



Minnesota Pollution Control Agency
 520 Lafayette Road North
 St. Paul, MN 55155-4194

Final Report Format
Surface Water Assessment Grant (SWAG)
 Appendix C

Doc Type: Grant Application

Instructions on Page 4

Grantee Information

REGENTS OF THE UNIVERSITY OF MINNESOTA (NATURAL RESOURCES RESEARCH INSTITUTE)
 Grantee name: _____ Contact name: Richard Axler
 Contact phone number: (218) 720-4316 Grant award: \$302, 067
 Contact e-mail: raxler@nrri.umn.edu
 Project title: St. Louis River Watershed streams & lakes: water quality/biological monitoring
 Grant budget period: Start date: 5/1/2009 End date: 6/30/2011
 Project time period covered by this report: Start date: 5/1/2009 End date: 6/30/2011

Section I - Work Plan

1. **Have you worked with Minnesota Pollution Control Agency (MPCA) Storage and Retrieval Water Data Repository (STORET/EQuIS) staff to establish all sites listed in your grant work plan?**

Yes No Date submitted: 5/28/2009

2. **Was monitoring data for these established sites submitted for storage into STORET/EQuIS annually?**

Field data submitted
 10/29/2010;
 Chemistry
 12/17/2010; all fish,
 macroinvertebrate,
 and habitat data were
 submitted prior to

Yes No Last submittal date: 01/2011

3. **Describe in detail the monitoring that has been conducted during the entire grant period. Please be specific by completing Table 1. The table should reflect all sites in your grant work plan, their site identifications (IDs), the number of samples to be collected according to the work plan and the number of samples actually collected (include Quality Assurance/Quality Control [QA/QC] sampling). If you were not able to meet your sampling obligations, describe in the comments section what sampling was missed and why. Refer to the end of this report for an example of the completed table.**

Table 1. Monitoring summary (see Table 1 attached)

Waterbody	Site ID#	Planned sampling		Actual sampling		Comments
		Parameter	No.	Parameter	No.	
lakes						See attachment
streams						See attachment

4. **Please describe progress in successfully carrying out aspects of the grant work plan other than actual field water monitoring. Attach copies of any documents or products that were produced (i.e., brochures, press releases, etc.).**

There are 3 important elements of this project that do not involve field sampling: (1) data dissemination to the general public via the www.lakesuperiorstreams.org website; (2) a comparison of NRRI's quantitative stream macroinvertebrate sampling methodology used for prior studies of North Shore Superior Basin streams (and elsewhere when applicable) to the MPCA SWA semi-quantitative macroinvertebrate method; and (3) an assessment of the potential utility of the NRRI stressor gradient developed from landscape GIS data. The Stressor Gradient related objectives were developed to: 1) assist MPCA in

prioritizing pour point sampling sites to potentially decrease overall SWA costs; 2) help locate potential reference condition ("least impacted" reaches within the St. Louis River watershed; and 3) help identify potential causes of impairment for sites that show impaired conditions using flow-accumulated anthropogenic stressors within subwatersheds. The Stressor Gradient related objectives and results are included in the Biological Monitoring section of the Proposal and Work Plan and will be reported under separate cover as an Interim Report before June 30, 2011 because complete data sets have only recently been received. A complete report will be submitted by August 15, 2011 after all statistical analyses have been completed and reviewed. No additional funding will be required for these analyses, and no invoices will be submitted to MPCA after June 30, 2011.

After the statistical analyses related to the stressor gradient are completed, there may be a publishable manuscript developed for a peer reviewed scientific journal regarding the comparisons with attribution of credit to MPCA partners and a request for scientific review. There will also be a webpage describing the project for the LSS website, and also an NRRI Now news magazine story targeting the general public. Copies of such end products will be sent to MPCA. Appropriate credit will also be given to MPCA for funding and data in any published papers or graduate theses that make use of the SWA-SLR data and/or results.

5. Describe in detail any problems, delays, or difficulties that have occurred in fulfilling the grant work plan. How did the grantee resolve these problems? Were there any change orders and/or amendments to the grant contract (work plan and/or budget)? If yes, list.

Five of the St Louis River watershed sampling sites were inaccessible during part of the 2010 sampling season due to either bridge and/or road construction.

There was some mis-communication between MPCA and NRRI staff regarding detailed chironomid morphology analyses that were not discovered until Spring 2011. In consultation with MPCA staff it was decided that the chironomid samples that were collected and sorted by NRRI from the macroinvertebrate collections would be sent to Rhithron Associates Inc in Missoula, Montana who have been performing these analyses for MPCA for other SWA projects in order to maintain consistency with the entire MPCA SWA data set.

The Stressor Gradient statistical analyses and the macroinvertebrate methodology comparison elements of the Biological Monitoring part of the project could not be completed before the grant's end date 6/30/2011. This was primarily due to the time it has taken for all of the macroinvertebrate taxonomic identifications to be completed and then the additional time to calculate their IBI scores. Note that the complete data set includes 34 sites sampled by NRRI in 2009 and 2010 and an additional 84 sites sampled by MPCA staff in 2009. The complete water quality data set for the MPCA sampled sites was received on 6/24/11 at which time there were still some gaps in the MIBI data set. These information gaps were noted in our second Interim Report (1/31/11) but were unavoidable. The stressor gradient related analyses have now been in progress for several weeks and we have set August 15, 2011 as a target date for submitting a summary report to MPCA. At that time we will plan a several hour long meeting with MPCA SWA staff to present and review the results before finalizing the report.

