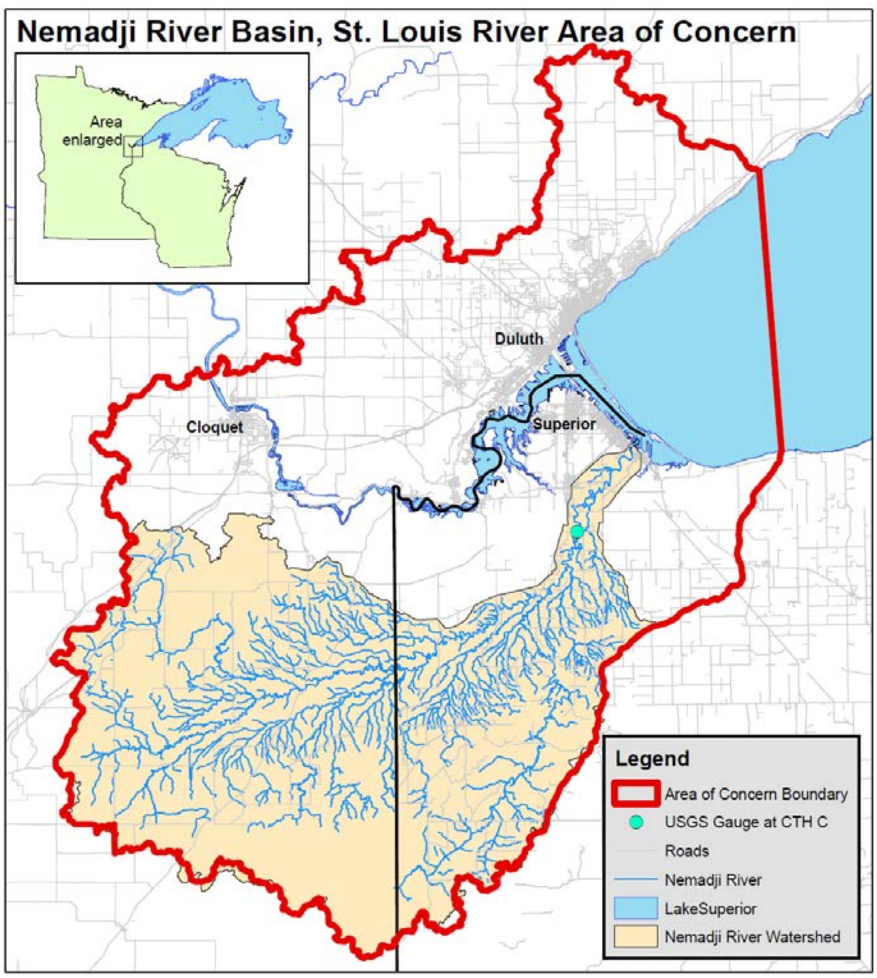

Figure 1: Map of Nemadji River Watershed in the St. Louis River Area of Concern.

Problem Definition

Significant data gaps prevent a complete understanding of the Nemadji River basin's impairments related to sediment. The Nemadji Basin Plan (NRCS 1998 and Robertson, 1996) estimated the average annual sediment load at the mouth of the Nemadji to be about 130,000 tons based on suspended sediment data collected at a USGS streamflow gauge on the Nemadji from the early 1970's, and flow data through the late 1990's. Since that data has been collected, land use patterns have changed, and the size of frequent and infrequent floods has also changed significantly (Fig. 2). However, a modern suspended sediment load and bedload have not been calculated.

The US Geological Survey (USGS) will collect suspended sediment concentration (SSC) and bedload data, develop a sediment/discharge rating curve, review historical sediment data, and provide a report summarizing modern average sediment loads on the Nemadji River compared to historical loads. A modern ongoing suspended sediment dataset collected by the Minnesota Pollution Control Agency (MPCA) includes 6 years of event-based total suspended solids (TSS) sampling with approximately 25 samples each year. However, suspended sediment loads based on TSS data are likely underestimating the actual suspended sediment load (Ellison et al., 2014). In order to be able to use the contemporary TSS dataset, the USGS will collect suspended sediment concentration data and develop a calibration relation with TSS data and calculate a modern suspended sediment load as well as bedload and total sediment load. These modern loads can be compared to previous loads calculated in the 1990's in the Nemadji Basin Plan using sediment monitoring data from the 1970's (NRCS 1998). The results from the comparison will be used to identify if sediment loading is increasing, decreasing, or similar to the late 1900's.

Additionally, turbidity and transparency data will be collected in order to develop rating curves with these parameters and suspended & bedload. Suspended sediment loads may also be compared to backscatter data from acoustic Doppler current profile (ADCP) measurements of velocity and discharge. The development of these rating curves will allow managers to collect simple, inexpensive data in the future and use it to calculate total sediment loads. The ability to do this will allow managers to continue monitoring of sediment loading in the in basin in the future if necessary, as well as allow managers to evaluate success of future projects before and after implementation.

This project is part of a larger assessment of the Excessive Loading of Sediment and Nutrients Beneficial Use Impairment in the Nemadji watershed, funded by the USEPA in 2015, which also includes evaluation of macroinvertebrate and fish communities in the Lower Nemadji River and modeling historic sediment loading scenarios.

