2010 Project Abstract
For the Period Ending June 30, 2012

PROJECT TITLE: Strategic Planning for Minnesota's Natural and Artificial Watersheds.
PROJECT MANAGER: David Mulla
AFFILIATION: University of Minnesota; Dept. Soil, Water & Climate
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WEBSITE: [If applicable]
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2010, Chp. 362, Sec. 2, Subd. 3h

APPROPRIATION AMOUNT: $327,000

Overall Project Outcome and Results

Artificial watersheds have significant areas that are drained using ditches and/or buried perforated pipes, leading to hydrologic characteristics that differ from natural watersheds. Water and pollutants from artificial watersheds often disturb the hydrologic regime and impair water quality in natural watersheds. This project aims to protect Minnesota's natural watersheds by disconnecting them from the artificial watersheds.

High resolution digital elevation models (DEMs) from LiDAR and corresponding digital orthoquad photos were obtained in Beauford Creek, Seven Mile Creek and Elm Creek Watersheds. These data were used along with GIS databases for land use, soils, and hydrologic networks to predict the locations of renewable wetlands. In the Beauford watershed (5,500 ac), logistic regression was able to accurately identify 69% of the potentially restorable wetland locations. Most of the error was due to very small wetlands that are difficult to identify using GIS techniques alone. In the Seven Mile Creek watershed (23,500 ac), logistic regression was able to accurately identify 70% of the potentially restorable wetland locations. In Elm Creek (186,600 ac), 94% of the potentially restorable wetlands were identified. These results show that it is possible to quickly and accurately identify a large proportion of larger restorable wetlands over large areas in Minnesota using straightforward terrain analysis techniques, soil databases and logistic regression.

The optimum locations for restoring wetlands were determined based on factors that included the location and extent of subsurface tile drains, the contributing area to the wetland, the distance between the potential wetland and nearby streams, ditches or county tile mains, the amount of discharge from subsurface tile drains to wetlands, and the ratio of drainage flow to wetland storage capacity. Using these criteria, 44 optimal sites for wetland restoration were identified in Beauford Creek watershed, while 75 sites were identified in Seven Mile Creek watershed. Placing wetlands at these locations is optimal in terms of intercepting, treating and reducing the effects of subsurface tile discharge to nearby drainage ditches.

More efficient approaches for processing LiDAR DEMs were developed using a supercomputer. The new methods run much faster than conventional methods for processing LiDAR DEMs on a personal computer. Terrain attributes for DEMs (e.g. slope, flow accumulation, stream power index, compound topographic wetness, etc) were calculated for all 42 Minnesota counties that have LiDAR data. We are exploring the possibility of using the Minnesota Geospatial Information Office web site to disseminate these LiDAR based terrain attributes.

Environment and Natural Resources Trust Fund (ENRTF)
2010 Work Program

Date of Report: Dec 30, 2011
Date of Next Progress Report: June 30, 2012
Date of Work Program Approval: June 16, 2010
Project Completion Date: June 30, 2012

I. PROJECT TITLE: Strategic Planning for Minnesota's Natural and Artificial Watersheds.

Project Manager: David Mulla
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Location: Statewide

Total ENRTF Project Budget:	**ENRTF Appropriation**	**$ 327,000**
	Minus Amount Spent:	**$ 276,816**
	Equal Balance:	**$ 50,184**

Legal Citation: M.L. 2010, Chp. 362, Sec. 2, Subd. 3h

Appropriation Language:
$327,000 is from the trust fund to the Board of Regents of the University of Minnesota to identify the interrelationship between artificial systems of drain tiles and ditches and natural watersheds to guide placement of buffers and stream bed restoration and modification.

II. PROJECT SUMMARY AND RESULTS:

Minnesota's natural and artificial watersheds are intimately linked. Artificial watersheds have significant areas that are drained using ditches and/or buried perforated pipes, leading to hydrologic characteristics that differ from natural watersheds. Water and pollutants from artificial watersheds often disturb the hydrologic regime and impair water quality in natural watersheds.

This project aims to protect Minnesota's natural watersheds by disconnecting them from the artificial watersheds. This can be done by using GIS techniques to identify locations that are suitable for installation of wetlands, riparian buffer strips, and perennial vegetation that will help manage the excess flows and contaminants from artificial watersheds. GIS data layers collected will include high resolution elevation and aerial photos where available, hydrology, land use, and soils. Efficient computer algorithms for analysis of high resolution elevation data and aerial photos will be developed to identify locations in the artificial watersheds where they are hydrologically connected to the natural watersheds. GIS techniques will be used to process the collected data layers and identify the optimum locations for wetlands, riparian buffer strips and perennial vegetation.

Project deliverables will include data maps, improved software for terrain analysis and image analysis, GIS based maps and reports documenting artificial watersheds and GIS based maps, and reports identifying optimal locations for the placement of wetlands and vegetated buffers to disconnect the artificial and natural watersheds. This project will lead to information that can be used to restore and maintain the integrity, purity and health of Minnesota's natural watersheds. Decoupling the artificial and natural watersheds is needed to reduce flooding and water quality impairments, expand wildlife habitat, increase supply of renewable energy, and reduce greenhouse gas emissions.