Section II - Participants in Project

6. Have there been any changes in project staff or contractors or has participation by companies or units of government changed? How many volunteers participated in monitoring activities during this project? Complete Table 2 by listing the contact information for your volunteers. Once your grant ends, the MPCA Citizen Lake/Stream Monitoring Program coordinators plan to contact these volunteers to see if they are interested in continuing to collect transparency data at their assigned sites.

There were no changes in project staff or contractors in 2010.

There was no successful volunteer recruitment for sites in this project although NRRI continues to coordinate with MN Waters Duluth staff to recruit CSMP volunteers. NRRI staff continue to encourage a comprehensive volunteer monitoring program and a coordinated network for physical, water quality, habitat, and biological indicators of condition in the St. Louis River Estuary and Watershed. We have continued to promote this concept, especially since the funding induced demise of the St. Louis River Watch program several years ago, and offer expert advice and review to potential partners. In particular, we began assisting a new City of Duluth program "Adopt-a-Park, initiated by Duluth Parks & Recreation Department in November 2009, and encouraged this group to expand their program to include park watersheds, and to include CSMP and other monitoring of the trout streams that are central features of the larger City Parks. The LakeSuperiorStreams.org website has continued to promote CSMP monitoring since its inception in 2003 and includes a section on volunteer programs at <http://www.lakesuperiorstreams.org/citizen/citizenMonitors.html>.

We are also in the process of compiling SWA funded data collected by the St. Louis River Alliance over the past few years from regional streams. These data will be posted on the www.lakesuperiorstreams.org website as spreadsheets available from any of the named stream websections on the LSS website.

Note: You do not need to complete the volunteer table below if your volunteers have not changed from those you identified on your last interim report.

Table 2. Volunteer contact information

Organization Name: _____

Grantee Contact: _____ Telephone Number: _____

Waterbody	Site ID#	Contact name	Address	Telephone number	E-mail address

7. Please describe training that you and/or an outside trainer provided to your project participants throughout the course of this grant. Include details on what the training covered, who administered this training and when it was offered (i.e., at the start of the grant, at the beginning of each field season, etc.).

Co-Project Manager Dan Breneman and field crew leaders met with MPCA SWA staff for training in MPCA's field protocols and QA procedures for biological sampling and habitat assessment in 2009. No training was conducted in 2010. NRRI has continued to interact with MPCA SWA staff throughout this project and will continue to do so after the grant officially ends with discussion focusing on both sampling design and macroinvertebrate methodology and condition metrics.

Section III - Evaluation Plan Results

8. Was the project a success? Did you achieve your goals?

The project was a success in that all major sample collection and analysis goals were achieved. The water quality data have been made available to the general public via the www.LakeSuperiorStreams.org website. We also plan to post all of the fish, macroinvertebrate, and habitat data, along with similar data sets from our 2008-2009 SWA - North Shore streams project. However, because of the complexity of these data sets we have delayed posting them directly and would prefer to simply link to MPCA's ultimate data "home" which has been in development. In addition the water quality data from this project are being used to supplement additional data and landscape analyses being conducted by NRRI scientists and a U. of Minnesota-Duluth graduate student (MS Water Resources Science) funded via a joint Minnesota and Wisconsin Sea Grant (NOAA) project investigating the stressor gradient and water quality in St. Louis River Estuary (SLRE) wetlands. These data will be shared with the larger community of scientists in the region interested in the SLRE, including the EPA-MED in Duluth and Superior NERR. The water quality data are also being incorporated into a larger set of data from North Shore Superior Basin streams, developed in part via a previous SWA grant to NRRI plus other funding sources over the past 10 -12 years. A different graduate student, advised by Drs R.Axler, G.Host and L.Johnson is working on an MS thesis (in this case UM-Duluth Integrated Biosciences Graduate Program) that will assess relationships between land use/land cover, weather/hydrologic regime, and water quality.

Lastly, the macroinvertebrate data will be incorporated into the larger NRRI data base that has been used in three previous or ongoing TMDL studies (Miller,Cr., Knife R., and Poplar R.). The macroinvertebrate data will also be useful in helping Dr. J. Schuldt at the U. of Wisconsin-Superior who is the lead on the Stressor Gradient- "bug" component of the previously mentioned SLRE Sea Grant funded study; and to A. Eliot from UW-Superior and her colleagues at the Wisconsin DNR who are monitoring the Wisconsin coastal zone of Lake Superior, including sites in the SLRE, via an EPA-GLRI grant over the next 3 years.

9. What would you recommend to others interested in attempting a project like yours?

We believe that the best long-term results will occur when SWA projects are carried out by groups having strong local/regional interest in using the data, in addition to having scientific expertise and technical training. .

10. Distribution of the project information is a legislative requirement for all SWAGs. How do you plan to distribute project information to interested parties (the media, businesses, Local Unit of Government [LUGs] etc.)? Is this information to be posted on your Web site? Is so, please supply the link to your Web site.