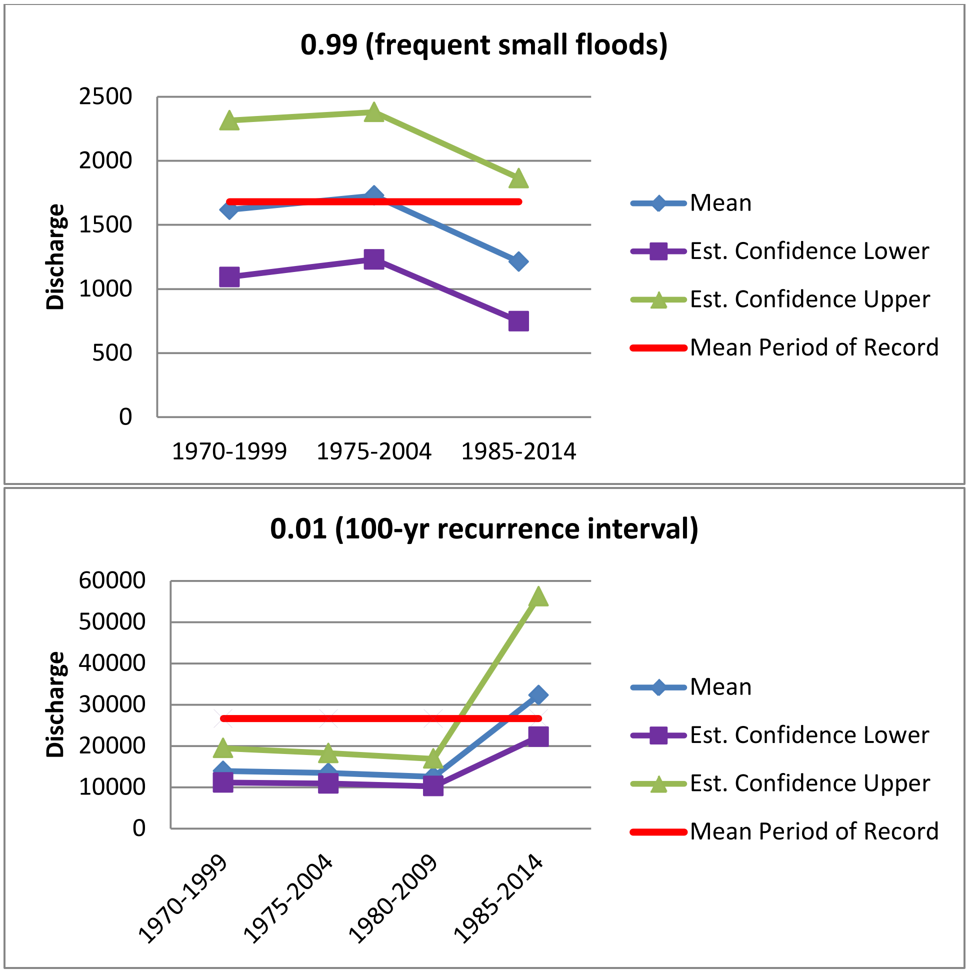

Figure 2: Trends in 30-yr moving averages of flood frequency characteristics for Nemadji River near South Superior, WI USGS ID 04024430 for frequent small floods and floods with a 1 percent probability of occurring in any given year. The decrease in the size of small frequent floods for the 1985-2014 period compared to previous periods reflects a regional drought conditions. The increase in the size of floods with a 1% probability for the same period is affected by the extreme flooding that happened in the Duluth area in 2012 (Czuba et al., 2012).

Project Data Quality Objectives

DQO 1 Calculate the modern total sediment load for the Nemadji River

- Develop a calibration relation between TSS and SSC data for Nemadji River
- Develop a sediment/discharge rating curve for Nemadji River
- Calculate modern suspended sediment load for the Nemadji River
- Calculate modern bed load for Nemadji River
- Calculate total sediment load for Nemadji River

DQO 2 Compare modern sediment loads on Nemadji River to historical loads and identify if sediment loading is increasing, decreasing, or similar to the late 1900’s.

DQO 3 Develop rating curves for suspended sediment concentration and particle size and bedload with

- Turbidity
- Transparency (secchi disk tube)
- Possibly Acoustic Doppler current profiler (ADCP)

The main data user for the data generated will be water resource managers within the DNR. Data representativeness, comparability, completeness, precision, and accuracy are each a part of the data quality objectives that must be considered during the project planning stages and during data assessment.

Data Representativeness

Representativeness expresses the degree to which sample data accurately represent the site, specific matrices, and parameter variations at a sampling point. Representativeness is a qualitative parameter which is dependent on both the proper design of the sampling program, proper selection of laboratory methods, and stability of the laboratory methods. The representativeness criterion is best satisfied by making certain that the sampling locations, procedures and quantities are selected based on the project objectives, that suitable analytical procedures are utilized, and that holding times are not exceeded.