III. PROGRESS SUMMARY AS OF *June 30, 2012*:

LiDAR derived high resolution digital elevation models and corresponding digital orthoquad photos were obtained as test cases for methodology development in Blue Earth County and Seven Mile Creek Watershed. These data were analyzed for terrain attributes such as slope, flow accumulation, stream power index and compound topographic wetness. Digital GIS databases for land use, soils, and hydrologic networks were also obtained for these areas.

Digital GIS databases for hydric soil coverages were obtained for each county in Minnesota. These databases can be used in conjunction with soil drainage class and compound topographic wetness to estimate potential locations for restorable wetlands. The hydric soil coverages were linked together to form a seamless database of hydric soils for the entire state.

A new algorithm was developed to more quickly process LiDAR derived Digital Elevation Models (DEMs). This algorithm involves use of parallel processing techniques that improve the efficiency of calculations. LiDAR derived DEMs are at finer scale resolution (typically 1-3 m) than conventional DEMs provided by USGS (30 m resolution). The finer scale resolution of LiDAR DEMs results in much larger datasets that are difficult to process efficiently, even with desktop computers that have a large amount of RAM memory. Using current software, there is a practical limit of processing DEMs with 7,000 x 7,000 cells. With the improved algorithm, computers can process much larger areas in shorter times.

A second algorithm was developed to more quickly process LiDAR derived DEMs. This algorithm performs the process of "flat resolution", whereby tiny elevation increments are included within subregions of the map so that every part of the landscape has a defined flow direction. This algorithm performs more than 100 times faster than the existing TauDEM algorithm.

A third algorithm was developed to more quickly fill in depressional areas in DEMs. Filling depressional areas is a prerequisite to more advanced terrain analysis products that include flow accumulation. The algorithm operates by flooding DEMs inwards from their edges using a priority queue to determine the next cell to be flooded. The resultant DEM has no depressions or digital dams: every cell is guaranteed to drain. This algorithm performs up to 37% times faster than the existing TauDEM algorithm.

A fourth set of algorithms were developed on the super computer to estimate flow directions, compute flow accumulation, and estimate primary and secondary terrain attributes based on LiDAR derived DEMs. Flow directions can be estimated using either the D-8 or D-infinite methods. For the D-8 method, flow accumulation is defined as the total number of cells whose flow ultimately passes through a given cell. For the D-infinite method, this definition is modified such that flow accumulation is the sum of all of the proportions of each cell's flow which ultimately passes through a given cell. Terrain attributes estimated include both primary (slope, curvature, flow direction, flow accumulation) and secondary (stream power index, compound topographic index) terrain features. The compound topographic index (CTI) increases as the potential for ponding of water on the landscape increases. Landscapes with large CTI values on relatively impermeable (hydric) soils have a good potential as sites for wetland restoration.

Depression filling, flat resolution, flow directions, and flow accumulation were run sequentially on both TauDEM and RichDEM for 42 of Minnesota's southern counties—an area representing approximately one-third of the state. TauDEM completed 39 of the runs while RichDEM completed all of them. The new algorithms with a single processor on the super computer ran an average of 7 times faster than TauDEM did with 16 processors. The trends of run-times versus county area show that TauDEM quickly becomes prohibitively long-running for larger counties. If TauDEM's run-times are projected to a single-processor system, computation takes an order of magnitude longer. In total, it would take approximately 3.2 months to process all of Minnesota on a desktop computer using TauDEM; the same operation would take 19.3 hours using new algorithms on the super computer.

A logistic regression technique was used with LiDAR derived DEMs to estimate restorable wetland locations in three small watersheds in the Minnesota River Basin. Small watersheds included Beauford (5,500 ac), Seven Mile Creek (23,500 ac) and Elm Creek (186,600 ac). Data from the National Wetland Inventory (NWI) and Restorable Wetland Inventory (RWI) were used to evaluate the accuracy of logistic regression. Accuracy of the logistic regression technique ranged from 69% in Beauford watershed to 90% in Elm Creek watershed.

Digitized tile drainage networks were obtained for Beauford watershed from Minnesota State University at Mankato. These were combined with wetland locations predicted by logistic regression to identify optimum places on the landscape for installation of restored wetlands that would treat and store upland water.

IV. OUTLINE OF PROJECT RESULTS*:*

RESULT/ACTIVITY 1: Geographic Spatial Databases

Description:

Spatial data for the project will be gathered and organized into a geographic database. These data will include elevation, soils, land cover, and slope combined with locations of tiles, ditches, streams, rivers and other surface water bodies. The topographic data will consist of standard statewide elevation based on USGS digital elevation models (DEMs) as well as Light Imaging Detection and Ranging (LiDAR) data. Slope data will help characterize terrain and will be estimated from the DEM data. Soils data will be pulled from statewide SSURGO coverages. Artificial soil drainage will be partially derived from locations specified as hydrologic classes C and D in the SSURGO database. Land cover will be based on the USDA-NRCS 2008 Crop

Land Database. DNR hydrologic data will be used to identify locations of ditches, streams, rivers and lakes.