The water quality data are now available, with accompanying metadata, as an EXCEL spreadsheet from the following two pages within the Lake Superior Streams website:

<http://www.lakesuperiorstreams.org/streams/stlouis.html>

http://www.lakesuperiorstreams.org/streams/duluthStream_selector.html

We will also create a hyper link to the MPCA's SWA-St. Louis River website as soon as MPCA's final Macroinvertebrate IBI (MIBIs) are calculated as per a presentation MPCA SWA staff made in Duluth on April 20, 2011 (Superior South Basin SWA) and June 13, 2011 (St. Louis River Watershed). Information from MPCA was made available to attendees at the June meeting via FTP directory /pub/tmp/HCC at files.pca.state.mn.us, but staff also demonstrated the use of a website section for viewing and acquiring information regarding staff decisions made during the data analysis process.

Within the LSS website, each stream has its 'own' web section that provides additional information, maps, and links to

historical reports. This website is heavily used and is a core element of the outreach and education program for the 25 organization Superior Regional Stormwater Protection Team. The website received over 1.2 million page requests and 4.9 million requests (hits) in FY 2009/10 and 1.0 million page requests and 4.1 million requests in FY 2010/2011; since its creation in late 2002 it has received 28.1 million requests (~ "hits") and 6.2 million requests for webpages of information. The website has received regional, state, and national/international awards for its environmental education content and promotion of community stewardship in the region.

11 Please provide any suggestions you may have for improving the MPCA's SWAGs, particularly as they relate to the application process and grant administration.

As per item #10 above, it would be extremely helpful to people interested in understanding the Assessment process for specific sites, if the MPCA SWA "transparency" website also allowed users to see all of the data, not just the water quality data when a standard has been exceeded. This was suggested to, and discussed, with MPCA staff at the June presentation in Duluth. Admittedly, the macroinvertebrate "raw" data poses challenges, but easy access to the water quality data should not be difficult as it must already be in the SWA Access data base. Referring the user back to EDA/Equis is problematic and seemingly unnecessary.

Section IV - Budget

12. Fill in Table 3. List below and identify any time extension amendments, any additional dollars incorporated into your project budget through an amendment and/or any dollars reallocated from one task to another through a change order after the original grant award.

N/A. Final Project Expenditures will be sent separately after University of Minnesota Fiscal Year 2010-2011 accounting summaries are completed.

Table 3. Project expenditures

Project budget	MPCA grant funds available	Total MPCA funds expended	Total remaining balance	Percent of budget expended
Objective 1: (Title)				
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Objective 2: (Title)				
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Objective 3: (Title)				
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Objective 4: (Title)				
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Objective 5: (Title)				
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Objective 6: (Title)				

Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Task:			\$ 0.00	%
Column Total	\$ 0.00	\$ 0.00	\$ 0.00	%

Instructions

The Minnesota Pollution Control Agency evaluates grants based on their contribution to the Minnesota Pollution Control Agency's (MPCA) mission. In preparing your Final report, please refer back to Exhibit A (the work plan and budget) in your grant contract and previous Interim reports.

The Final grant report should be a comprehensive report that includes results in the form of data and information that best demonstrates progress toward achieving the objectives as identified in your grant work plan. The MPCA will use the information from this grant contract and others to document progress toward meeting the objectives to external parties, such as taxpayers and the legislature. The MPCA staff (Project Manager) will work with the Grantee on what the best ways are to accomplish this information requirement.

Project grantees are required to complete and submit a draft and a final report as outlined in the grant contract and work plan, covering the entire grant budget period. **Failure to submit a complete Final report may result in the loss of grant funds, the withholding of additional grant disbursements or being removed from consideration for future grant funding.**

A grantee may fill in the blanks in the form provided, or **you may tailor the form to more accurately fit your project (work plan).** Since projects are very diverse, the latter method may work best. This form is available electronically.

The report shall be sent to the attention of your MPCA Project Manager electronically.

Example:

Table 1. Monitoring summary

Waterbody	Site ID#	Planned sampling		Actual sampling		Comments
		Parameter	No.	Parameter	No.	
Lake A	71-***)	Chl-A, TP, Secchi	10	Chl-A, TP, Secchi	10	All required sampling completed.
Stream A	S****)	TP, TSS, DO, pH,conductivity	22	TP, TSS, DO, pH,conductivity	15	Stream ran dry for several months and prevented us from obtaining planned samples

Table 1. Planned and actual sample collection for the 34 stream sites within the St Louis River watershed for 2009-2010.

