A

APPENDIX A

Public Participation Materials

Harris Pond Lake Association receives grant

By Kathleen McGwin

Harris Pond Lake Association received word that they have been approved for funding under the Wisconsin's Lake Planning Grant Program. The award covers a project period through June 30, 2012. The grant amount is $16,374 divided into two phases. The local share is $5,458 for both phases combined, part of which can be in donated or volunteer labor.

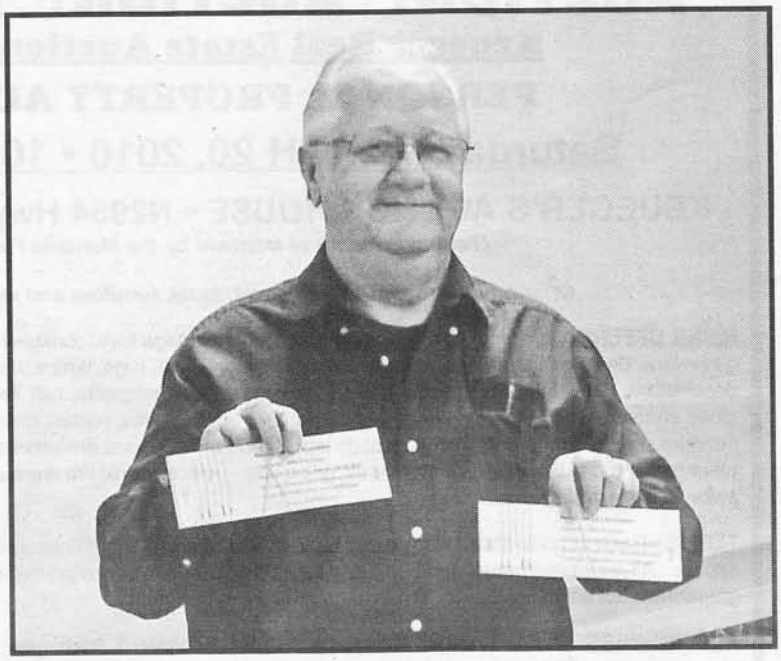
Phase I includes, "enhancing the knowledge…understanding of natural ecosystems," as well as water level assessments, sediment depth survey, and review of historical fisheries data. Phase II includes conducting an aquatic plant survey of native and exotic plants as well as purple loosestrife and the mapping of plant communities.

Harris Pond is part of the Montello River and Lake Watershed and this project is to interface with the Montello River Watershed data collected by UW-Stevens Point. That study has concluded and will be presented to the public on Friday, March 19 at 1 PM, with a location yet to be announced.

"This is the first step to look at our lake," said President Kent Pfeifer at Saturday's Association meeting where the Board and community members began discussing the upcoming project.

The funding will be formally announced at a special "Kick Off" meeting on Saturday, April 17 at 9 AM at the Harris Fire House Community Room. Everyone interested is invited.

The Association is continuing fund raising efforts and will have an Election Day Bake Sale on April 6 from 7 AM until sold out at the Fire House Community Room. Additionally, raffle tickets are being sold and can be purchased from any Harris Pond Lake Association member or by calling Treasurer Bill Sawicki at 608-296-2517. Only 300 $20 tickets will be sold and prizes are: 1st place, $1,000; 2nd place, $500; four 3rd place prizes of $100; and 22 4th place prizes of $50.



Treasurer of the Harris Pond Lake Association Bill Sawicki announced that fund raising raffle tickets are being sold. Only 300 tickets are available with 28 prizes totaling $3,000. The funds raised will help pay the match required in the recently announced Wisconsin Lake Planning Grant awarded to the Association. Information about the grant will be presented at a special kick-off meeting on April 17 at 9 AM at the Harris Fire House Community Room. An Election Day bake sale will take place on April 6 in the community room starting at 7 AM. (Photo by Kathleen McGwin)



Presentation Outline

- Onterra, LLC
- Why Create a Management Plan?
- Elements of a Lake Management Planning Project
  - Data & Information
  - Planning Process



Onterra, LLC

- Founded in 2005
- Staff
  - Four full-time ecologists
  - Two part-time ecologists
  - One Intern
- Services
  - Science and planning
- Philosophy
  - Promote realistic planning
  - Assist, not direct



Why create a lake management plan?

A goal without a plan is just a wish!

Elements of an Effective Lake Management Planning Project

Data and Information Gathering

Environmental & Sociological

Planning Process

Brings it all together



Data and information gathering

- Study Components
  - Water Quality Analysis
  - Watershed Assessment
  - Aquatic Plant Surveys
  - Fisheries Data Integration
  - Stakeholder Survey
  - Shoreland Assessment
  - Sediment Survey

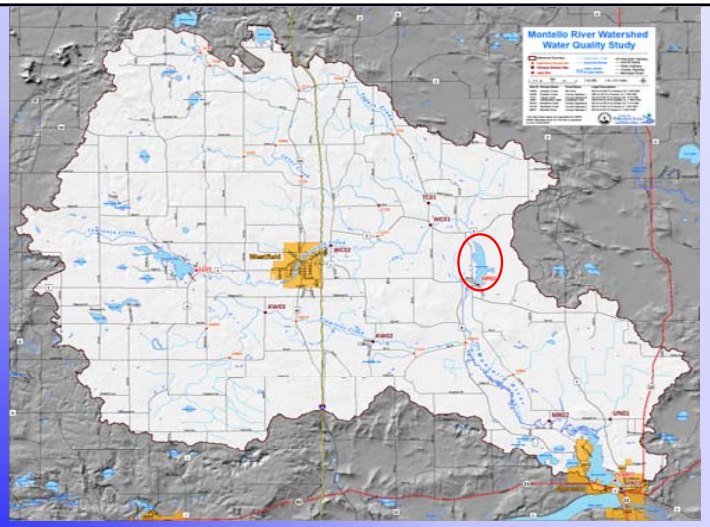


Water Quality Analysis

- General water chemistry
- Nutrient analysis
  - Lake trophic state (Eutrophication)
  - Limiting plant nutrient

Part of Montello River Watershed Project
UW-Stevens Point





Aquatic Plant Surveys

- Concerned with both native and non-native plants

Non-native Aquatic Plants

Curly-leaf Pondweed



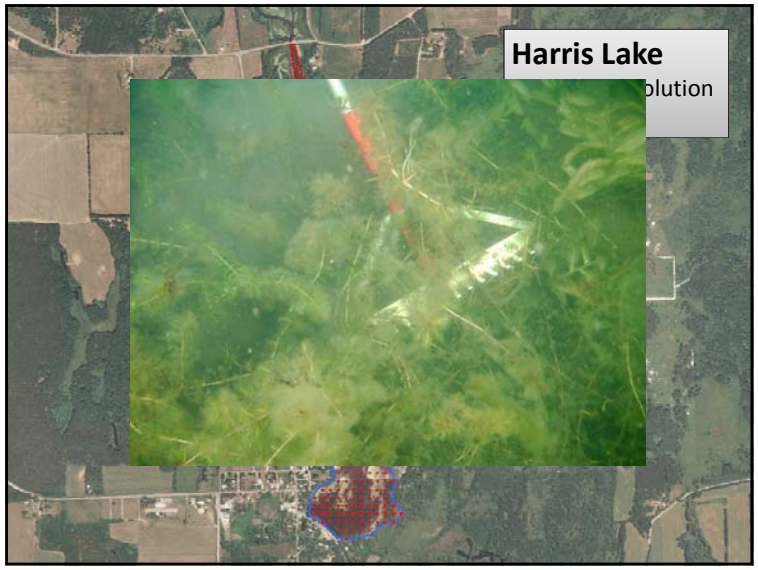
Non-native Aquatic Plants

Eurasian Water Milfoil



Aquatic Plant Surveys

- Concerned with both native and non-native plants
- Multiple surveys used in assessment
  - Curly-leaf pondweed survey
  - Point-intercept survey



Aquatic Plant Surveys

- Concerned with both native and non-native plants
- Multiple surveys used in assessment
  - Curly-leaf pondweed survey
  - Point-intercept survey
  - Plant community mapping

Fisheries Data Integration

- No fish sampling completed
- Assemble data from WDNR, USGS, & USFWS
- Fish survey results summaries (if available)
- Use information in planning as applicable



Stakeholder Survey

- HPLA completed survey in 2008
- Results will be integrated within management plan



Shoreland Assessment

- Shoreland area is important for buffering runoff and provides valuable habitat for aquatic and terrestrial wildlife.
- It does not look at lake shoreline on a property-by-property basis.
- Assessment ranks shoreland area from shoreline back 35 feet

Urbanized → Range → **Natural**





Sediment Survey

Sediment build-up is a concern among lake residents

Depth of Soft Sediment
- 129 Locations
- Water depths 6 feet or less



Planning Process

Planning Committee Meetings

Study Results (including a stakeholder survey)
Conclusions & Initial Recommendations
Management Goals
Management Actions
Timeframe
Facilitator(s)

↓

Implementation Plan



Thank You

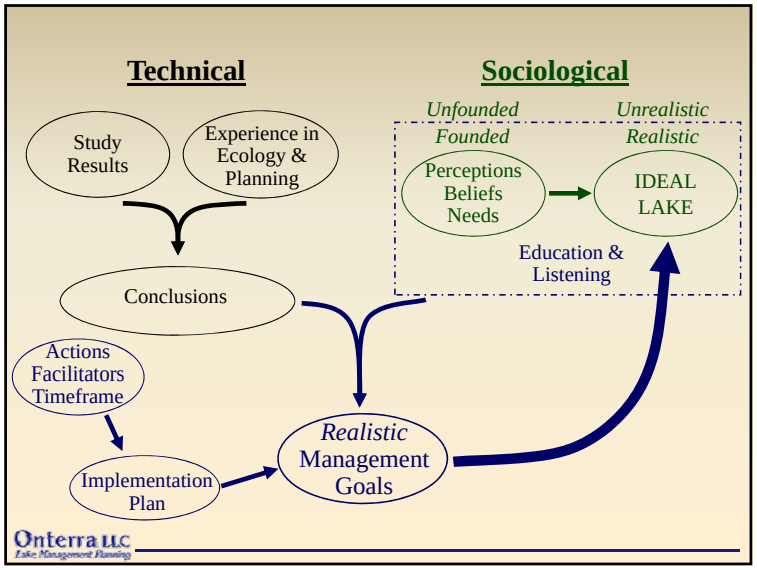
Many of the graphics used in this presentation were supplied by:

Wisconsin Lakes Partnership

UW Extension

Wisconsin Dept. of Natural Resources


The Planning Process
…it's not as easy as you may think.