The sampling site is located at CTH C, where an existing stream flow gage is located (USGS ID 04024430). This location was chosen in order to maximize the proximity to the mouth of the Nemadji while minimizing confounding effects of the seiche. The site is located downstream of major tributaries, and has a very narrow watershed area downstream (See Fig. 1), so sediment measurements taken at this site will representative approximately the sediment load delivered to the mouth of the river. However, because the site is located 11.9 miles upstream from the mouth, the effects of the seiche on measured suspended and bed loads will be minimal.

For suspended sediment and bedload sampling, the equal-width increment (EWI) equal transit rate (ETR) method will be used. The samples are collected at multiple verticals across a channel cross section, and the composite sample is an integration of the horizontal and vertical variability that naturally occurs across the channel. Therefore the composite sample represents the sediment carried by the entire river, not just a portion of the river. It is especially important to use EWI-depth integrating techniques in streams with a high sand load because of the potentially uneven vertical and horizontal distribution of fine sand through the water column. The bed material sampling will be done at a subset of the intervals used for suspended sediment/bedload sampling. These methods will ensure that results are representative of the entire cross section.

Sediment data can be highly influenced by local and temporal environmental factors. The data collected during this project will be representative of the conditions of the Nemadji River during the time of sampling (2015 field season). The TSS-SSC correlations and the sediment load calculated will be considered representative of a “modern” range of flow conditions, meaning the average flow conditions in 2015 $\pm$ 5 years.

Comparability

Comparability expresses the confidence with which one data set can be compared with another. Comparability is defined as similarity of chemical or physical results from different batches of samples or different sampling events. Sample data may be compared with other measurement data if consistent documented analytical procedures are used for similar samples and sampling methods and conditions.

The location of the sampling site is the same as it was for the sediment load calculated for the late 1900’s, so that we can compare the sediment load calculated then to this one.

Methods used to calculate sediment loads have improved since the 1990’s, so the methods used here while similar, are slightly different. The bedload was measured using a Helley-Smith sampler which is not recommended by the USGS where the median diameter of bed material is less than 0.5 mm, and median diameter of the bed material at the study sites ranged from 0.34 to 1.8 mm (Rose, 1980). Here, a BL-84 sampler will be used, which has a nozzle expansion ratio of 1.4, which helps reduce an oversampling of sand problem observed with an older model Helley-Smith with a nozzle expansion ratio of 2.33 (Edwards and Glysson, 1999). These changes will be documented and considered in the final report when comparing the results of this study to previous studies.

Completeness

Completeness is defined as the percentage of measurements or amount of data required in order to make water quality management decisions. The completeness goal is that all data necessary to meet the data quality objectives above is collected. Completeness of the deliverable will be measured for each set of data received by dividing the number of valid (passing QA/QC requirements) measurements actually obtained by the number of measurements made. Completeness has been set at 90 %.

This empirical determination of completeness still does not answer the question as to whether or not all data necessary will be generated in order to adequately meet the objectives above. One consideration to ensure completeness is confirming all sediment carried is sampled. This study includes collection of suspended sediment, bedload sediment, and bed material. Another consideration for completeness is sampling a broad range of rain events throughout the field season from snowmelt to the end of the water year. This should result in an adequate dataset to develop sediment relationships. Because the start of this study was pushed back to July 1st, 2015, additional sampling during snowmelt in April 2016 is included. At the end of the first season, the range of events will be assessed. If it is determined that the sampling has not been done during an adequate range of precipitation events, additional data collection (in addition to snowmelt) in 2016 will be considered and added if necessary as the budget allows.

Precision

Precision is a measure of the degree to which two or more measurements are in agreement. Precision measures the reproducibility of measurements under a given set of conditions. Field precision (variance) is assessed through the collection and measurement of field replicates. There will be one field replicate collected for this study.

Accuracy

Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy measures the bias of the measurement system. Sources of this error are the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analysis. Accuracy in the field is assessed through the adherence to all sample handling, preservation, and holding times.

The Kentucky Sediment Lab has standard procedures for laboratory quality control, which are found in the *Quality-Assurance Plan for the Analysis of Fluvial Sediment by the U.S. Geological Survey Kentucky Water Science Center Sediment Laboratory* (Shreve & Downs, 2005). Table 1 below shows the control limits that will be applied to the analyses.

Table 1. MINIMUM DETECTION-LIMIT AND ACCURACY CRITERIA FOR SEDIMENT LABORATORY ANALYSES			
[µS /cm. microsiemens per centimeter at 25 degrees Celsius; >, greater than; mg/L, milligrams per liter; NTU, nephelometric turbidity units]			
Measured property	**Type of analysis**	**Accuracy criterion (percent)**	**Detection limit**
Sediment concentration	Filtration 0-50 mg/L	15	0.5 mg/L
	Filtration >50 mg/L	5	0.5 mg/L
Particle-size distribution	Pipet	5	(1)
	Visual accumulation tube	5	(2)
	Sieve	5	(2)
Turbidity	Nephelometric	10	0.1 NTU
Specific conductance	Electrometric		Not applicable
	10-100µS /cm	5	
	> 100µS /cm	2	
(1) Silt-clay concentration must be at least 1,000 milligrams per liter. (2) Mass of sand must be at least 0.05 gram.			

Task Description and Schedule

More detailed information on specific tasks can be found below under Sample Process Design.