2009-2010		Planned		Actual	
StationAlias	Station_ID	parameter	No.***	parameter	No.
09LS001	S000-021	DO, T, EC, E. coli, T-Tube, water level, photos, TSS, VSS, TP, TN, NH4-N, NO3/NO2-N, SO4, Hardness, E. coli	19	DO, T, EC, E. coli, T-Tube, water level, photos, TSS, VSS, TP, TN, NH4-N, NO3/NO2-N, SO4, Hardness, E. coli	18
09LS004	S003-611	same as above	19	same as above	18
09LS013	S005-759	same as above	19	same as above	18
09LS016*	S004-594	same as above	19	same as above	0
09LS027**	S005-761	same as above	19	same as above	12
09LS039	S005-763	same as above	19	same as above	18
09LS048	S005-764	same as above	19	same as above	18
09LS051	S005-765	same as above	19	same as above	18
09LS056	S005-768	same as above	19	same as above	18
09LS061	S005-770	same as above	19	same as above	18
09LS068**	S000-597	same as above	19	same as above	15
09LS073**	S004-601	same as above	19	same as above	13
09LS080	S000-119	same as above	19	same as above	18
09LS090	S005-750	same as above	19	same as above	18
09LS095	S005-751	same as above	19	same as above	18
09LS102	S005-752	same as above	19	same as above	18
89LS026	S000-596	same as above	19	same as above	18
97LS033	S005-755	same as above	19	same as above	18
97LS090	S005-303	same as above	19	same as above	18
97LS093	S000-046	same as above	19	same as above	18
98LS050	S005-756	same as above	19	same as above	18
98NF115	S005-757	same as above	19	same as above	18
09LS011**	S005-758	DO, T, EC, E. coli, T-Tube, water level, photos, TSS, VSS, TP, TN, NH4-N, NO3/NO2-N, E. coli	19	DO, T, EC, E. coli, T-Tube, water level, photos, TSS, VSS, TP, TN, NH4-N, NO3/NO2-N, E. coli	13
09LS034	S005-762	same as above	19	same as above	18
09LS052	S005-766	same as above	19	same as above	18
09LS057	S005-769	same as above	19	same as above	18
09LS064	S000-589	same as above	19	same as above	18
09LS070**	S000-592	same as above	19	same as above	12
09LS071	S005-748	same as above	19	same as above	18
09LS082	S001-065	same as above	19	same as above	18
09LS084	S005-749	same as above	19	same as above	18
09LS111	S005-753	same as above	19	same as above	18
97LS019	S005-754	same as above	19	same as above	18
97LS077	S005-767	same as above	19	same as above	18

- * The FDL Band requested that we not sample this location
- ** These sites could not be sampled during some of 2010 due to construction projects
- *** MPCA personnel collected the initial May 2009 sample because the project budget had not been approved by that time

6/20/2011 emr

Table 2. Lake monitoring summary for 2009-2010.

2009-2010 Sampling Dates	THOMPSON 09-0007	SAND(Y) 09-0016	KANE 38-0651	BASS 58-0128	BUTTERBALL 69-0044	CADOTTE 69-0114	CLEARWATER 69-0397	SABIN (EMBARRASS PIT) 69-0429	LONG 69-0495	BASS 69-0553	LOST 69-0556	COE 69-0562	ESQUAGAMA 69-0565	DEEPWATER 69-0858
May	5/17/2010	5/17/2010	5/20/2010	5/17/2010	5/20/2010	5/18/2010	5/17/2010	5/18/2010	5/18/2010	5/18/2010	5/18/2010	5/18/2010	5/18/2010	5/19/2010
June	6/16/2009 6/22/2010	6/16/2009 6/9/2010	6/18/2009 6/10/2010	6/16/2009 6/9/2010	6/19/2009 6/10/2010	6/18/2009 6/7/2010	6/23/2009 6/9/2010	6/24/2009 6/7/2010	6/17/2009 6/7/2010	6/18/2009 6/7/2010	6/24/2009 6/7/2010	6/23/2009 6/7/2010	6/24/2009 6/10/2010	6/23/2009 6/8/2010
July	7/13/2009 7/13/2010	7/13/2009 7/13/2010	7/16/2009 7/20/2010	7/29/2009 7/13/2010	7/15/2009 7/16/2010	7/16/2009 7/16/2010	7/13/2009 7/13/2010	7/20/2009 7/15/2010	7/20/2009 7/15/2010	7/20/2009 7/15/2010	7/20/2009 7/15/2010	7/20/2009 7/15/2010	7/20/2009 7/15/2010	7/17/2009 7/12/2010
August	8/18/2009 8/9/2010	8/18/2009 8/9/2010	8/20/2009 8/10/2010	8/18/2009 8/9/2010	8/20/2009 8/10/2010	8/19/2009 8/12/2010	8/26/2009 8/11/2010	8/26/2009 8/12/2010	8/19/2009 8/12/2010	8/19/2009 8/12/2010	8/19/2009 8/12/2010	8/19/2009 8/12/2010	8/26/2009 8/12/2010	8/17/2009 8/11/2010
September	9/18/2009 9/22/2010	9/18/2009 9/13/2010	9/17/2009 9/16/2010	9/18/2009 9/13/2010	9/17/2009 9/16/2010	9/15/2009 9/14/2010	9/18/2009 9/13/2010	9/17/2009 9/14/2010	9/15/2009 9/14/2010	9/15/2009 9/14/2010	9/15/2009 9/14/2010	9/15/2009 9/14/2010	9/22/2009 9/14/2010	9/21/2009 9/15/2010
Parameters														
profiles (secchi, DO, T, EC, pH)	9	9	9	9	9	9	9	9	9	9	9	9	9	9
chlorophyll	9	9	9	9	9	9	9	9	9	9	9	9	9	9
total phosphorus	9	9	9	9	9	9	9	9	9	9	9	9	9	9
total nitrogen**	5	5	5	5	5	5	5	9*	5	5	5	5	5	5
alkalinity	1	1	1	1	1	1	1	1	1	1	1	1	1	1
color	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	*There were 4 samples collected at depth for Sabin/Embarrass Pit in 2010													
	**Total nitrogen was analyzed and reported gratis by NRRI Central Analytical Lab													
6/24/2011	emr													