These databases will be gathered, reviewed for content and accuracy, converted as necessary for cross-layer spatial compatibility (so they accurately overlay with each other) and then maintained as the knowledge base for analysis using GIS and topographic software.

Maps will be produced showing locations of the naturally- versus the artifically-delineated watersheds across Minnesota. These maps and reports will provide information relating to:

- The current state of these watersheds;
- Where these watersheds are relative to political boundaries (municipal, township, county, metropolitan);
- How these watersheds interact and affect the natural and public environment;
- Why these two types of watersheds need to be disconnected;
- How various land cover elements (ex: tiles or ditches) affect hydrological processes; and
- How wetlands and vegetation buffers will help to disconnect these two types of watersheds and improve public and natural environmental health.

A picture is worth a thousand words. These maps will be the visual representation of the background, study site and goals of this project. This type of representation will help users of all backgrounds to better understand the scope, need and application of the work that we will do in this project.

Electronic versions of all maps and and reports will be made freely available for public download via a website. Hardcopy maps and reports will be printed and made available for distribution during public presentations by University of Minnesota staff and to governmental or public entities as requested. Some maps will have to be printed on large-format graphic printers which increase printing costs. Note that presentations and meetings about this study will extend well into the study period or potentially even after the study period, so these maps and reports will be used during the entire project period.

Summary Budget Information for Result/Activity 1: **ENRTF Budget: $59,000**
Amount Spent: $ 29,745
Balance: $ 29,255

Deliverable/Outcome	**Completion Date**	**Budget**
1. Assembled spatial databases	June 2011	$49,000
2.Data maps and reports	December 2011	$10,000

Result Completion Date: December, 2011

Result Status as of June 30, 2012

LiDAR derived high resolution digital elevation models and corresponding digital orthoquad photos were obtained as test cases for methodology development in Blue Earth County and Seven Mile Creek Watershed. These data were analyzed for terrain attributes such as slope, flow accumulation, stream power index and compound topographic wetness. Digital GIS databases for land use, soils, and hydrologic networks were also obtained for these areas.

Digital GIS databases for hydric soil coverages were obtained for each county in Minnesota. These databases can be used in conjunction with soil drainage class and compound topographic wetness to estimate potential locations for restorable wetlands. The hydric soil coverages were linked together to form a seamless database of hydric soils for the entire state.

Result Status as of June 30, 2012

Digital GIS coverages for tile drained land in Beauford watershed were obtained from Minnesota State University at Mankato.

The connections between these landscapes and potentially restorable wetlands will be analyzed in Result/Activity 3, and locations suitable for storage of water on the landscape will be identified.

Final Report Summary:

RESULT/ACTIVITY 2: Computer Topographic Analysis Software

Description: Custom software was developed to extract critical landscape features from the geographic spatial database and represent connections between the natural and artificial watersheds. This software will be custom-tailored and calibrated for accuracy with data from several well-studied small watersheds. The computer code in this software has the capacity to efficiently analyze large datasets typical of LiDAR DEMs.

Calibration results will be discussed with experts for accuracy and usefulness towards project goals. Software refinement will be on-going until calibration results are acceptable to experts who are knowledgable about agriculture and watershed management. Software development and calibration routines will also be documented and posted on the project website. Project background and methods will be presented at public meetings and conferences as needed or requested.

Summary Budget Information for Result/Activity 2: **ENRTF Budget: $84,000**
Amount Spent: $ 79,000
Balance: $ 5,000

Deliverable/Outcome	**Completion Date**	**Budget**
1. Procedures and documentation of methods	Dec. 2011	$42,000
2.Geographic software and documentation	Dec. 2011	$42,000

Result Completion Date: Dec. 2011

Result Status as of June 30, 2012

A new algorithm was developed to more quickly process LiDAR derived Digital Elevation Models (DEMs). This algorithm involves use of parallel processing techniques that improve the efficiency of calculations. LiDAR derived DEMs are at finer scale resolution (typically 1-3 m) than conventional DEMs provided by USGS (30 m resolution). The finer scale resolution of

LiDAR DEMs results in much larger datasets that are difficult to process efficiently, even with desktop computers that have a large amount of RAM memory. Using current software, there is a practical limit of processing DEMs with 7,000 x 7,000 cells. With the improved algorithm, computers can process much larger areas in shorter times.

Result Status as of June 30, 2012

A second algorithm was developed to more quickly process LiDAR derived DEMs. This algorithm performs the process of "flat resolution", whereby tiny elevation increments are included within subregions of the map so that every part of the landscape has a defined flow direction. This algorithm performs more than 100 times faster than the existing TauDEM algorithm.

A third algorithm was developed to more quickly fill in depressional areas in DEMs. Filling depressional areas is a prerequisite to more advanced terrain analysis products that include flow accumulation. The algorithm operates by flooding DEMs inwards from their edges using a priority queue to determine the next cell to be flooded. The resultant DEM has no depressions or digital dams: every cell is guaranteed to drain. This algorithm performs up to 37% times faster than the existing TauDEM algorithm.