- A QAPP will be completed by WDNR Staff with assistance from USGS Staff in May - June 2015.
- Sediment Sampling during 10 events: July 2015 –July 2016
    - Suspended Sediment Concentration
    - Bedload
    - Bed material
    - TSS (usually by MPCA), turbidity, transparency, temperature,
    - Ancillary acoustic data related to sediment surrogate development
- Develop Sediment Transport Relations: June - December 2016
    - Suspended, Bedload, Total Load
    - Calculate annual and event loads
    - Review historical relations
    - Quantitatively and qualitatively compare shifts in relations
    - Develop relation between SSC and TSS
    - Modern sediment load and comparison to historic load calculated in Nemadji Basin Plan
    - Comparison of modern bedloads to historic bedloads with assessment of different bedload monitoring methods in order to better interpret historic data.

- Describe any differences in loads in terms of possible variations in climatic patterns, using context from regional and Lake Superior streamflow trends (Fitzpatrick and others, in prep), analyses of floods for the period of record at the Nemadji gage.

Personnel, Special Training Requirements or Certifications

Prior to any work-related effort, all staff will be trained in sampling techniques by experienced personnel. All project personnel will also have met program safety training requirements.

The U.S. Geological Survey Kentucky Water Science Center Sediment Laboratory provides primary analytical laboratory support to USGS.

Documentation and Records/Data Management

Data management will be carried out through USGS standard protocols (Shreve and Downs, 2005). Data will be reviewed by USGS staff for potential outliers and other possible problems. A final report summarizing results will be produced by the PI.

Data will be stored in the USGS National Water Information System and available to the public in 2017. All data will be transferred to and stored on DNR computers. Data will be entered into WDNR's SWIMS database.

B. Measurement/Data Acquisition

Sample Process Design (Experimental Design) & Methods

Sediment samples will be collected by the USGS at the existing USGS streamflow gauge (USGS ID 04024430, See Figure 1) along with ongoing discharge measurements that are made during approximately 10 runoff events from July 2015 through July 2016. Discharge measurements are routinely collected as part of existing funding from Wisconsin Department of Natural Resources and the USGS Cooperative Water Program to run the realtime streamflow gauge (http://waterdata.usgs.gov/usa/nwis/uv?site_no=04024430). During each sampling, suspended sediment, bedload, and bed material samples will be collected using standard methods in Edwards and Glysson (1999). Samples will be analyzed at the USGS Kentucky Water Science Center Sediment Lab. For more information about analysis see *Analytical and Data Analysis Requirements* below.

Suspended Sediment Concentration

For suspended sediment sampling, the equal-width increment (EWI) equal transit rate (ETR) method is used with a depth-integrating model D-74 sampler (Fig. 3). Water is collected at multiple verticals across a channel cross section and at the Nemadji gauge the distance between verticals will be about 5 ft for about 15-20 total verticals). The composite sample is an integration of the horizontal and vertical variability that naturally occurs across the channel, and therefore represents the sediment carried by the entire river, not just a portion of the river. It is especially important to use EWI-depth integrating techniques in streams with a high sand load because of the potentially uneven vertical and horizontal distribution of fine sand through the water column depending on the particle size shown in Figure 4.

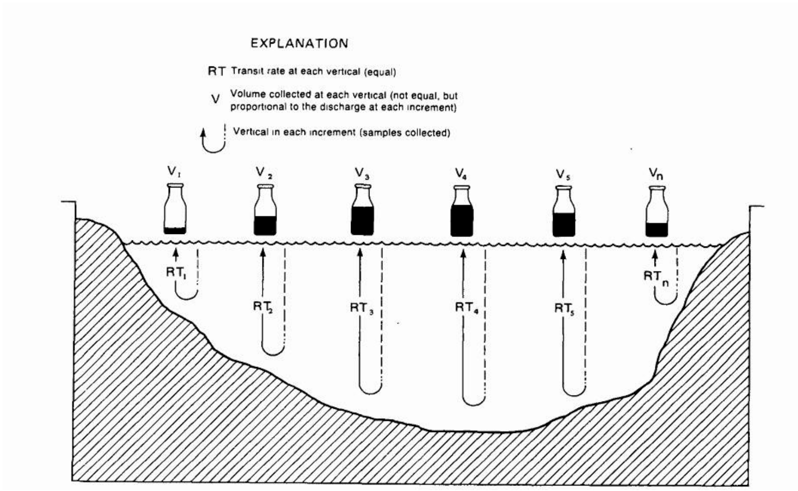

Figure 3: Example of Equal Width Increment equal transit rate (Edwards and Glysson, 1999).