**MINNESOTA SURFACE WATER ASSESSMENT
MONITORING GRANT PROGRAM (SWAG)
FY 2009 CLEAN WATER LEGACY ACT**

**St. Louis River Watershed Streams and Lakes:
Water quality/biological monitoring**

*Biological Monitoring Addendum:
Stressor Gradient & Macroinvertebrate Sampling Protocol Assessment
(Provisional Draft Analysis)*

Project Managers: Richard Axler, Dan Breneman, Valerie Brady, Lucinda Johnson

Project Scientists: Elaine Ruzycki, Jerry Henneck, Jennifer Olker,
George Host, Terry Brown, Will Bartsch

Natural Resources Research Institute
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Project Collaborators: Scott Niemela, Joel Chirhart, Ben Lundeen, Michael Kelly
John Sandberg, Jesse Anderson, Pam Anderson

Minnesota Pollution Control Agency
Surface Water Assessment Team

Submitted to: MPCA

Date: June 29, 2011

NRRI Technical Report: NRRI/TR-2011/XX

Project No. 00009742 (U. of Minnesota)

Contract No. Con000000018654 (U. of Minnesota)



NATURAL RESOURCES
RESEARCH INSTITUTE



Surface Water Assessment St. Louis River Watershed: Streams and Lakes: Water quality/biological monitoring

Biological Monitoring Addendum: Stressor Gradient & Macroinvertebrate Sampling Protocol Assessment (Provisional Draft Analysis)

I. Introduction

This provisional report is an addendum to the Surface Water Assessment Final Report entitled *Surface Water Assessment St. Louis River Watershed: Streams and Lakes: Water quality/biological monitoring* submitted to the MPCA electronically on June 29, 2011. That final report summarizes the water quality, habitat, macroinvertebrate, and fish data previously submitted to MPCA as the major part of this SWA project. This provisional report represents a detailed summary of the statistical analyses that the Natural Resources Research Institute (NRRI) at the University of Minnesota-Duluth is conducting using the data collected from this project together with previous and ongoing landscape stressor analyses conducted by NRRI via other funding sources over the past several years.

II. Background

The Minnesota Pollution Control Agency (MPCA) Surface Water Assessment targeted the St. Louis River watershed for an intensive biological monitoring effort during 2009-2011. This assessment effort resulted in numerous 303(d) listings for potentially impaired fish and macroinvertebrate communities when statewide Index of Biotic Integrity standards were completed in the winter of 2010. This project is in the process of identifying potential chemical, physical, and biological stressors responsible for the impairments described above by using EPA's Stressor Identification process, coupled with MPCA's newly-developed watershed stressor indices and land use – land cover maps. The information generated from this project is critical for developing Total Daily Maximum Load studies and guiding implementation practices for restoring and improving water quality, physical habitat, and biological integrity in the St. Louis River and its tributaries.

In addition to the MPCA SWA project, there are other collaborative efforts in progress in the St. Louis River watershed in which NRRI has been involved for which these new SWA generated data sets represented an opportunity to:

- 1) Further develop and verify a GIS-based sub watershed scale stressor index by testing the utility of a site selection technique with a variety of biological and habitat condition observations not previously available at the temporal and spatial scale provided by the 2009-10 efforts; and
- 2) Evaluate the continuity of standardized macroinvertebrate sampling techniques so prominent biological metrics can be applied to a variety of sampling protocols. Ultimately, these results will not only improve the effectiveness of future study designs, but allow more efficient use of both archived data sets and a variety of sampling techniques.

Aquatic and landscape ecologists at the University of Minnesota Duluth's Natural Resources Research Institute (NRRI) have been developing landscape models that link land use/ land cover to related watershed stressors over the past 20 years. A host of conditions (e.g., geology, hydrology, biology, and anthropogenic activity) specific to a watershed can influence relationships acting on the landscape, altering results from one watershed to the next, limiting the reliability of set parameters for predicting cause and effect relationships. Ultimately, developing tools that help to better understand the consistent links between landscape scale and watershed characteristics is expected to lead to more sound resource management decisions. By developing these procedures, the result will be a more effective response to changing local habitat condition and the resulting biotic community.