Technical
Sociological
Unfounded
Unrealistic
Founded
Realistic
Study Results
Experience in Ecology & Planning
Perceptions Beliefs Needs
IDEAL LAKE
Education & Listening
Conclusions
Actions Facilitators Timeframe
Realistic Management Goals
Implementation Plan
Onterra LLC

Harris Pond Lake Association

Harris Pond
Management Planning Project
Planning Meeting I
August 29, 2011

Tim Hoyman, CLM
Onterra LLC
Lake Management Planning

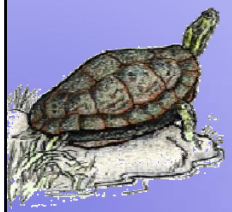
Presentation Outline

- **Lake Management Planning Project Overview**
- **Study Results**
  - Water Quality (Montello Watershed Info)
  - Watershed (Montello Watershed Info)
  - Aquatic Plants
    - Native Aquatic Plant Surveys
    - Curly-leaf Pondweed Findings
- **"Big Picture"**
- **Goals and Actions Discussion**



Study and Plan Goals

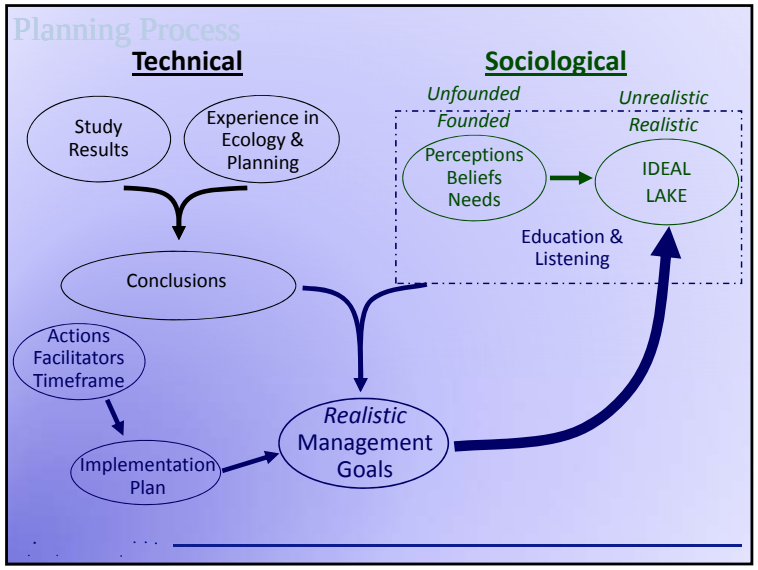
- Collect & Analyze Data
- Construct Updated & Useable Plan

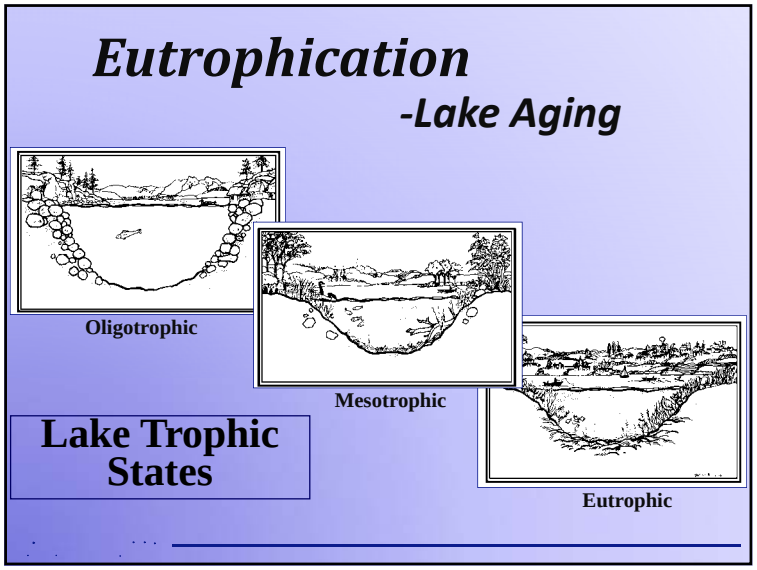


The Planning Process

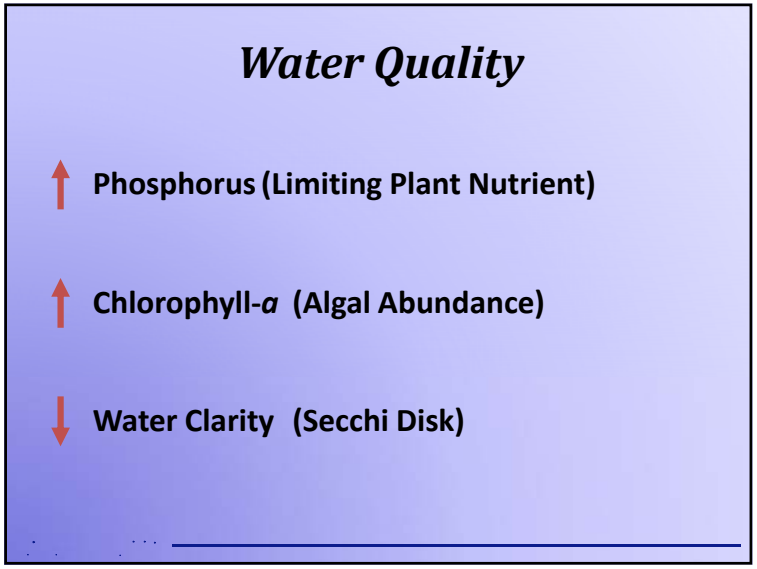
…it's not as easy as you may think.



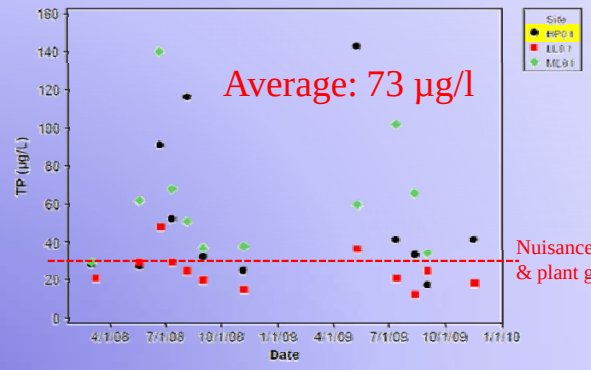

Planning Process
Technical
Sociological
Study Results
Experience in Ecology & Planning
Unfounded
Founded
Unrealistic
Realistic
Perceptions Beliefs Needs
IDEAL LAKE
Education & Listening
Conclusions
Actions Facilitators Timeframe
Implementation Plan
Realistic Management Goals


Eutrophication
-Lake Aging
Oligotrophic
Mesotrophic
Eutrophic
Lake Trophic States


Cultural Eutrophication
Accelerated eutrophication caused by human activity.


Water Quality
Phosphorus (Limiting Plant Nutrient)
Chlorophyll-a (Algal Abundance)
Water Clarity (Secchi Disk)

Total Phosphorus

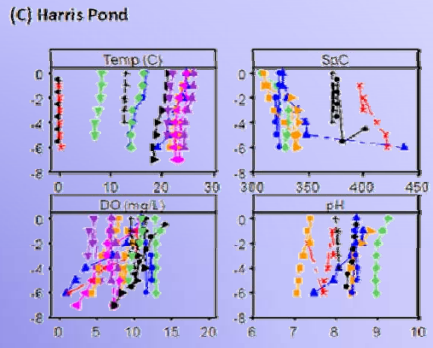


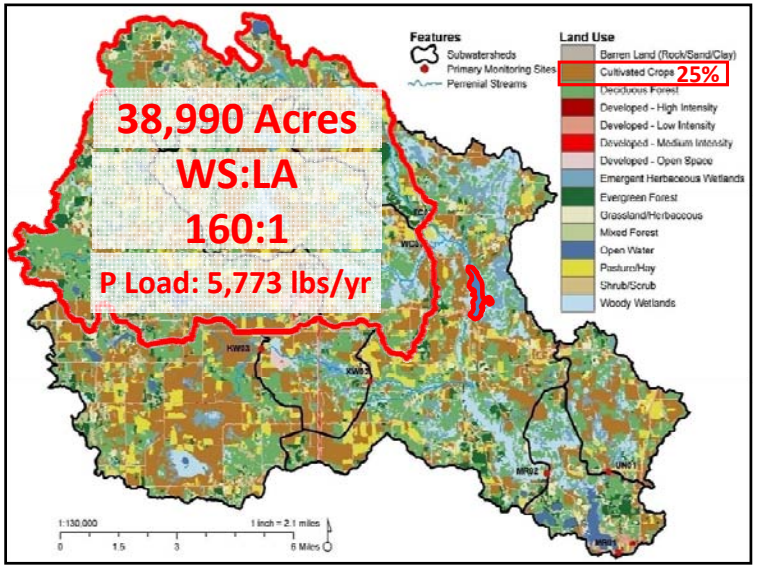
Shallow Lakes are Special



Aquatic Plants are Important

Dissolved Oxygen





Shoreland Assessment

- Shoreland area is important for buffering runoff and provides valuable habitat for aquatic and terrestrial wildlife.
- It does not look at lake shoreline on a property-by-property basis.
- Assessment ranks shoreland area from shoreline back 35 feet