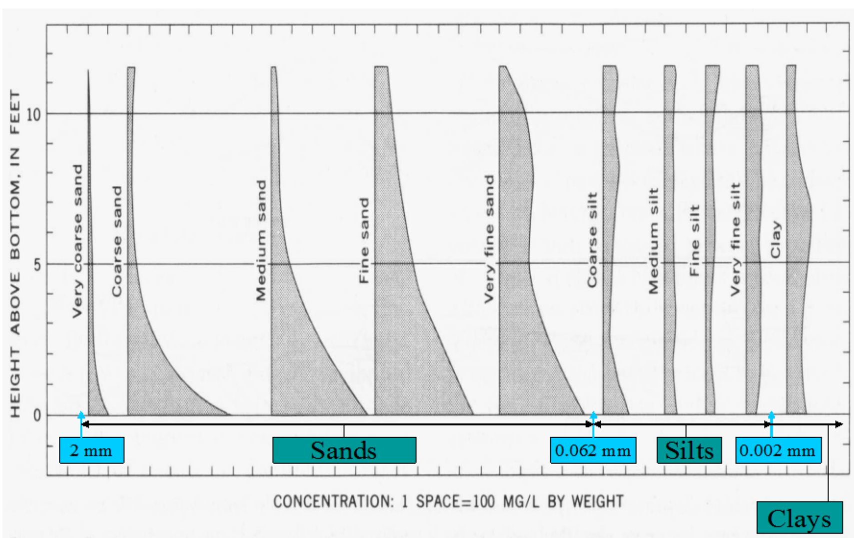

Figure 7.—Discharge-weighted concentration of suspended sediment for different particle-size groups at a sampling vertical in the Missouri River at Kansas City, Mo.

Figure 4: Discharge-weighted concentration of suspended sediment for different particle-size groups at a sampling vertical in the Missouri River at Kansas City, MO (Guy, 1969).

There is an un-sampled zone near the bed that is not sampled by the depth-integrating suspended sediment samplers, usually in the range of 10 cm (Fig. 5). Some of this zone is captured by the bedload sampler.

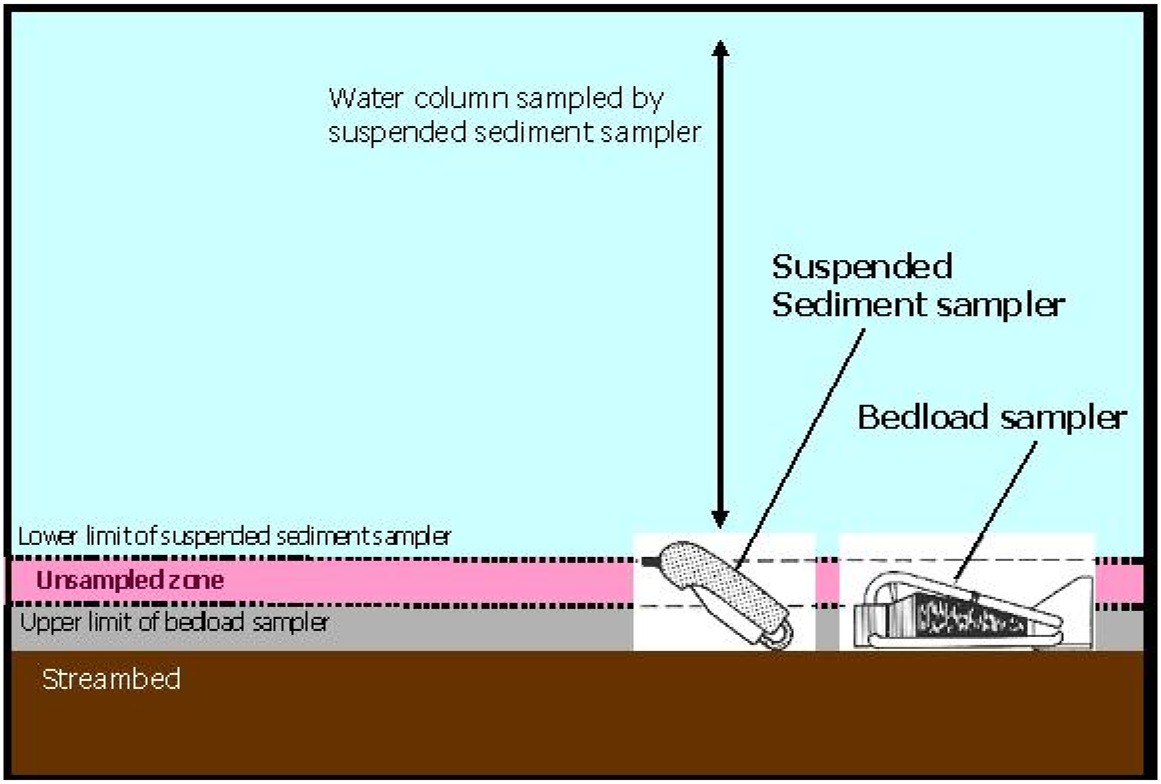

Figure 5: Diagram showing the sampling zone for suspended and bedload samplers.

Detailed methods for collected suspended sediment samples are as follows:

a. Insert clean pint bottle into sampler and check to make sure that nozzle and air exhaust are clean.
b. Lower the sampler into the water. (Make sure the sampler is oriented to the flow before lowering nozzle below water surface.)
c. Traverse the full depth and return to the surface with a constant transit rate. Immediately reverse the sampler when the sampler touches the bottom. Make sure to use the same rate at all verticals. Test deepest/fastest vertical first to make sure transit rate is not too fast or slow. The sampler can be lowered more slowly than raised, as long as the same lowering/raising rates are used at all the verticals.
d. A bottle can be used for more than one vertical but be sure not to overfill. Overfilled means the water surface in the bottle is above the nozzle or air exhaust (see Fig. 6). If the bottle is overfilled, discard the sample and redo all the verticals included in that bottle.
e. Glass pint bottles can be composited into larger plastic jar, being sure to remove all material from the pint bottles. It is of utmost importance that no water is lost from this transfer process.

f. Label composite bottle(s) with site, date, and mean time. Mark water line on bottles with grease pencil. Make sure lid is tight (secure with lab labeling tape or electrical tape) and put in ziploc bag for extra insurance if needed.