A fourth set of algorithms were developed on the super computer to estimate flow directions, compute flow accumulation, and estimate primary and secondary terrain attributes based on LiDAR derived DEMs. Flow directions can be estimated using either the D-8 or D-infinite methods. For the D-8 method, flow accumulation is defined as the total number of cells whose flow ultimately passes through a given cell. For the D-infinite method, this definition is modified such that flow accumulation is the sum of all of the proportions of each cell's flow which ultimately passes through a given cell. Terrain attributes estimated include both primary (slope, curvature, flow direction, flow accumulation) and secondary (stream power index, compound topographic index) terrain features. The compound topographic index (CTI) increases as the potential for ponding of water on the landscape increases. Landscapes with large CTI values on relatively impermeable (hydric) soils have a good potential as sites for wetland restoration.

Depression filling, flat resolution, flow directions, and flow accumulation were run sequentially using both TauDEM and the new algorithms on the supercomputer for 42 of Minnesota's southern counties—an area representing approximately one-third of the state. TauDEM completed 39 of the runs while the new algorithms on the supercomputer completed all of them. The new algorithms with a single processor on the supercomputer ran an average of 7 times faster than TauDEM did with 16 processors. The trends of run-times versus county area show that TauDEM quickly becomes prohibitively long-running for larger counties. If TauDEM's run-times are projected to a single-processor system, computation takes an order of magnitude longer. In total, it would take approximately 3.2 months to process all of Minnesota on a desktop computer using TauDEM; the same operation would take 19.3 hours using new algorithms on the supercomputer.

Final Report Summary:

RESULT/ACTIVITY 3: Analyses of Artificial Watershed Improvements

Description:

Methods for defining critical areas for mitigation, and methods for decoupling the natural and artificial watersheds (ex: wetland restoration) will be refined and applied to the assembled databases. Critical landscape features will be identified and documented in maps and reports. Critical landscape features are regions that have a high potential for runoff and are in close proximity with surface water features. Wetland restoration is most feasible for critical landscape features that also have a high potential for collecting runoff and are located on soils with slow permeability (Hydrologic Classes C and D).

Final analyses will be conducted with the GIS and custom computer algorithms. The results will be validated with field observations, public input, and expert opinion. Critical locations in the watersheds will be identified to determine where buffers and wetlands can be placed naturally and where landscape modifications would be desirable and feasible. These locations will be based on criteria such as proximity to surface water, soil hydrologic class and terrain analysis attributes involving Stream Power Index (SPI) and Compound Topographic Index (CTI).

Final maps and reports will document these results. They will be made available electronically and in hard-copy form for agency and public use. The Board on Soil and Water Resources (BWSR), the Soil and Water Conservation Districts (SWCD) and the Minnesota Agriculture Department are the public agencies which will most likely be interested in these maps and reports. In addition, there will likely be significant interest in the software and map products from the DNR and MPCA. Given the growing regulatory environment concerning water quality, municipalities and county governments will be interested as well.

Maps and reports will be made available through the LCCMR website, as well as websites at BWSR and the University of Minnesota.

Summary Budget Information for Result/Activity 3: **ENRTF Budget: $184,000**
Amount Spent: $ 168,071
Balance: $ 15,929

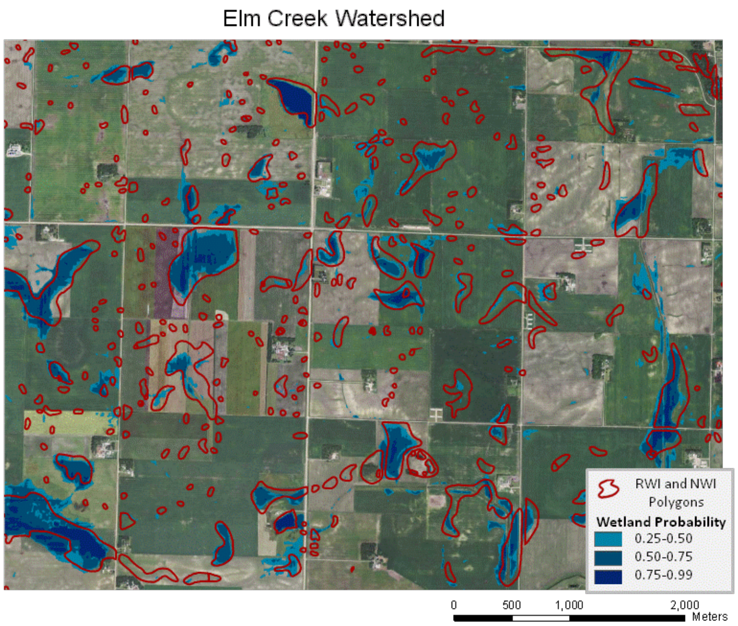
Deliverable/Outcome	**Completion Date**	**Budget**
1. GIS-based maps and reports analyzing and documenting the artificial watershed of the state. These maps and reports will be made freely available for public use.	June 2012	$92,000
2. GIS-based maps and reports identifying the locations within artificial watersheds which are optimal for treating tile drain effluents based on considerations of topography, soils, and environmental benefits.	June 2012	$92,000

Result Completion Date: June 30, 2012

A logistic regression model was developed to predict the locations of renewable wetlands. The model is based on terrain attributes such as Compound Topographic Index (CTI), slope and curvature. It also uses percent hydric soils.