Landscape Stressors-

Since in-stream biota and ecosystem processes reflect landscape conditions, underlying geology, and human activities in a watershed, it is critical to understand the spatial extent over which data should be collected in order to sufficiently capture potential sources of impairment. It is also imperative that we understand the utility of existing GIS-based data in identifying potential sources of impact on aquatic resources (Danz et al 2003). Booth et al (2001) found that benthic invertebrate assemblages (B-IBI scores) responded linearly to urbanization in the Puget Sound region, whether it was measured at the sub-basin, riparian scale (200m buffer), or a local scale (200m buffer extending 1 km upstream). To the best of our knowledge, that approach represents the only study examining the effects of spatial scale in detecting effects of urban development impact. That study did not, however, address the impacts of data resolution and did not account for the spatial position of land uses within the watershed. Recent investigations show that the spatial position of patches can have a large influence on the potential sources of land-based inputs to streams (Gergel 2005; Baker et al. *in press*). Riparian characteristics, including the connectivity of riparian vegetation (or conversely, the number and size of gaps), has been shown to influence predictions of cropland impacts on streams. These studies, however, were either based on models of hypothetical landscapes (Gergel?), or in relatively large, heavily urbanized or agricultural landscapes (Baker et al. *in press*). The 2009-2011 SWA effort provided an opportunity to quantifying the effects of anthropogenic influence in the St. Louis River watershed, and critically evaluate the predictive capability of a GIS-based procedure for isolating impaired watersheds, and help guide future aquatic resource management decisions.

III. SWA – St. Louis River Biological Monitoring & Stressor Assessment Objectives

NRRI proposed to assist the MPCA with biological monitoring in the St. Louis River (SLR) watershed and to also test a site selection procedure for identifying impaired and reference reaches within watersheds. NRRI collected macroinvertebrate, fish, and habitat data at all of the targeted sites in the St. Louis River watershed listed by MPCA that could be sampled using EPA's wadeable stream methods (final tally = 22 sites). We also collected similar data sets from 12 additional sites chosen using an anthropogenic stressor gradient previously created for the SLR watershed with funding from MPCA and EPA-GLNPO in 2007-08 (Contract Officer M. Hershfield MPCA-Duluth). These data sets were then pooled with fish, habitat, macroinvertebrate, and a limited set of water quality measurements that were collected by MPCA staff at an additional 84 (of a potential pool of 131 *pour point* identified sites) and used for a series of exploratory statistical analyses.

The Project Work Plan stated:

Objective 3: Assess stream condition within the St. Louis River watershed by providing reach-scale data; and test a hierarchical site selection procedure for cost-effectively identifying impaired and reference reaches within sub-watersheds.

- 3-1. Provide macroinvertebrate (and accompanying water quality data, see Objective 2 above) to assess condition of the SLR watershed by evaluating 16 MPCA target sites and 14 additional sites chosen across an anthropogenic stressor gradient in a major subbasin of the SLR watershed. (Only reaches that can be sampled under wadeable stream protocols will be included). The following three subobjectives will be accomplished using NRRI in-kind support to assess the potential benefits of using NRRI's GIS-based stressor gradient approach for site selection. Using SWAG for the SLR to fund the WQ and biological data collection to enable these study elements was suggested by MPCA.*
- 3-2. Use the macroinvertebrate data collected in 3-1 for a pilot-study test of the relationship strength of site condition and landscape-level stressors based on MPCA's "pour point" sampling strategy (16 target sites) vs a flow-weighted stress gradient selection procedure (14 additional sites) that quantifies the cumulative anthropogenic stress from upstream to downstream within a watershed.*
- 3-3. Locate potential reference condition ("least impacted" reaches within the St. Louis River watershed.*
- 3-4. Identify potential causes of impairment for sites that show impaired conditions using flow-accumulated anthropogenic stressors within subwatersheds.*

We previously created a quantitative anthropogenic stressor gradient for the SLR basin based on landscape data (e.g., land use, road density, pollution point sources, population density, etc.) Unique stressor scores based on this landscape data were assigned to each watershed in the basin, beginning with the smallest first-order watersheds. Scores were then "accumulated" along the river network to derive a cumulative stressor gradient for the entire basin, including all of its major subbasins. Frequency distribution scores for the basin were then used to define a "St. Louis River Stress Scale". The scalability of the data allows for stressor analyses at scales from the entire watershed down to unique small subwatersheds. Currently, potential sample sites are selected based on a static assessment of stressors, which are evaluated for whole watersheds. Using the spatially explicit stressor gradient for site selection will allow managers to both locate and sample areas likely to be impaired and to locate and sample reaches likely to represent "reference" condition. Scores for individual stressors will allow managers to identify a priori the potential causes of impairment, thereby ensuring that appropriate sampling methods and indicators are employed. In addition, existing metrics (e.g., IBIs) can be calibrated against the stressor gradient to ensure that they encompass the suite of stressors of a region.

NRRI has now obtained or received from MPCA nearly all the data required to complete the analyses and comparisons discussed in our proposal. These include macroinvertebrate data collected following MPCA methods for all surface water assessment locations, and macroinvertebrate data collected following NRRI methods from a sub-set of overlap locations. MPCA has provided fish assemblage abundance and metric scores, habitat observations, and water quality data collected following MPCA methods. NRRI habitat data using a transect method is also available for the overlap sample locations. NRRI has

generated the landscape stressor data for all of the pour-point sub-watersheds and overlap sites associated with the above data sets.

The only data still to be acquired are the MPCA MIBI scores for 34 sites where NRRI sampled invertebrates using MPCA methods. These data are needed to complete the analyses outlined below. If MPCA can apply the same metric scoring process used on the surface water assessment locations to the NRRI overlap sites, those invertebrate metric comparisons will enhance the data summary. NRRI can eventually generate these values, although to ensure quality assurance, oversight from MPCA staff would be recommended.