Urbanized Range **Natural**





Shoreline Assessment Category Descriptions

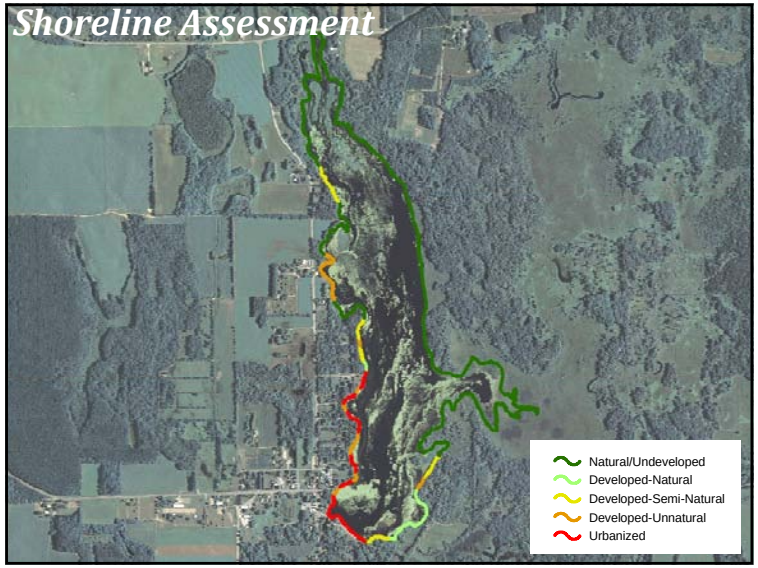
More Natural Habitat



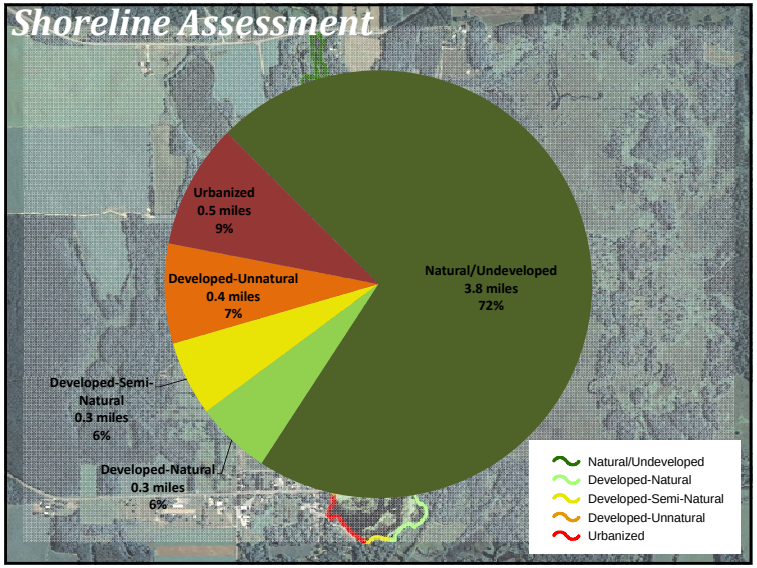
Urbanized | Developed-Unnatural | Developed-Semi-Natural | Developed-Natural | Natural/Undeveloped

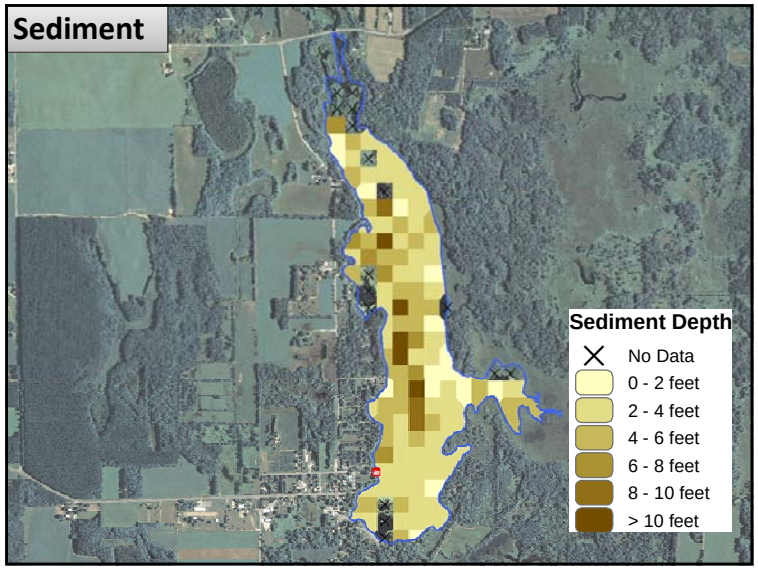
Greater Need for Restoration

Shoreline Assessment



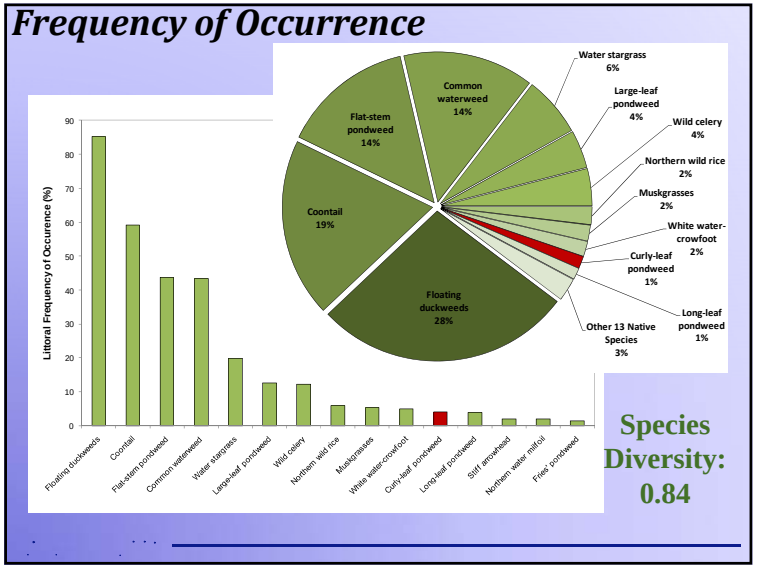
Shoreline Assessment




Sediment
Sediment Depth
No Data
0 - 2 feet
2 - 4 feet
4 - 6 feet
6 - 8 feet
8 - 10 feet
> 10 feet





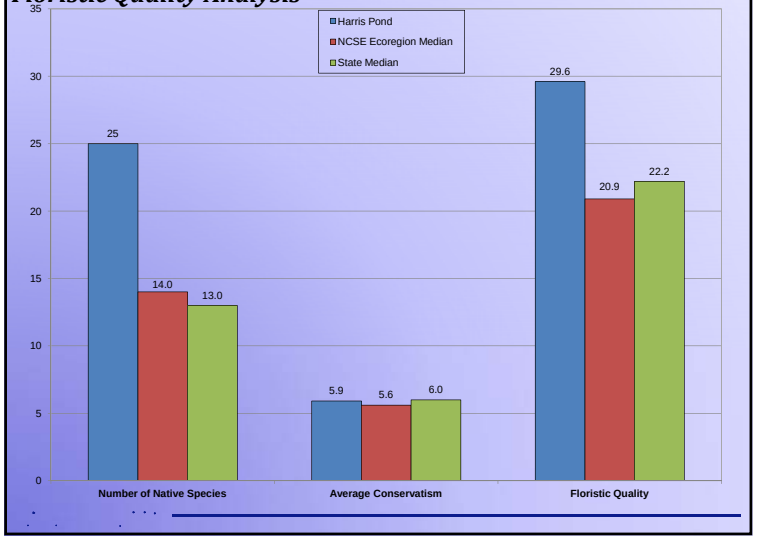

Frequency of Occurrence
Water stargrass 6%
Common waterweed 14%
Large-leaf pondweed 4%
Wild celery 4%
Northern wild rice 2%
Muskgrasses 2%
White water-crowfoot 2%
Curly-leaf pondweed 1%
Long-leaf pondweed 1%
Other 13 Native Species 3%
Floating duckweeds 28%
Coontail 19%
Flat-stem pondweed 14%
Littoral Frequency of Occurence (%)
Species Diversity: 0.84

Aquatic Plants

Wisconsin Ecoregions



Floristic Quality Analysis

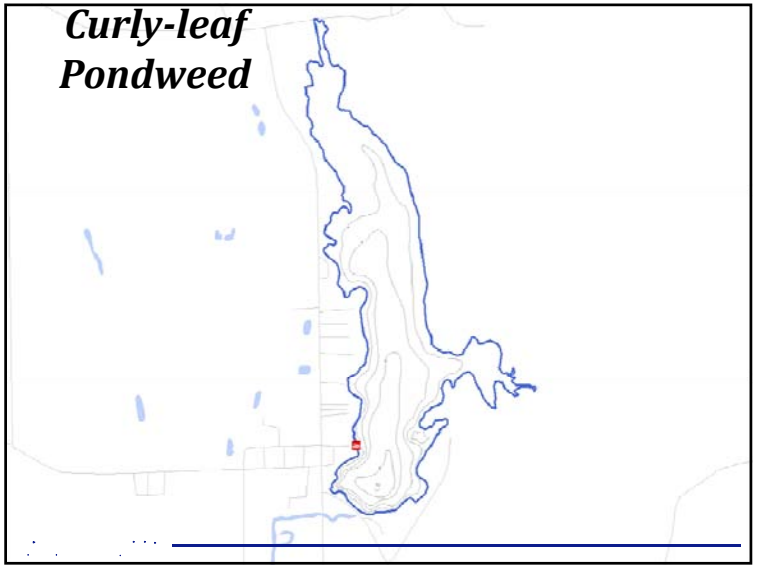


Non-native Aquatic Plants

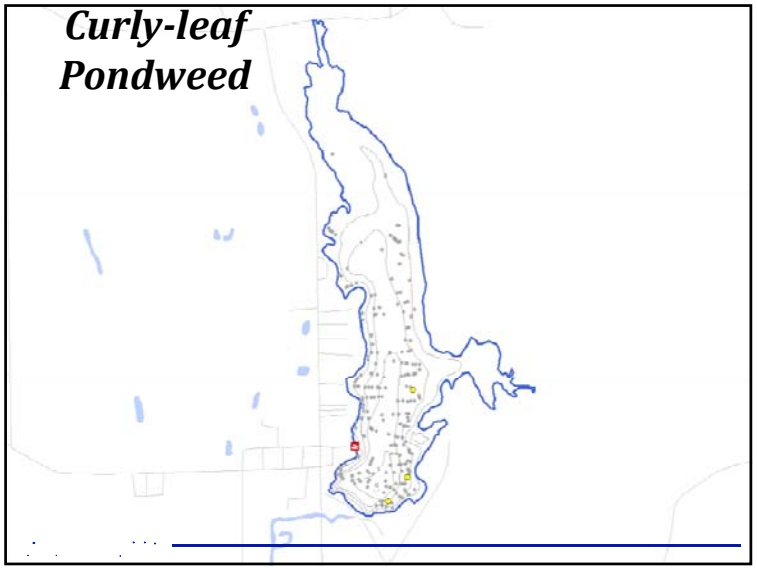
Curly-leaf Pondweed



Curly-leaf Pondweed



Curly-leaf Pondweed



Conclusions

- Watershed
  - Very large compared to lake – indicating that even significant changes in land cover (phosphorus yield) would lead to only subtle changes in Harris Pond productivity.
- Water Quality
  - Determined by watershed and phosphorus load.
  - Even with high phosphorus levels, lake's clarity is good indicating that plant community is keeping lake in *Clear State*

Conclusions

- Sediment
  - A great deal of soft sediments have accumulated in lake; however, much of that sediment is likely from plant production/decomposition and only a portion is from watershed sedimentation.
- Aquatic Plants
  - Aquatic plant community is of moderate diversity, but of relatively high quality.
  - Aquatic plant community is critical in maintaining water clarity.
  - CLP was located, but likely not causing issues at this time.