Result Status as of June 30, 2012

A logistic regression model was evaluated in three small watersheds within the Minnesota River Basin using data from the National Wetlands Inventory (NWI) and Renewable Wetlands Inventory (RWI). In the Beauford watershed (5,500 ac), logistic regression was able to accurately identify 69% of the potentially restorable wetland locations. Most of the error was due to very small wetlands that are difficult to identify using GIS techniques alone. In the Seven Mile Creek watershed (23,500 ac), logistic regression was able to accurately identify 70% of the potentially restorable wetland locations. In Elm Creek (186,600 ac), 94% of the potentially restorable wetlands were identified (Fig. 1 below). These results show that it is possible to accurately identify a large proportion of larger restorable wetlands using straightforward terrain analysis techniques, soil databases and logistic regression.



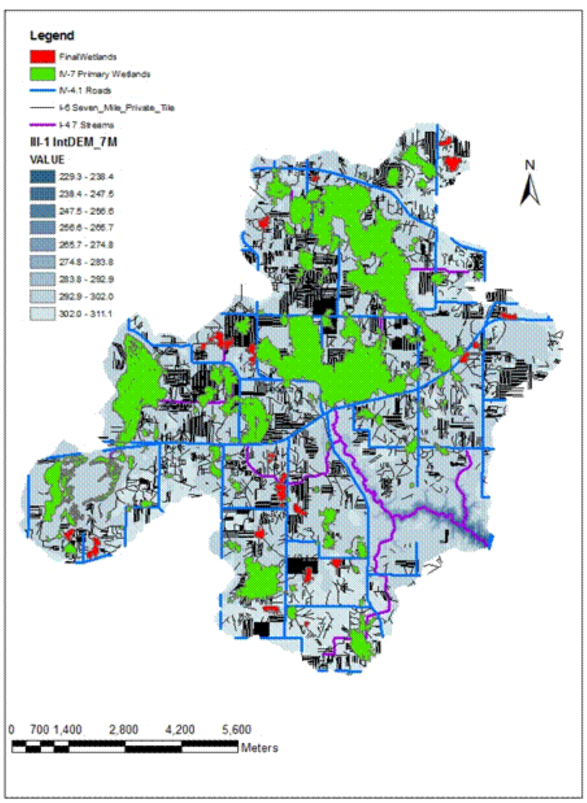
Based on the good accuracy observed between logistic regression estimates of wetland location and wetlands from the NWI or RWI databases, the logistic regression wetland algorithm was run on the University of Minnesota supercomputer for all 42 Minnesota counties with LiDAR DEMs.

In Beauford watershed, a database of digitized tile drainage networks was obtained from Minnesota State University at Mankato. This database was combined with wetland locations from logistic regression to identify the optimum locations for restoring wetlands based on their potential for storing and treating upland drainage water. A similar database of digitized tile drainage networks was obtained from Kevin Kuehner for Seven Mile Creek watershed.

The steps in the process for identifying optimum wetland locations include: 1) identify regions with dense subsurface tile drain networks upslope of potentially restorable wetlands, 2) estimate area and storage depth of potentially restorable wetlands, 3) eliminate potentially restorable wetlands smaller than 0.1 ac, 3) estimate the amount of water drained from upslope tile networks, 4) eliminate potentially restorable wetlands with storage volumes smaller than the volume of water drained from upslope tile drain networks, 5) potentially restorable wetlands can also be evaluated based on soil productivity and distance to drainage ditches. It is often economical to restore wetlands on marginally productive cropland rather than highly productive cropland. There may also be advantages to siting wetlands close to drainage ditches so that farmers can keep crop production in larger contiguous areas rather than fragmenting their production area.

These steps were divided into those that are used as primary screening criteria to reduce the number of potential wetland sites from a very large number to a number that is more optimum. The primary screening criteria included 1) contributing area to the wetland, 2) the ratio of wetland area to contributing area (W/C), 3) the distance between the potential wetland and nearby streams, ditches or county tile mains (SDC), and 4) the wetland area. Sequential application of these primary screening criteria, with appropriate threshold values, reduced the number of potential wetland sites from 1,137 to 44 sites in Beauford Creek watershed and from 3,297 to 75 sites in Seven Mile Creek watershed.

Secondary screening criteria were applied to potential wetland sites resulting from primary screening. Secondary screening criteria included 1) the ratio of drainage flow to wetland storage capacity (F/S), 2) the ratio of tile drained area to wetland area (T/W), and 3) the ratio of wetland area to depressional area (W/D). Simultaneous application of these secondary screening criteria reduced the number of potential wetland sites from 44 to 10 in Beauford Creek watershed and from 75 to 21 sites in Seven Mile Creek watershed. Fig. 2 below shows the locations of all potential wetlands (in green) based on the logistic regression model in comparison to the locations of the 21 optimum sites (in red) based on primary and secondary screening. Black lines indicate the location of subsurface tile drains, while ditches and streams are purple.