The remainder of this report summarizes the status and some preliminary of our exploratory analyses. These results are provisional and since we have been informed that all missing data from MPCA will be sent “soon”, we intend to submit a final report for MPCA staff review by August 15, 2011. Our original intent was to submit provisional **Tier 1** (see below) results prior to June 30, 2011, but although we have a substantial set of statistical results for all parameters, we decided it would be imprudent to distribute this information before NRRI scientists had been able to more carefully review and discuss the data as a group.

IV. Summary of data analysis status and TENTATIVE OBSERVATIONS (as of June 28, 2011)

Our analyses will:

1. Determine whether MIBI scores generated from multiple habitats using MPCA composite sampling techniques or from NRRI wadeable stream protocols provide similar biological condition assessment.

Question: How differently do the MIBI scores (and component metrics) differ for the same sites due to the macroinvertebrate sampling method (MPCA vs. NRRI)?

Analysis: This question will be addressed using paired t-tests (**tier 1**). A broader community comparison using the whole invertebrate community (not metrics) will be addressed in a paired comparison using non-metric multidimensional scaling (NMDS) (**tier 1**). Based on the outcomes of these analyses, we will investigate whether or not there are ways to cross-walk data for the two methods to generate comparable metric and/or MIBI scores no matter which macroinvertebrate collection method was used (**tier 2**).

- Paired comparison of MIBI for these 12 sites not possible at this time (MIBI score for NRRI methods not yet calculated by MPCA)
- Paired comparison for NRRI generated invertebrate traits not yet completed
- Preliminary results from the NMDS (Non-metric Multidimensional Scaling) show that the invertebrate communities appear very different depending on the sampling methodology both when D-net methods were compared and when MPCA D-net method was compared to NRRI D-net plus Hess samples.

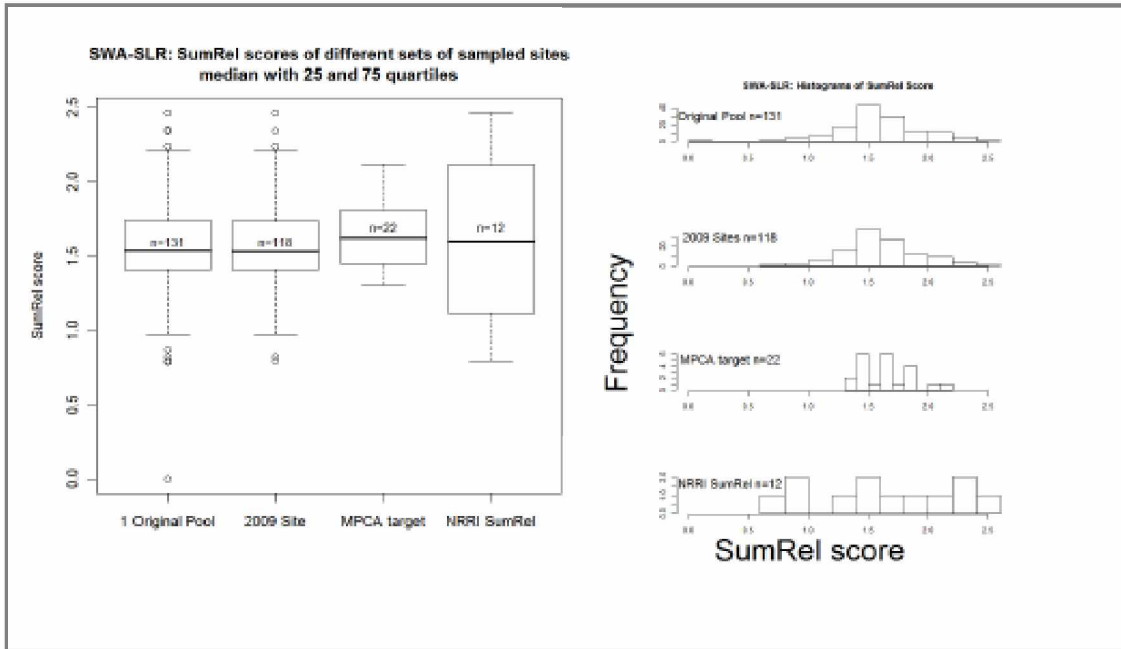


Figure 1. Summary of SumRel distributions for relevant SWA-SLR Watershed data sets

2. Test the relationship strength of biological site condition assessments and landscape-level stressors based on MPCA’s pour-point sampling strategy (22 target sites) vs. a flow-weighted stress gradient selection procedure (12 additional sites) that quantifies the cumulative anthropogenic stress from upstream to downstream within a watershed.

Question: How well do MPCA and NRRI site selection methods for identifying “intensive sampling” sites perform at actually identifying the “best” and “worst” condition pour-points within the St. Louis River watershed?

Analysis: We will compare NRRI’s stressor gradient site selection method with MPCA’s site selection method using water quality data and MIBI and fish IBI scores. Using these data, we will determine how well each of these methods correctly identify the best and worst condition pour point locations for intensive sampling (**tier 1**). As a second level of investigation, we will categorize all sampled sites (n = 118) by stream type (i.e., typical riffle/pool sequence with rocky substrate, peat-bottom streams, etc), and then re-run the above comparison to determine whether or not either site selection method actually detected sites that represent the best and worst conditions (**tier 2**).