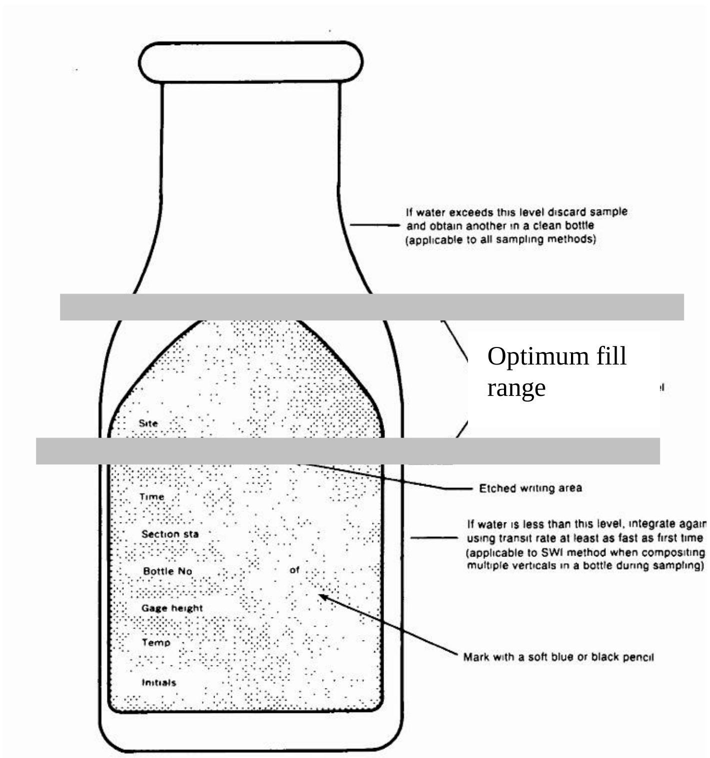

Figure 6. Example of filling of pint water bottles for suspended sediment samples (from Edwards and Glysson, 1999)

The SSC samples will be used to calibrate the TSS samples collected simultaneously by the USGS at a single point and depth in the cross section, replicating field methods used by MPCA. The USGS and MPCA will try to coordinate to the extent possible to collect SSC samples at the same time as the MPCA collects TSS samples; however, if the coordination of sampling is not possible, the USGS will collect a grab sample using a weighted open-bottle sampler. The USGS will collect the sample from approximately 0.3 to 1 m below the water surface in the centroid of flow, depending on the total flow depth.

Bedload Sampling

Bedload samples will be collected with a BL-84 sampler, which has a nozzle expansion ratio of 1.4 (which helps reduce an oversampling of sand problem observed with an older model Helley-Smith with a nozzle expansion ratio of 2.33) (Edwards and Glysson, 1999). Bedload samples will be collected at the same verticals as the suspended sediment samples. The single equal-width-increment (SEWI) method is used (Edwards and Glysson, 1999). A sample bag mesh size of 0.25 mm will be used. Mesh size will be recorded in field notes. A tetherline/stayline will be used to help secure the position of the sampler on the bottom, if needed. Care will be used to position the sampler on the bottom without dropping it or digging it into the bottom, or having it skewed by rocks or large wood. Sampling times per vertical are usually 30 seconds. The sampler is raised carefully so that no sediment is lost out the nozzle. The mesh sampling bag is emptied when about half full otherwise it may become clogged. Samples are composed into containers. Two passes at the transect are done. Bedload samples are transferred from a large tub, tray, or bowl into plastic containers with tight fitting lids. Containers are labelled and put into sealable plastic bags. The bedload sampling techniques are more exploratory, are potentially more problematic, and more dependent on site conditions than the suspended sediment techniques. Bedload samples will be dried, weighed and sieved at the U.S. Geological Survey WI Water Science Center preparatory laboratory using techniques in Edwards and Glysson (1999) and Guy (1969).

Bed Material

Bed material samples will be collected using a BMH-54 and BMH-60 for a subset of 5 verticals used for the suspended and bedload samples using techniques in Edwards and Glysson (1999). Samples from each vertical will be kept separate and analyzed for particle size (full sand/gravel sieving and sand/fine determinations) at the USGS I Water Science Center preparatory laboratory using techniques in Edwards and Glysson (1999) and Guy (1969).

Additional Data Collection

At the same time the sediment samples are collected field measurements of water temperature, transparency (100-cm Secchi disk tube), and turbidity (portable turbidimeter) will be made by USGS staff.