Result Status as of June 30, 2012

Final Report Summary:

V. TOTAL ENRTF PROJECT BUDGET:

Personnel: $ 308,000

Clarence Lehman	(30% FTE) $68,000
Haibo Wan Post-doc	(100% FTE) $80,000
Richard Barnes Programmer	(100% FTE) $40,000
Joel Nelson	(7% FTE) $10,000
Jake Galzki	(100% FTE) $100,000
Kevin Betts	(5% FTE) $10,000

Equipment/Tools/Supplies: $10,000

Equipment/Tools include 2 laptops with enough hard-drive and RAM to store and process GIS and LiDAR spatial data. These spatial data are very large datasets of detailed terrain data and require high-speed processors and large-capacity storage units – both for the computer's harddrive, and for external back-up and storage. Current university laptops that meet these requirements are used full-time for other projects.

Additional supplies and tools include the purchasing of published data (maps) supplementing agricultural spatial data and large-capacity external back-up data drives. Additionally, rewriteable CDs/DVDs and other supplies will be purchased to mail or distribute software programs, maps and documents.

Travel: $ 4,000

Travel expenses include travel for field surveys done for data verification, calibration and validation. This also includes travel to or the hosting of workshops or meetings for presentation or discussion of project goals, methodologies or results.

Additional Budget Items: $ 5,000

Additional items include license fees for specialized ESRI ArcGIS and other software necessary for the laptop computer processing of large spatial data layers.

TOTAL ENRTF PROJECT BUDGET: $327,000

Explanation of Capital Expenditures Greater Than $3,500: None

VI. PROJECT STRATEGY:

A. Project Partners: ***David Mulla*** (UMN Soil, Water, and Climate) is the project manager. He will supervise a GIS specialist (**Joel Nelson**), and a Research Fellow (**Jake Galzki**) who are both familiar with GIS and terrain analysis techniques. In addition, ***Clarence Lehman*** (UMN, Ecology) will provide his long-time software expertise to design algorithms, carry out the computer computations, data processing, and geographic mapping. ***Donald Wyse and Kevin Betts*** (UMN, Agronomy) will contribute their expertise on agricultural systems, including parameters related to their drainage and sustainability. They will provide essential connections with government and industry, including those who must supply information and those who can use the results. ***A Post-Doc*** (**Haibo Wan** UMN) will provide support for software development, geographic information systems and spatial database development, integrating this with hydrogeology and watershed modeling. Project team partners will coordinate their efforts with several other ongoing related research efforts including the LCCMR Ecological Ranking of CRP project led by Julie Klocker at BWSR, the MDA Targeting BMP project led by David Mulla, and the LCCMR water/biofuel project led by Clarence Lehman.

B. Project Impact and Long-term Strategy: High-resolution LiDAR data are presently available for a fraction of the state, and the entire state will be covered by 2012. The methods developed in this project will be immediately available to utilize it as LiDAR data emerges. The state-wide results will be available as drainage systems are gradually rebuilt and improved as they age. The beneficial consequences of this project will therefore ripple through the century.

C. Other Funds Proposed to be Spent during the Project Period: None.

D. Spending History: None.

VII. DISSEMINATION: Results of this project will be disseminated through reports submitted to LCCMR and other interested entities. Presentations about project results will be organized with various agency and NGO entities.

VIII. REPORTING REQUIREMENTS: Periodic work program progress reports will be submitted not later than December and June of each year. A final work program report and associated products will be submitted between June 30 and August 1, 2012 as requested by the LCCMR.

IX. RESEARCH PROJECTS:

Attachment A: Budget Detail for 2010 Projects - Summary and a Budget page for each partner (if applicable)

Project Title: *Strategic Planning for Minnesota's Natural and Artificial Watersheds.*

Project Manager Name: *David Mulla*

Trust Fund Appropriation: $ *327,000*

1) See list of non-eligible expenses, do not include any of these items in your budget sheet