- Site selection methods:
 - i. Original Pool n=131
 - ii. MPCA target n=22 (HUC11 level, ease-of-access)
 - iii. NRRI Stressor Gradient selection n=12

- SumRel scores (Relative Stress):
 - 2009 sampled sites (n=118 combining all MPCA and NRRI sampled sites) captured the full range and had a similar distribution of SumRel scores as the original pool of 131 sites.
 - 2009 sites had a fairly normal distribution, with the majority of sites with moderate SumRel scores (1.0-2.0)
 - NRRI SumRel selected sites (n=12) covered the full range of SumRel (based on the design of selecting sites evenly distributed across the SumRel gradient)
 - MPCA target sites (n=22) had a similar median and interquartile range as the original pool (n=131) and all 2009 sampled sites (n=118), but did not capture the full range, with no sites in either extreme (reference or impaired)

- Water Quality (WQ)
 - In general, the water quality parameters that were measured at the MPCA target and NRRI SumRel selected sites had similar ranges, medians, and IQRs. The exceptions were that the MPCA target sites had a compressed range for Total Phosphorus, Total Nitrogen, Ammonia (NH₄-N), NO₂NO₃-N, Turbidity (field measured), and 1/T-tube (inverse to normalize the strongly non-linear data). The range for these WQ parameters in MPCA target sites was half that found in the NRRI SumRel selected sites.
 - SumRel was most strongly correlated with EC₂₅ (p>0.75), for both the MPCA target sites and the NRRI SumRel selected sites.
 - Other WQ parameters showed non-linear or wedge-shaped relationships with SumRel. For TP, TN, NH₄-N, NO₂NO₃-N, and Turbidity (lab and field) the range of values was much larger at high SumRel scores than at low SumRel scores, suggesting local or perhaps weather-dependent responses in highly impacted areas.

- Fish IBI
 - Neither the MPCA target sites nor the NRRI SumRel selected sites contained the full range of Fish IBI scores found in the entire set of sites sampled in 2009.
 - FIBI at MPCA target sites was overall higher than that from all sites and did not include any sites that would be considered poor to very poor (FIBI < 29). However, this site selection method did identify multiple sites in the excellent range (FIBI ≥ 65).

- FIBI at NRRI SumRel selected sites was generally lower than that from all sites and did not include any sites with FIBI > 80 . However, this site selection method did detect 3 sites in the poor to very poor range (FIBI < 29) and 3 sites in the excellent range (FIBI ≥ 65).
 - SumRel was not highly correlated with FIBI (looks like flat line for all sites) however, there was a non-significant negative trend in the NRRI SumRel selected sites. For these 12 sites, the higher FIBI scores were found at sites with the least impacted watersheds (lowest SumRel scores). The lack of relationship between SumRel and FIBI when all sites are included may be due to different responses in the large number of sites that have intermediate SumRel scores or due to different responses by habitat type.
- Macroinvertebrate IBI
 - Both MPCA target sites and the NRRI SumRel selected sites contained most of the full range of MIBI scores found in the entire set of sites sampled in 2009. Both site selection methods had slightly higher medians than that from the entire set of sites.
 - MPCA targeted sites (n=22) contained the full range of MIBI and included several sites in both the Very Poor range (MIBI < 20) and the Excellent range (MIBI ≥ 80).
 - NRRI SumRel selected sites (n=12) had a similar median MIBI to the MPCA target sites, but did not include as many sites with low MIBI scores. This site selection method identified one site in the Very Poor range (MIBI < 20) and one site in the Excellent range (MIBI ≥ 80).
 - SumRel was not highly correlated with FIBI, but had an overall negative trend (less impacted watershed with low SumRel score had higher MIBI scores). This negative trend was stronger and significant in the NRRI SumRel selected sites, but did not exist in the MPCA targeted sites. Again, the stronger trend in the NRRI SumRel selected sites could be due to different responses in the large number of sites that have intermediate SumRel scores or due to different responses by habitat type.
- **Next step for site selection comparison:** Subsample the entire set of 118 sampled pour-points to get multiple sets of n=12, n=24, n=48, and n=96 to evaluate the minimum number of sites to sample to most efficiently characterize the condition of the St. Louis River Watershed

- Evaluate with means and ranges for MIBI, FIBI, and several WQ parameters

Figure 2. Stressor gradient schematics for the Upper St. Louis River watershed. A higher SumRel score represents a higher level of anthropogenic stress within the sub-watersheds. Upper left = major sub watersheds; upper right = SumRel scores derived via Arc Hydro delineations for all 131 potential pour point defined catchments. Lower left = land use land cover (NRR1); Lower right = SWA-SLR sampling sites. Note that the subcatchments are not precisely defined by the sampling points, they are the catchments formed by the union of the ArcHydro subcatchment containing the sampling point, and all the subcatchments upstream. So they may contain small amount of land below the sampling point, but this is generally very small proportionally, so unless it contains WLSSD or another major source of “stress”, it shouldn't be a problem (these will be carefully evaluated before finalizing the analyses).