Thank You

Many of the graphics used in this presentation were supplied by:

Wisconsin Lakes Partnership

UWEX Extension

Wisconsin Dept. of Natural Resources



Harris Pond Management Planning Project

- Project Components
  - Watershed / Water Quality (Supplied by Montello Study – UWSP)
  - Aquatic Plant Surveys
  - Soft Sediment Study
  - Meetings and Discussion with Planning Committee
    - Detailed Results and Conclusions
- "Big Picture" - Conclusions
  - Water quality / Watershed condition
  - Aquatic Plants (Native and Exotic)
  - Sediment accumulation concerns
- Management Goals



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Conclusions

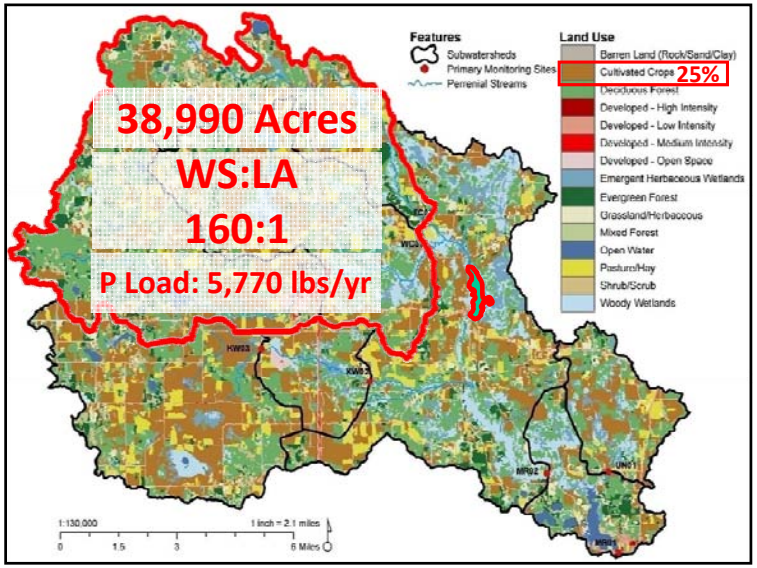
Watershed

- Very large with much agricultural land
- Nutrient input of great concern

Water Quality

- Water quality is *impaired*
- Excessive nutrients spur aquatic plant growth

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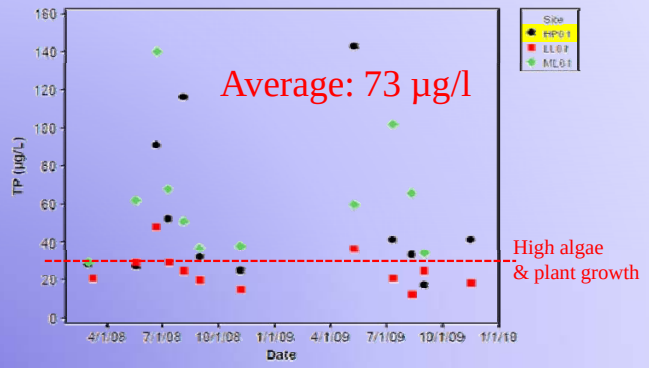
Phosphorus

- *Limiting Nutrient*
- *Controls Plant Abundance (Productivity)*
  - *Algae*
  - *Macrophytes*



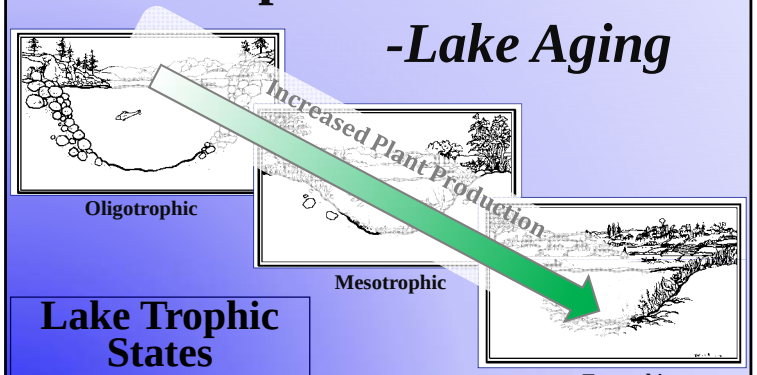
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Total Phosphorus



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Eutrophication *-Lake Aging*



Lake Trophic States

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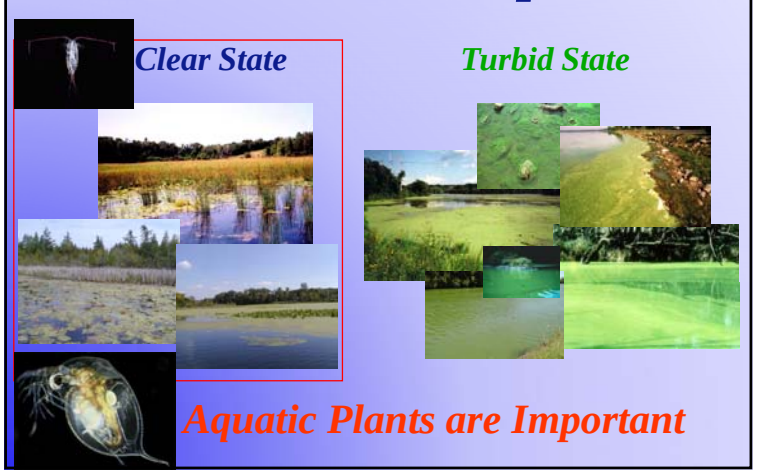
Conclusions

Aquatic Plants

- Aquatic plant community is moderately healthy
  - Relatively high species richness for ecoregion
  - Species present are indicative of a disturbed system
  - Curly-leaf pondweed and purple loosestrife populations threaten ecosystem health, but are not out of control at this point

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Shallow Lakes are Special



Aquatic Plants are Important

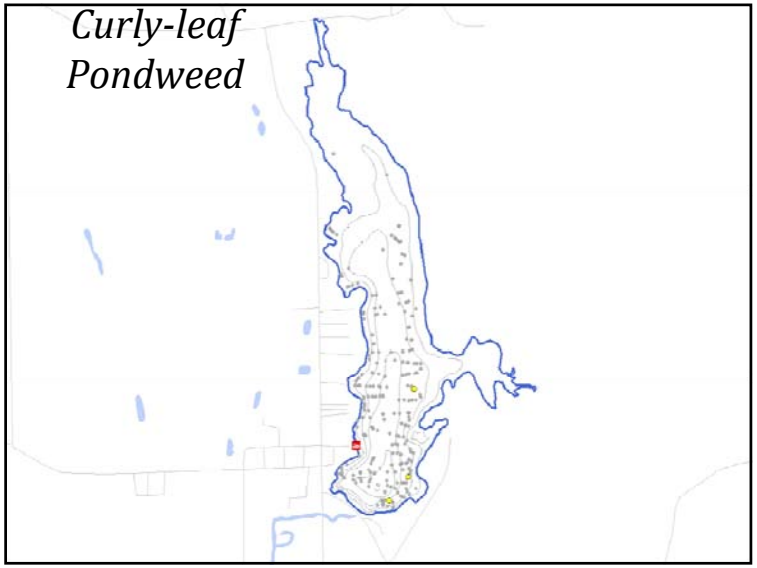
Non-native Aquatic Plants

Curly-leaf Pondweed



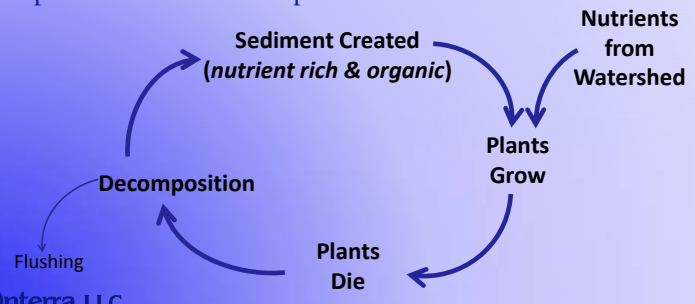
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Curly-leaf Pondweed

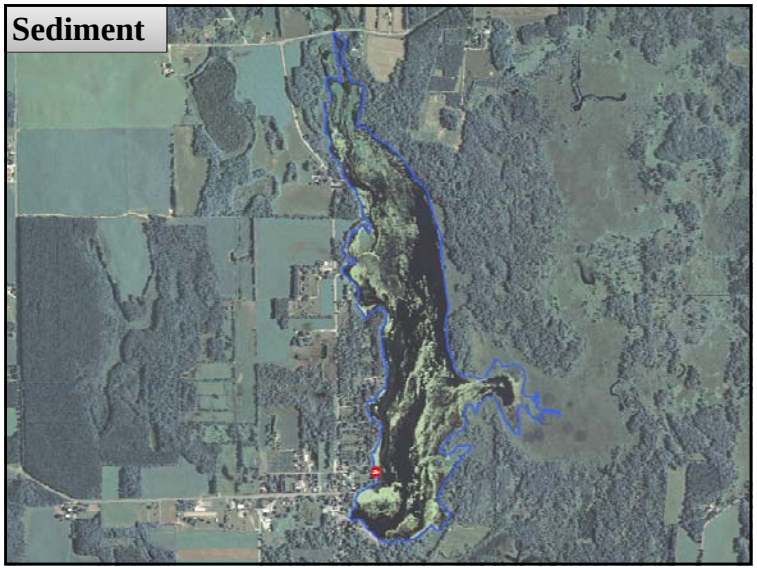


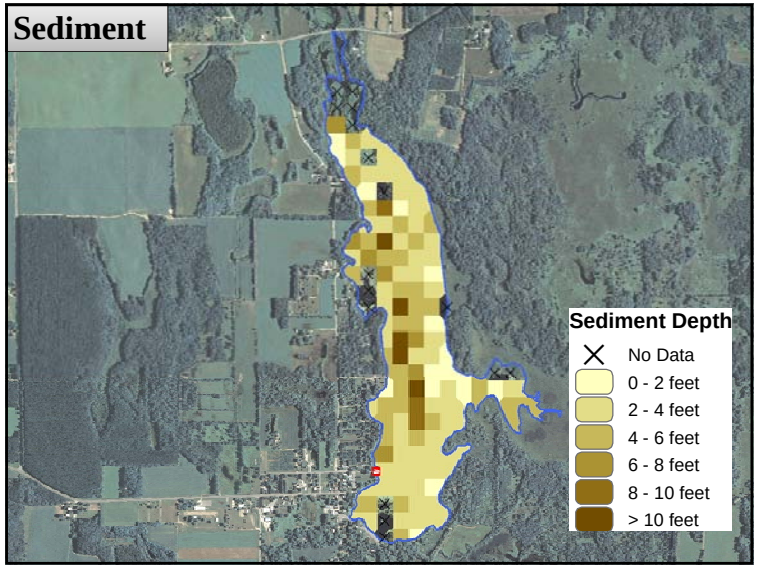
Conclusions

- Sediment build-up is occurring
  - Some sediment introduced via north tributary
  - Majority of sediment build-up is through plant production and decomposition