2) Remove any budget item lines not applicable

	July 2010 to Dec 2010			Jan 2011 to Dec 2011			Jan 2011 to June 2013				
2010 Trust Fund Budget	**Result 1 Budget:**	Amount Spent *(date)*	Balance *(date)*	**Result 2 Budget:**	Amount Spent *(date)*	Balance *(date)*	**Result 3 Budget:**	Amount Spent *(date)*	Balance *(date)*	**TOTAL BUDGET**	**TOTAL BALANCE**
BUDGET ITEM	*Geographic Spatial Database*			*Computer Topographic Software*			*Analyses of Artificial Watershed Improvements*				
PERSONNEL: total wages plus benefits	51,500	24,769	26,731	79,000	79,000	0	177,500	165,460	12,040	308,000	38,771
Clarence Lehman (30% FTE)	15,000	15,000	0	38,000	38,000	0	15,000	18,137	-3,137	68,000	-3,137
Post-Doc Haibo Wan (100% FTE)	30,000	0	30,000	36,000	36,000	0	54,000	24,741	29,259	120,000	59,259
Kevin Betts (5% FTE)							10,000	10,001	-1	10,000	-1
Joel Nelson (7% FTE)				5,000	5,000	0	5,000	14,605	-9,605	10,000	-9,605
Richard Barnes						0		54,962	-54,962	0	-54,962
Jake Galzki (100% FTE)	6,500	9,769	-3,269				93,500	43,014	50,486	100,000	47,217
[1]**Computers - NOT ALLOWED** unless unique to the project	1,500	2,476	-976				1,500	1,011	489	3,000	-487
Printing	500	0	500	2,000	0	2,000				2,500	2,500
[2]**Supplies** *(maps, computer supplies)*	2,000	0	2,000	1,000	0	1,000	1,500	100	1,400	4,500	4,400
[3]**Travel expenses in Minnesota**	1,000	0	1,000	2,000	0	2,000	1,000	0	1,000	4,000	4,000
[4]**Other** *(GIS software and other licenses)*	2,500	2,500	0				2,500	1,500	1,000	5,000	1,000
COLUMN TOTAL	**$59,000**	$29,745	$29,255	**$84,000**	$79,000	$5,000	**$184,000**	$168,071	$15,929	**$327,000**	**$50,184**

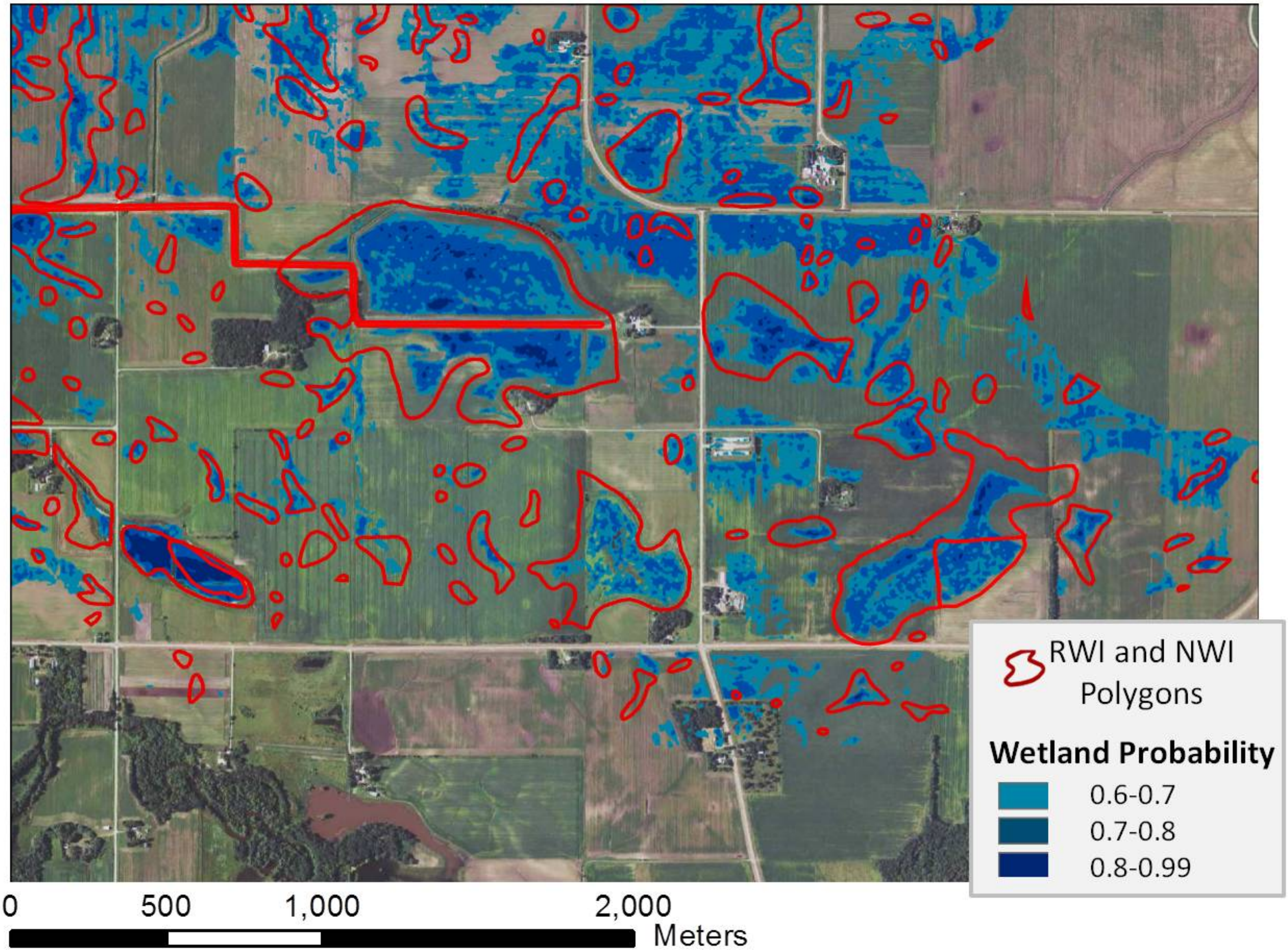
[1] Two computers with enough harddrive and RAM to store and process GIS and LiDAR spatial data