In addition to turbidity, additional ancillary data collected during the simultaneous discharge measurement with an acoustic Doppler current profiler can be used to develop surrogates for suspended sediment concentration and particle size and bedload. Specifically acoustic backscatter from the ADCP can be used to develop rating curves for suspended sediment concentration and particle size (Gray and Gartner, 2009). Moving bed tests (2 loops) will be done to begin to develop a surrogate relation between bed velocity and bed-load transport rates (Gray et al., 2010). Ancillary data for the ADCP discharge data are available for historical discharge measurements as well as future discharge measurements.

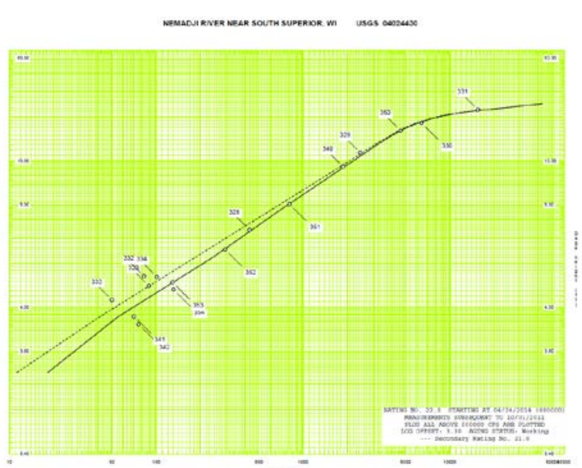

Figure 7. Example of one stage shift from the Nemadji gage.

All equipment and gear used in waterbodies outside of the Nemadji River shall be decontaminated according to WDNR protocols prior to and following use in the Nemadji River (Manual Code 9183.1 Boat, Gear, and Equipment Decontamination Protocols; WDNR Best Management Practices for Boat, Gear, and Equipment Decontamination, April 2015).

Analytical and Data Analysis Requirements

Samples will be handled and shipped to the USGS Kentucky Water Science Center Sediment Lab according to the protocols specified by the Sediment Lab. The combined time for sample storage at the field and consolidation sites should not exceed 120 days.

All suspended sediment analyses will be conducted by the US Geological Survey Kentucky Water Science Center Sediment Laboratory according to the standard lab protocols described in Quality-Assurance Plan for the Analysis of Fluvial Sediment by the U.S. Geological Survey Kentucky Water Science Center Sediment Laboratory (Shreve, E.A. and Downs, A.C., 2005).

Suspended Sediment Concentration

The SSC samples will be composited into a single sample for the cross section and analyzed for suspended-sediment concentration and particle-size determinations at the Kentucky Water Science Center Sediment Laboratory using standard methods (Guy, 1969) and under a quality assurance plan (Shreve and Downs, 2005). The exact particle size determination used will depend on the concentration of the sediment and the minimum amount needed for analyses.

The instantaneous discharge at the time of sampling will be used with the results from the suspended sediment concentration analyses to calculate an instantaneous daily suspended sediment load (tons/day). These daily loads will be used to develop a load/discharge regression relation, which will be used, along with mean daily streamflow data, to calculate an annual suspended sediment load (Guy, 1969).

Bedload

The composited bedload samples will be dried at 105 deg C, weighed, and sieved for sand and gravel sizes at the USGS Kentucky Sediment Laboratory or the Wisconsin Water Science Center to obtain bedload mass and sand and larger particle sizes.

For calculating bedload, the “total cross-section method” is used (Edwards and Glysson, 1999). This method requires that (1) the sample times at each vertical are equal, (2) the verticals were evenly spaced across the cross section, and (3) the first sample was collected at ½ the sample width from the starting bank or edge with active bedload transport. These requirements are met with the sample collection methods used in the Nemadji. The following formula is used to calculate bedload:

$$Q_B = K*(W_T/t_T)*M_T$$

Q_B = bedload discharge, as measured by bedload sampler, in tons per day;
W_T = total width of stream from which samples were collected, in feet, and is equal to the increment width (W_i) times *n* (*n* = total number of vertical samples);
t_T = total time the sampler was on the bed, in seconds, computed by multiplying the individual sample time by *n*:

M_T = total mass of sample collected from all verticals sampled in the cross section, in grams; and
K = 0.381 = conversion factor for a 3-inch nozzle (BLH-84).

Example of a bedload calculation from a small sandbed stream in west-central Wisconsin:

W_T = 2.8 ft
n = 11 verticals
t_T = 11 * 20 = 220 seconds (sampler was left on the bed for 20 seconds at each vertical)
M_T = 20 g

Q_B = 0.381 * (2.8/220)*20 = 0.09 tons/day = 175 lbs/day

Bed Material
Bed material samples from each vertical will be kept separate and analyzed for particle size (full sand/gravel sieving and sand/fine determinations) at the USGS Kentucky Water Science Center or WI Water Science Center (Guy, 1969). These data will be used, along with the suspended sediment concentration data to estimate a total sediment load using the Modified Einstein Procedure (Einstein, 1950; Colby and Hembree, 1955; http://ponce.sdsu.edu/onlinemodifiedeinstein.php)

Additional Data Analysis
Additional data analyses methods by USGS staff will include a review of historical concentration and load data. The historical data will be compared to the data collected during this study. A statistical comparison will be done for the suspended sediment rating curves. Additional statistical procedures will be done if possible for total sediment loads and bedload but there will likely be too little data to complete more than a qualitative visual comparison. Results of this analysis will show trends and will be used to direct future data collection needs or management actions needed, and will meet the data quality objectives defined above.