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Conclusions

Sediment Build-up

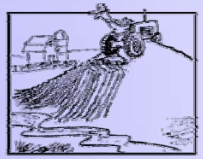
- Potential solutions are limited
  1. Watershed work to reduce nutrient inputs to lake
  2. Dredging to remove sediments
  3. Drawdown to compact sediments

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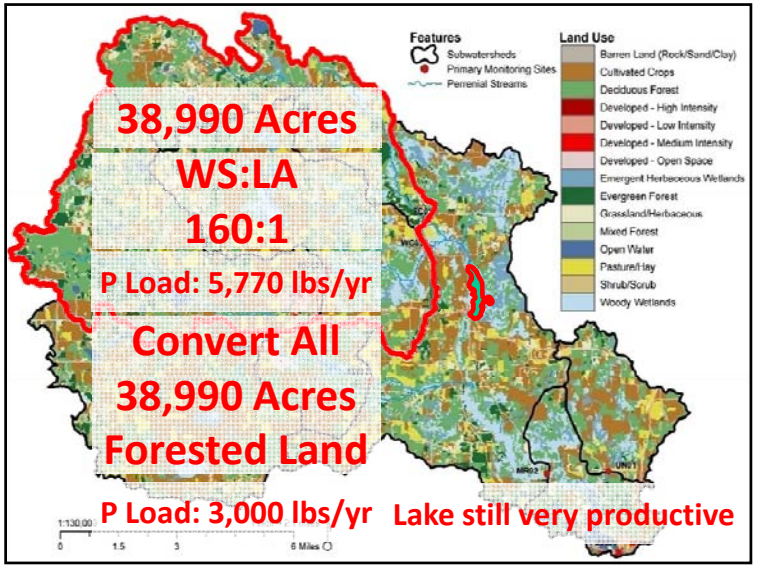
Conclusions

Sediment Build-up

- Potential solutions are limited
  1. Watershed work to reduce nutrient inputs to lake
     - No-till crop fields, buffer strips, sediment basins, etc.
     - 38,990 acres of land, high WS:LA
     - Costly and time consuming to implement
     - **Incredible changes to watershed would yield minimal lake response**



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Conclusions

Sediment Studies

- Potential solutions are limited
  1. ~~Watershed work to reduce nutrient inputs to lake~~
  2. Dredging to remove sediments
     - Effective, immediate results
     - Permitting is very difficult
     - Opens up habitat for CLP expansion
     - Very costly

Dredging Cost Example

Conservative Estimate: $15/cu.yd.

1 acre → 3 feet deeper = 4,840 cu.yd.

X $15/cu.yd.

$72,600



Image credit: Green Bay Press Gazette

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Conclusions

Sediment Studies

- Potential solutions are limited
  1. ~~Watershed work to reduce nutrient inputs to lake~~
  2. ~~Dredging~~
  3. Drawdown to compact sediments
     - Compact organic soils (2-4 feet gain)
     - Less costly to implement
     - Short term loss of recreation & economic revenue
     - Logistical / sociological hurdles



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Harris Pond Management Goals

- Goal 1 – Maintain Current Water Quality Conditions
  - Monitor water quality through CLMN
  - Begin with Secchi disk readings

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Harris Pond Management Goals

- Goal 2 – Monitor and manage AIS on Harris Pond
  - Reduce occurrence of purple loosestrife
    - Minor infestation
    - Hand removal efforts needed
  - Monitor CLP populations
    - Scattered population – not causing problems now
    - Professional mapping in 2013, repeat ~3 years

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Harris Pond Management Goals

- Goal 3 – Research Sediment Accumulation Issue in Harris Pond
  - Continue research on drawdown activities
    - Monitor Ted Johnson's DD projects
    - Maintain relationships with WDNR
      - Ted Johnson - DD's
      - David Stertz - Dam issues
      - David Bartz - Fisheries

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Thank You

Many of the graphics used in this presentation were supplied by:

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B

APPENDIX B

Stakeholder Survey Response Charts and Comments

About You

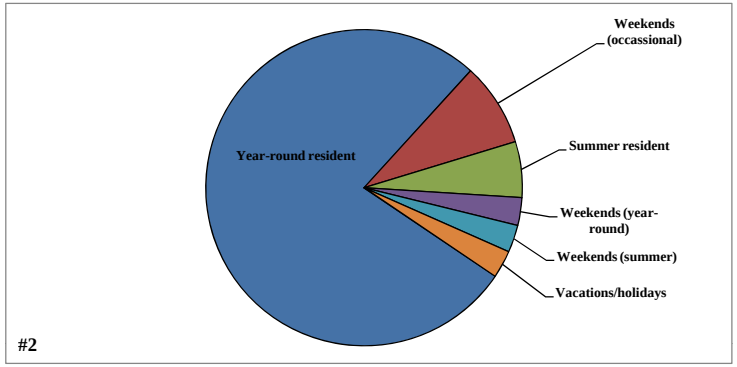
#1 How long have you lived in the Harrisville/Montello Watershed or visited/recreated on Harris Pond?

	%
High	92.0
Low	1.0
Average	31.0

68% of respondents lived near the pond from 9 to 53 years

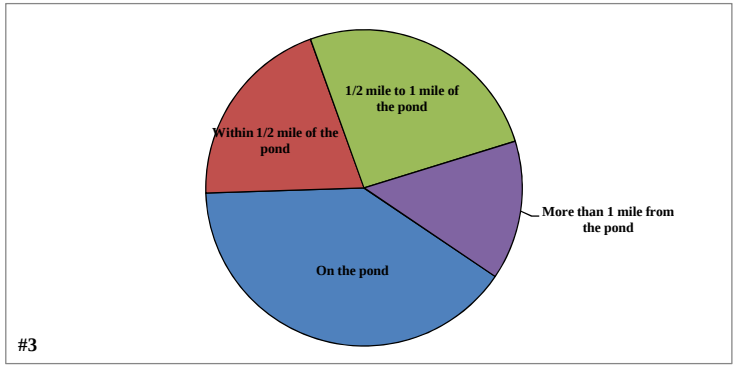
#2 What best describes the time you spend on Harris Pond?

	%
Year-round resident	77.0
Weekends (occassional)	8.5
Summer resident	5.7
Weekends (year-round)	2.8
Weekends (summer)	2.8
Vacations/holidays	2.8



#3 Where do you own or rent property?

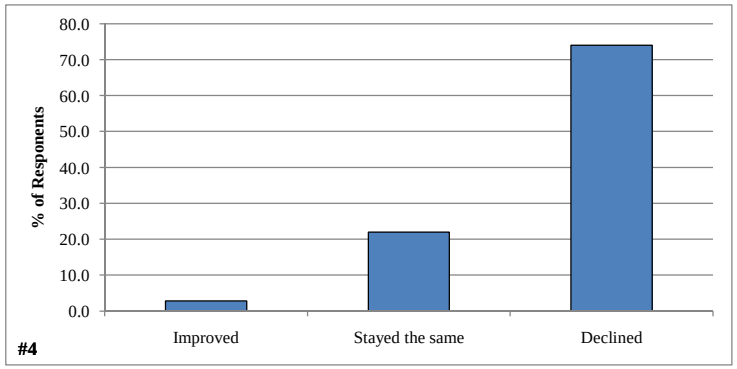
	%
On the pond	40.0
Within 1/2 mile of the pond	20.0
1/2 mile to 1 mile of the pond	25.7
More than 1 mile from the pond	14.2



Water Quality and Quantity

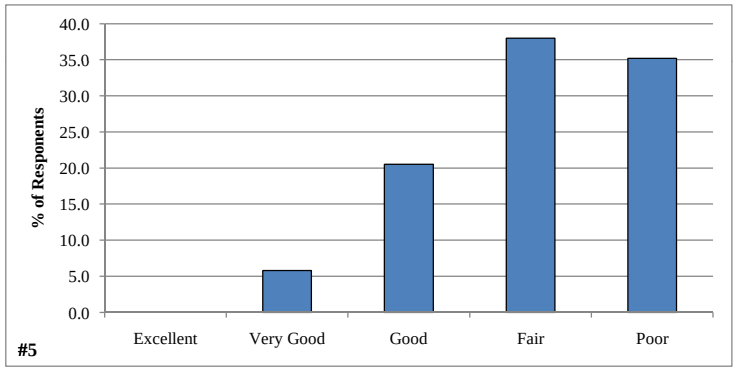
#4 In general, since you have lived near the pond, do you feel that the pond water quality has:

	%
Improved	2.8
Stayed the same	22.0
Declined	74.0



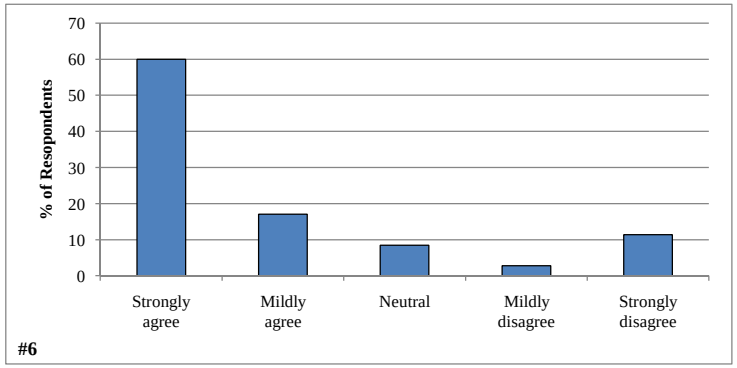
#5 How would you rate the water quality in Harris Pond this past year?

	%
Excellent	0.0
Very Good	5.8
Good	20.5
Fair	38.0
Poor	35.2



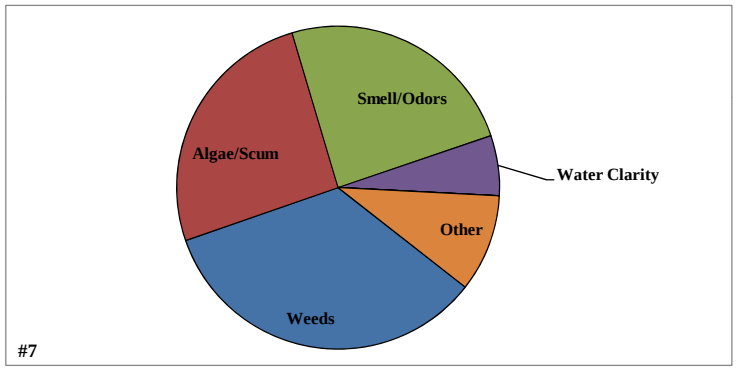
#6 The presence of native aquatic plants is essential to maintaining the water quality and water clarity of Harris Pond.