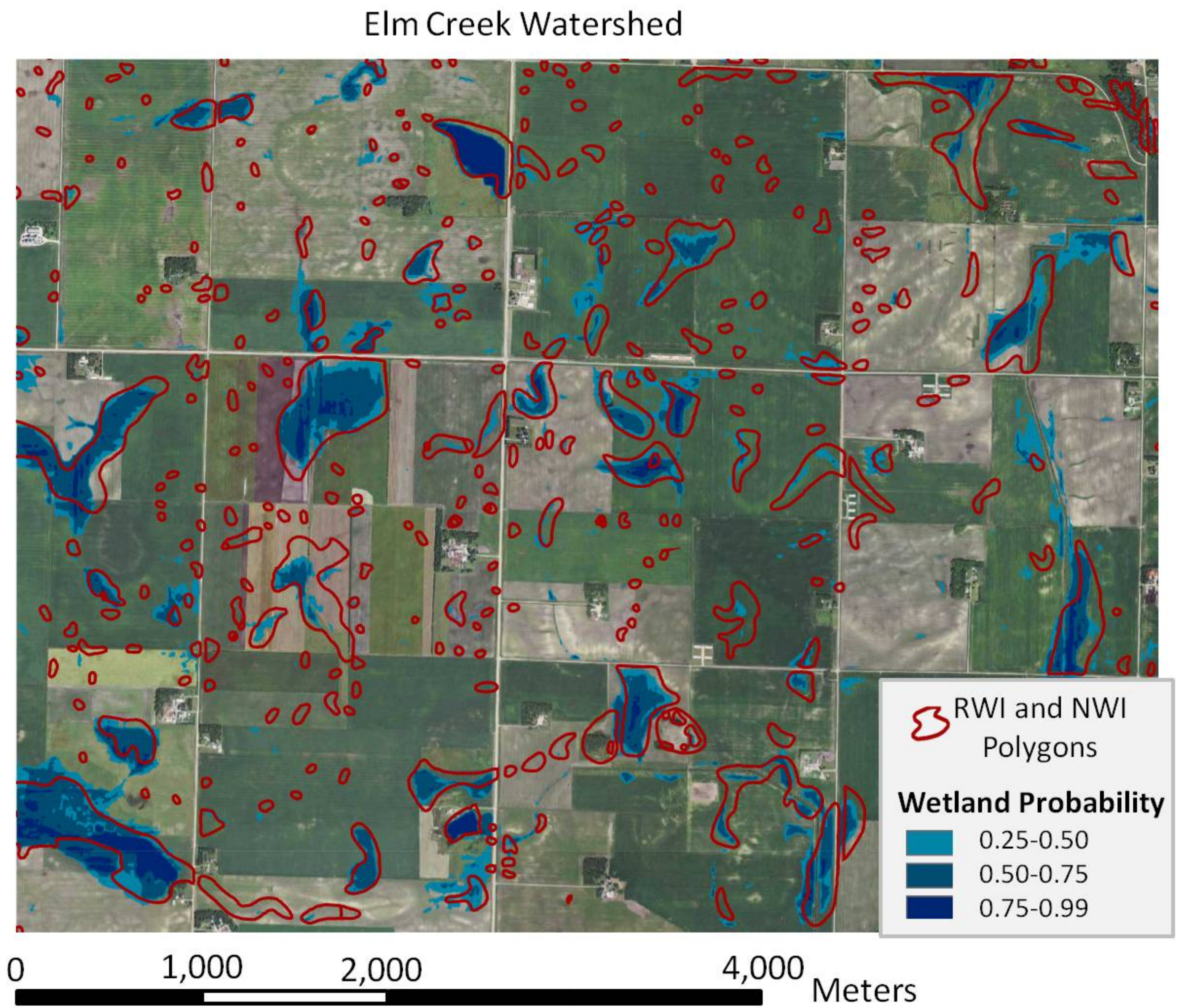
[2]Supplies include acquisition of published data (maps) describing/supplementing agricultural spatial data, large-capacity external back-up data drives and CD/DVDs and other supplies to mail or distribute software programs, maps and documents.

[3]Travel expenses include travel for field surveys done for data verification, calibration and validation. Travel also includes travel to workshops or meetings for presentation or discussion of project goals, methodologies or results.

[4]Other includes license fees for specialized ESRI ArcGIS and other software necessary for the laptop computer processing.

Beauford Watershed




Elm Creek Watershed
RWI and NWI Polygons
Wetland Probability
0.25-0.50
0.50-0.75
0.75-0.99
0
1,000
2,000
4,000
Meters

Seven Mile Creek Watershed