Lastly, the historical record of stage discharge rating shifts for the USGS gaging station will be analyzed for channel bed elevation changes related to large waves of sand that pass through the channel following major events or upstream landslides using methods in Juracek and Fitzpatrick (2009). Significant shifts have been observed in the Nemadji River gaging station record (Fig. 7). This will be used to identify potential changes.

Quality Control Requirements
In general, quality control measures for all types of sampling for this project will include following standard USGS protocol during sampling, choosing suitable analytical procedures, and following all standard laboratory protocols and QC procedures. This will allow comparison of this dataset with other datasets with consistent documented sampling methods and conditions and analytical procedures. The USGS has well-defined standard protocols for sediment sampling as cited under the methods above that will be followed during this project. The USGS Kentucky Sediment Lab operates under a Quality Assurance Plan (Shreve and Downs, 2005). The USGS Kentucky Sediment Lab participates in the Sediment Laboratory Quality Assurance Project in order to ensure that the physical sediment data produced or used by the USGS are of a known quality and are sufficient to provide long-term comparability and consistency on a national basis. Results from the SLQA studies may be used to assess variability in environmental data and to improve laboratory performance.

Data collected will be reviewed by the Kentucky Sediment Lab as per standard QC protocol. Data will be again reviewed for outliers or other irregular data by USGS staff prior to data analysis.

C. Assessment/Oversight and Data Validation

Reports to Management

The WDNR project manager is responsible for quarterly reporting for this grant to the EPA. Quarterly reports will be entered into the SWIMS project by the 15th of the month following the end of the quarter.

A final report will be produced by the PI with assistance from USGS staff. The final report will include the following:

- Modern sediment load and comparison to historic load calculated in Nemadji Basin Plan
- Comparison of modern bedloads to historic bedloads with assessment of different bedload monitoring methods in order to better interpret historic data.
- Describe any differences in loads in terms of possible variations in climatic patterns, using context from regional and Lake Superior streamflow trends (Fitzpatrick and others, in prep), analyses of floods for the period of record at the Nemadji gage.

This report will be used to inform and direct future management actions related to the Excessive Loading of Sediment and Nutrients beneficial use impairment on the Nemadji River in the St. Louis River Area of Concern.

Data Review, Validation, or Verification

During sediment sampling, field staff will assess efforts to ensure data is collected as described in the Quality Assurance Project Plan. If sediment samples are not able to be collected using the methods outlined here, field methods will be modified. The experienced USGS staff hydrologists will use their expert discretion to adapt field methods as necessary to complete surveys. Any changes to the methods outlined here will be documented in field notes and included in the final report.

After data is collected and analyzed, the PI will review data to determine whether there are potential problems with the data. If there are problems with the data, corrective action will be taken. Samples may be re-analyzed samples if necessary and possible. If problems necessary, re-sampling will be considered and completed as needed.

Reconciliation with Data Quality Objectives

The data quality objectives are as follows:

DQO 1 Calculate the modern total sediment load for the Nemadji River

- Develop a calibration relation between TSS and SSC data for Nemadji River
- Develop a sediment/discharge rating curve for Nemadji River
- Calculate modern suspended sediment load for the Nemadji River
- Calculate modern bed load for Nemadji River
- Calculate total sediment load for Nemadji River

This data quality objective will be met through collection of suspended sediment, bedload, and bed material data at a site at CTH C, collocated with an existing USGS stream gage. An existing 7-year TSS dataset that was collected at the same location will be uses to develop relationships between TSS and SSC/bedload/bed material. Based on these relationships, a modern sediment load will be calculated.

DQO 2 Compare modern sediment loads on Nemadji River to historical loads and identify if sediment loading is increasing, decreasing, or similar to the late 1900's.

This data quality objective will be met through synthesizing the results of DQO 1 and comparing them to previous sediment loads calculated in the 1990's in the Nemadji Basin Plan using sediment monitoring data from the 1970's (NRCS 1998). USGS staff will review historical concentration and load data, and a statistical comparison will be completed to determine the significance of changes. Additional statistical comparisons will be done if possible. Due to a limited amount of data, comparisons may be qualitative. However, the comparison will allow trends to be identified (increasing, decreasing, similar sediment loads), and will be used to inform future data collection needs and/or management actions needed.

DQO 3 Develop rating curves for suspended sediment concentration and particle size and bedload with

- Turbidity
- Transparency
- Potentially acoustic Doppler current profiler (ADCP)

Turbidity and ADCP data will be collected during field sampling events, and thus will be able to be compared to sediment data (suspended sediment, bedload) collected. Relationships will be developed such that turbidity and/or ADCP data could be collected in the future as a surrogate for sediment data in order to calculate total sediment loads. The ability to do this will allow managers to continue monitoring of sediment loading in the in basin in the future if necessary, as well as allow managers to evaluate success of future projects (e.g. implementation of best management practices, stream stabilization, reforestation, etc.) before and after implementation.

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