	%
Strongly agree	60.0
Mildly agree	17.1
Neutral	8.5
Mildly disagree	2.8
Strongly disagree	11.4



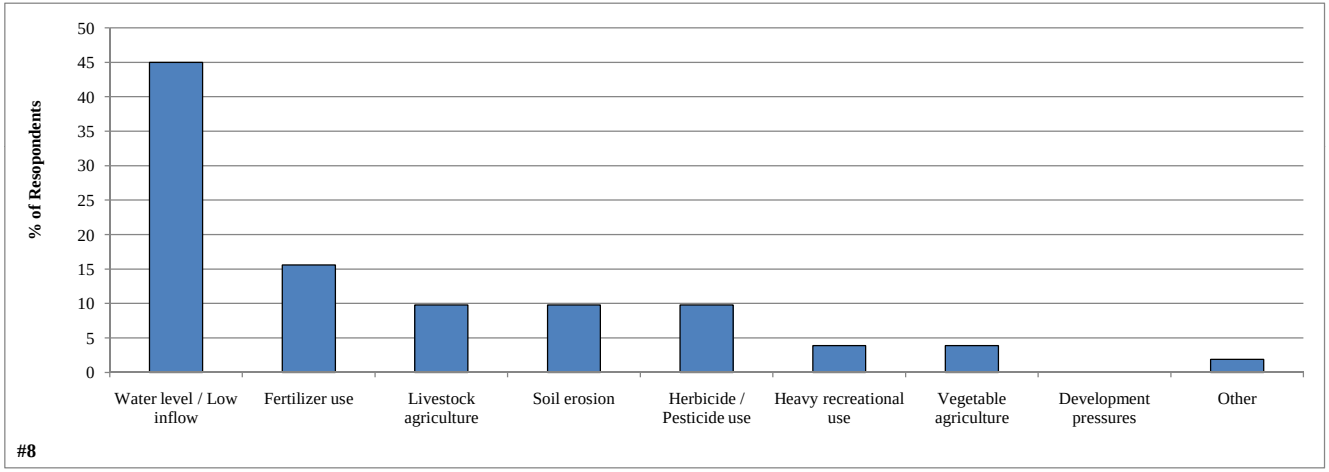
#7 Which of the following do you think are the major water quality problem(s) facing the pond?

	%
Weeds	34.0
Algae/Scum	25.6
Smell/Odors	24.3
Water Clarity	6.0
Litter	0.0
Other	9.7



#8 If you indicated that water quality has declined, which of the following issues, in your opinion, may have contributed to this decline?

	%
Water level / Low inflow	45.0
Fertilizer use	15.6
Livestock agriculture	9.8
Soil erosion	9.8
Herbicide / Pesticide use	9.8
Heavy recreational use	3.9
Vegetable agriculture	3.9
Development pressures	0.0
Other	1.9



Fishing

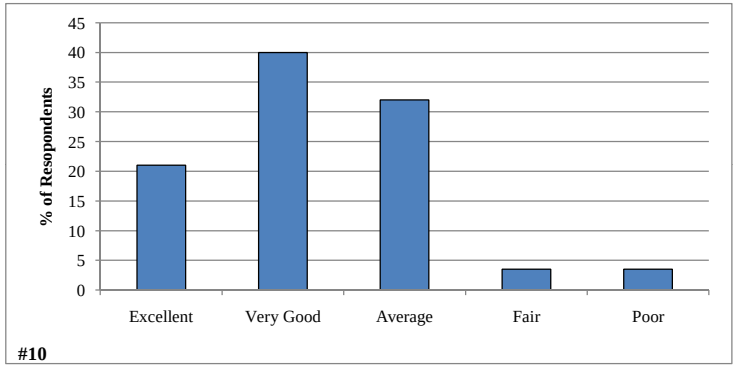
#9 How long have you fished in Harris Pond?

	%
High	85.0
Low	0.0
Average	24.9

68% of respondents fished the pond from 5 to 45 years

#10 How would you rate the fishing on the pond?

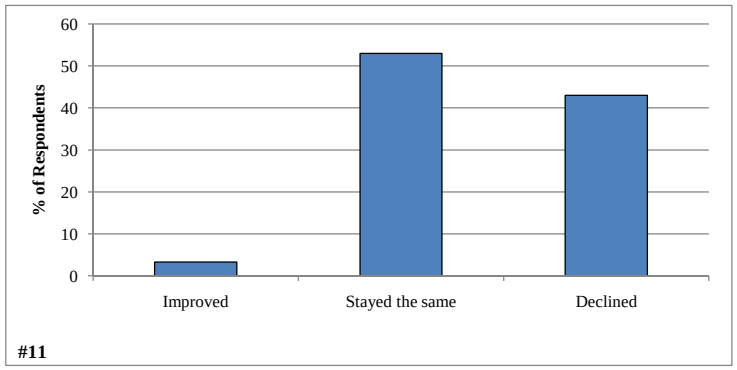
	%
Excellent	21.0
Very Good	40.0
Average	32.0
Fair	3.5
Poor	3.5



#10

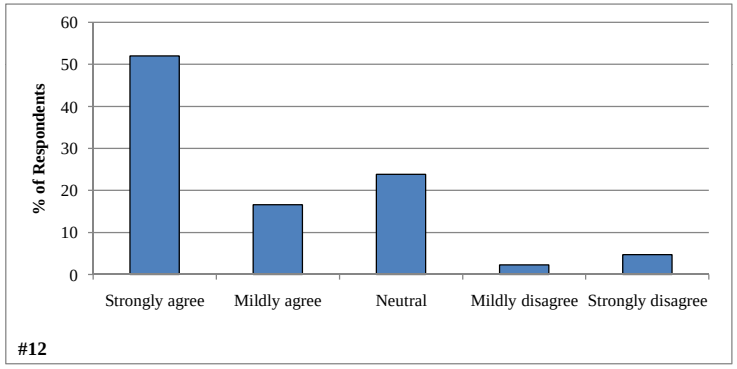
#11 In general, how has the quality of the fishing on Harris Pond changed since you started?

	%
Improved	3.3
Stayed the same	53.0
Declined	43.0



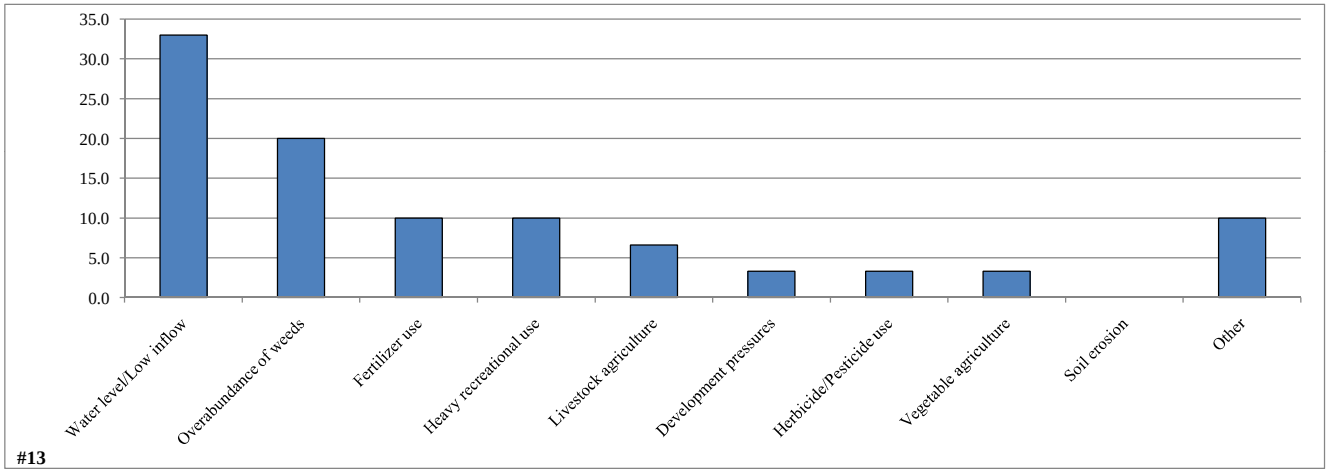
#12 Healthy native aquatic plant beds improve the quality of fishing.

	%
Strongly agree	52.0
Mildly agree	16.6
Neutral	23.8
Mildly disagree	2.3
Strongly disagree	4.7



#13 If you indicated that the fishing quality has declined, please indicate which of the following issues, in your opinion, may have contributed to this decline.

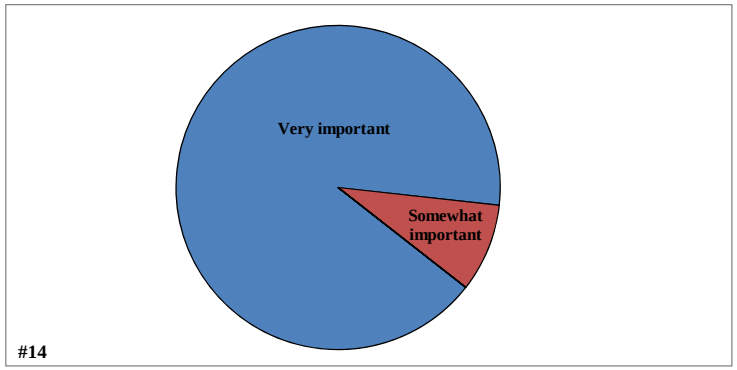
	%
Water level/Low inflow	33.0
Overabundance of weeds	20.0
Fertilizer use	10.0
Heavy recreational use	10.0
Livestock agriculture	6.6
Development pressures	3.3
Herbicide/Pesticide use	3.3
Vegetable agriculture	3.3
Soil erosion	0.0
Other	10.0



Wildlife

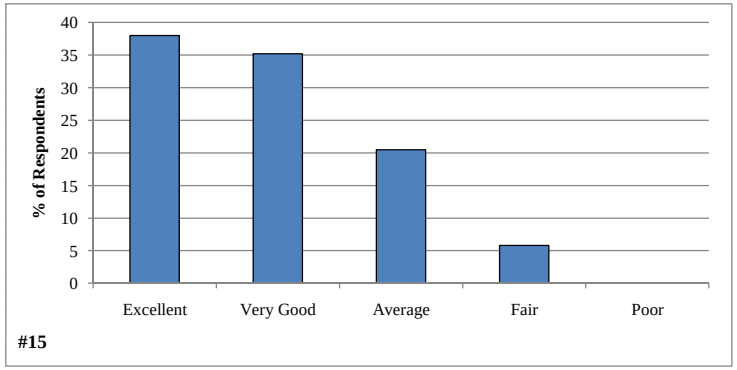
#14 How important is wildlife habitat and wildlife (ducks, geese, squirrels, songbirds) to you?

	%
Very important	91.0
Somewhat important	8.8
Not very important	0.0
Not important I dislike wildlife	0.0



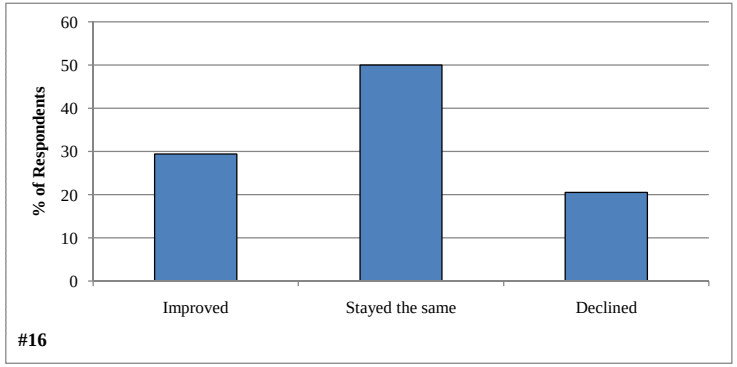
#15 How would you rate the overall wildlife habitat near/in the pond?

	%
Excellent	38.0
Very Good	35.2
Average	20.5
Fair	5.8
Poor	0.0



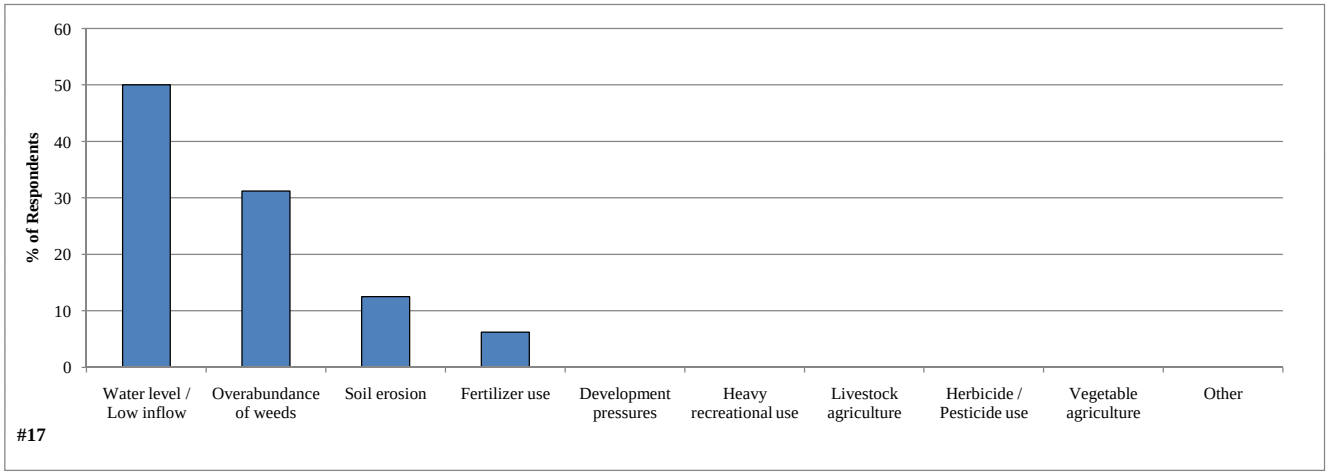
#16 How has the quality of wildlife habitat in Harris Pond changed since you have been around?

	%
Improved	29.4
Stayed the same	50.0
Declined	20.5



#17 If you indicated that the wildlife quality has declined, please indicate which of the following issues, in your opinion, may have contributed to this decline.

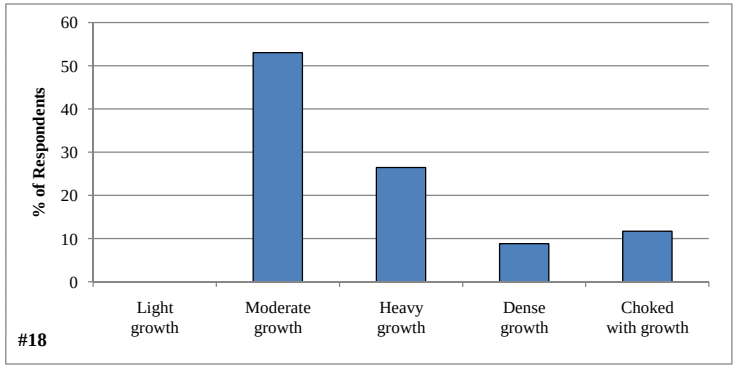
	%
Water level / Low inflow	50.0
Overabundance of weeds	31.2
Soil erosion	12.5
Fertilizer use	6.2
Development pressures	0.0
Heavy recreational use	0.0
Livestock agriculture	0.0
Herbicide / Pesticide use	0.0
Vegetable agriculture	0.0
Other	0.0



Aquatic Plants

#18 Which statement best describes your opinion of a desirable amount of aquatic plant growth in Harris Pond?

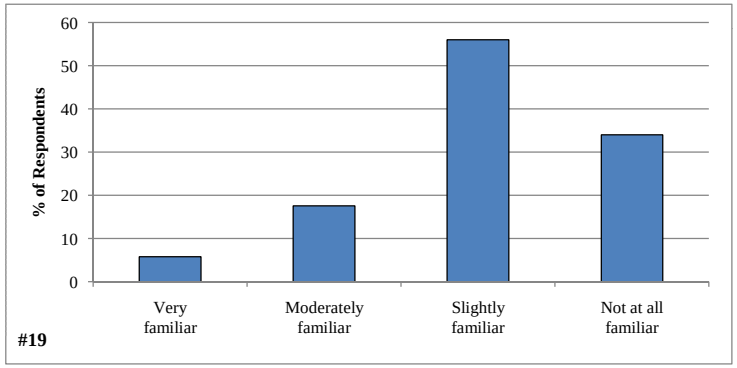
	%
Light growth	0.0
Moderate growth	53.0
Heavy growth	26.4
Dense growth	8.8
Choked with growth	11.7



Native Aquatic Plants

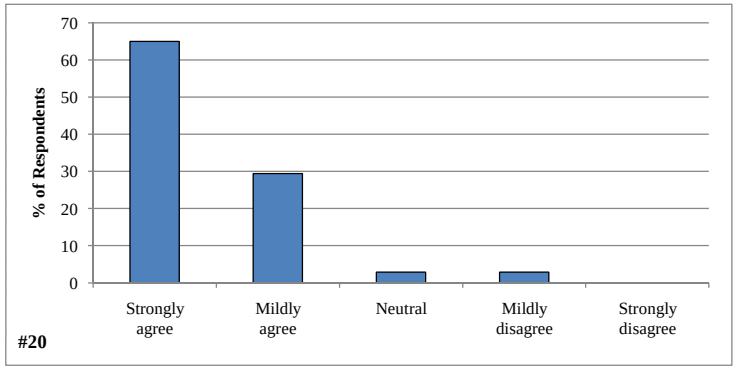
#19 Please rate your level of familiarity with issues related to native aquatic plants and pond ecology.

	%
Very familiar	5.8
Moderately familiar	17.6
Slightly familiar	56.0
Not at all familiar	34.0



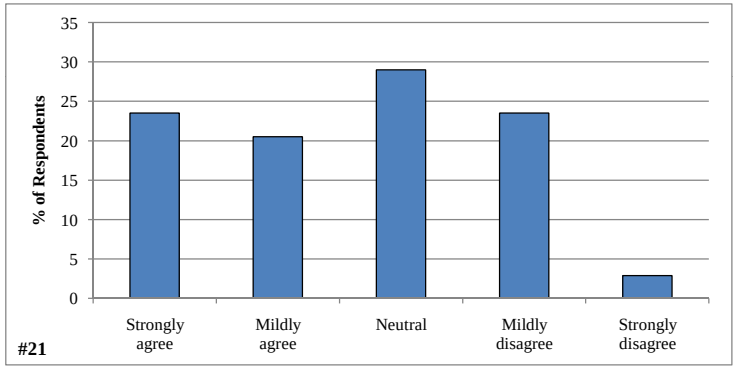
#20 Native aquatic plants serve important functions that maintain the health of Harris Pond.

	%
Strongly agree	65.0
Mildly agree	29.4
Neutral	2.9
Mildly disagree	2.9
Strongly disagree	0.0



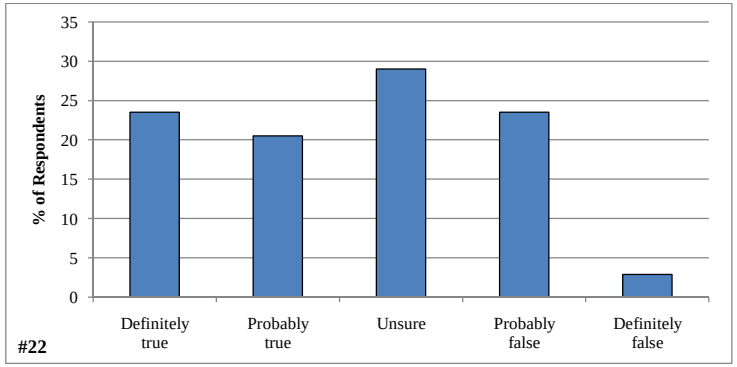
#21 Abundant floating and emergent native aquatic plants are signs of an unhealthy pond.

	%
Strongly agree	23.5
Mildly agree	20.5
Neutral	29.0
Mildly disagree	23.5
Strongly disagree	2.9



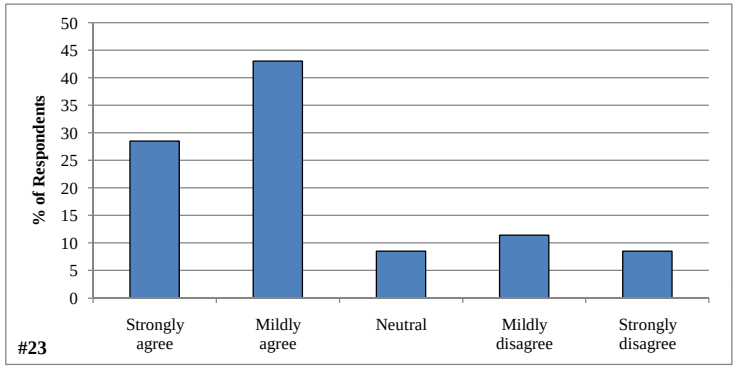
#22 Removal of native aquatic plants is harmful to the pond's health (water quality, biotic balance).

	%
Definitely true	45.0
Probably true	17.1
Unsure	22.8
Probably false	11.4
Definitely false	5.7



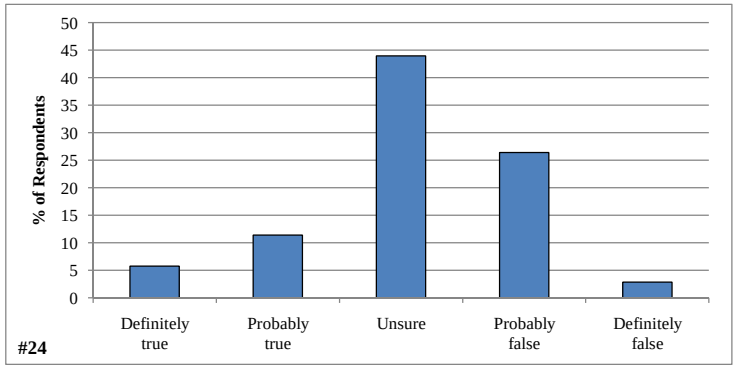
#23 Native aquatic plants add to the scenec beauty of Harris Pond.

	%
Strongly agree	28.5
Mildly agree	43.0
Neutral	8.5
Mildly disagree	11.4
Strongly disagree	8.5



#24 Native aquatic plants reduce the economic values of the pond in the long-term.

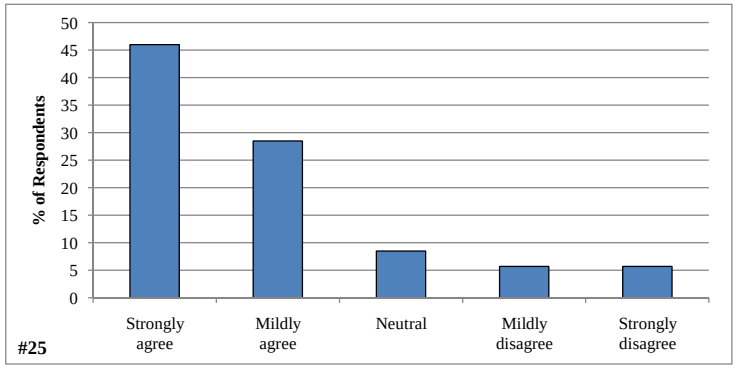
	%
Definitely true	5.8
Probably true	11.4
Unsure	44.0
Probably false	26.4
Definitely false	2.9



Exotic Aquatic Plants

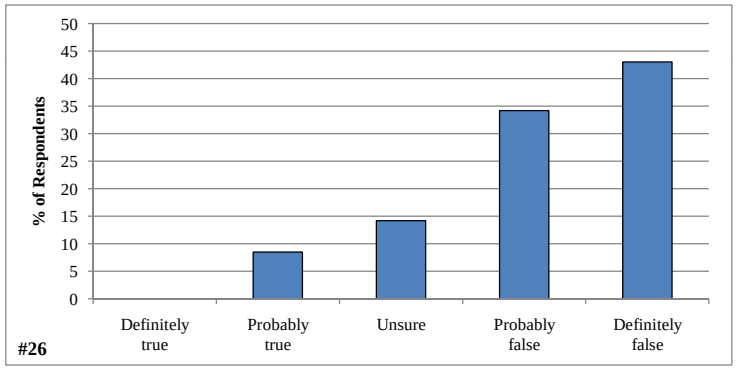
#25 Abundant floating and emergent exotic aquatic plants are signs of an unhealthy pond.

	%
Strongly agree	46.0
Mildly agree	28.5
Neutral	8.5
Mildly disagree	5.7
Strongly disagree	5.7



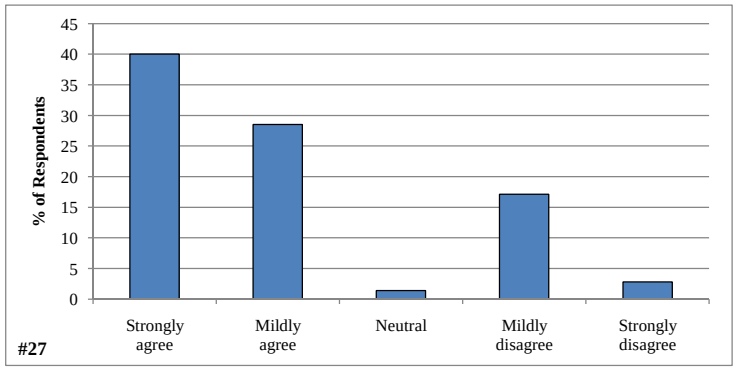
#26 Removal of exotic aquatic plants is harmful to the pond's health (water quality, biotic balance).

	%
Definitely true	0.0
Probably true	8.5
Unsure	14.2
Probably false	34.2
Definitely false	43.0



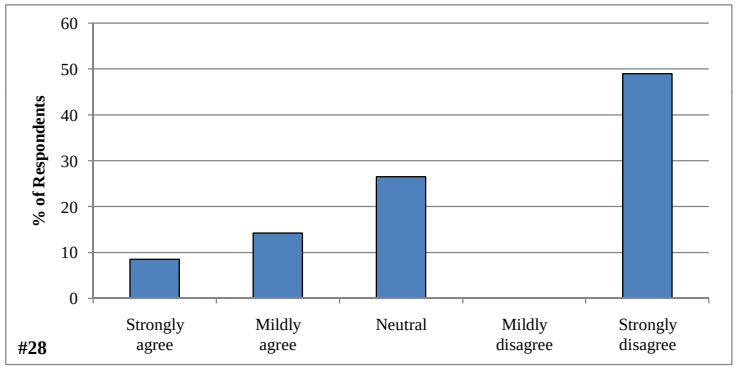
#27 I believe the use of an aquatic plant harvester for the control of Eurasian water milfoil in Harris Pond is an acceptable management tool.

	%
Strongly agree	40.0
Mildly agree	28.5
Neutral	1.4
Mildly disagree	17.1
Strongly disagree	2.8



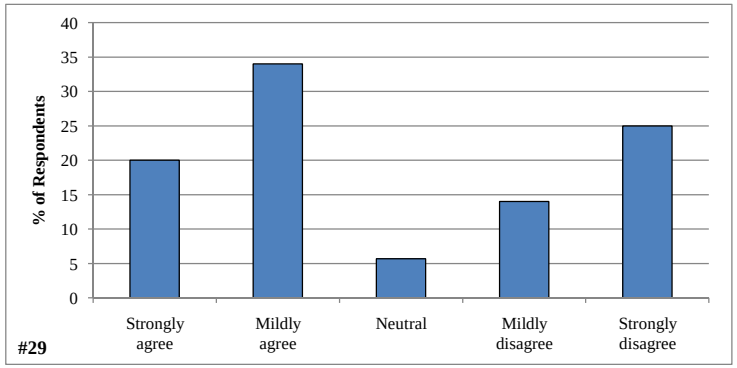
#28 I believe the use of a winter drawdown for the control of Eurasian water milfoil in Harris Pond is an acceptable management tool.

	%
Strongly agree	8.5
Mildly agree	14.2
Neutral	26.5
Mildly disagree	0.0
Strongly disagree	49.0



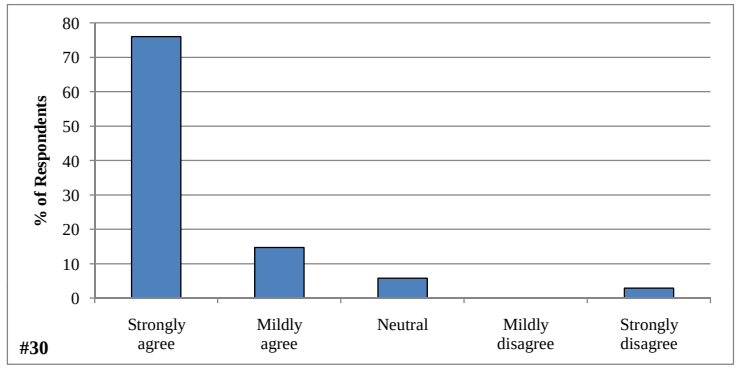
#29 I believe the professional application of chemicals for the control of Eurasian water milfoil in Harris Pond is an acceptable management tool.

	%
Strongly agree	20.0
Mildly agree	34.0
Neutral	5.7
Mildly disagree	14.0
Strongly disagree	25.0



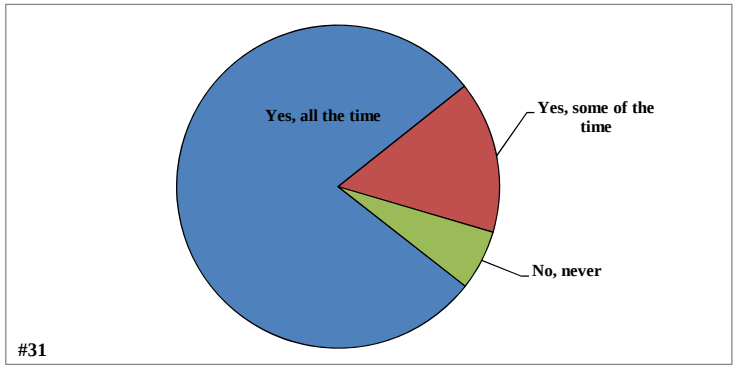
#30 Low water level flows can create conditions that enhance growth of aquatic plants in Harris Pond.

	%
Strongly agree	76.0
Mildly agree	14.7
Neutral	5.8
Mildly disagree	0.0
Strongly disagree	2.9



#31 To help prevent the spread of exotic plants into Harris Pond, do you clean your boat, trailer and fishing equipment before using it in Harris Pond after it has been used in another lake?

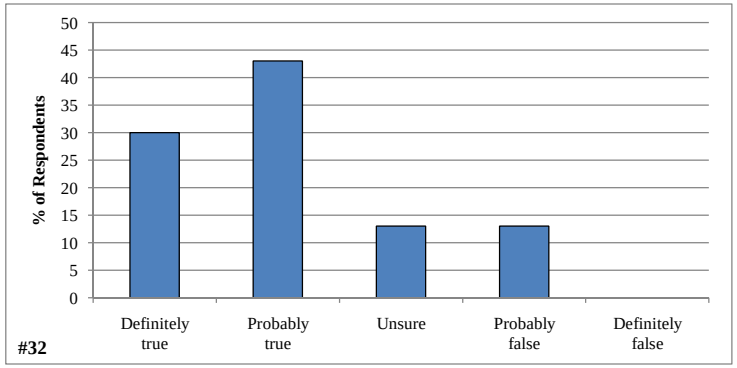
	%
Yes, all the time	76.0
Yes, some of the time	14.7
No, never	5.8



Shoreline Residents

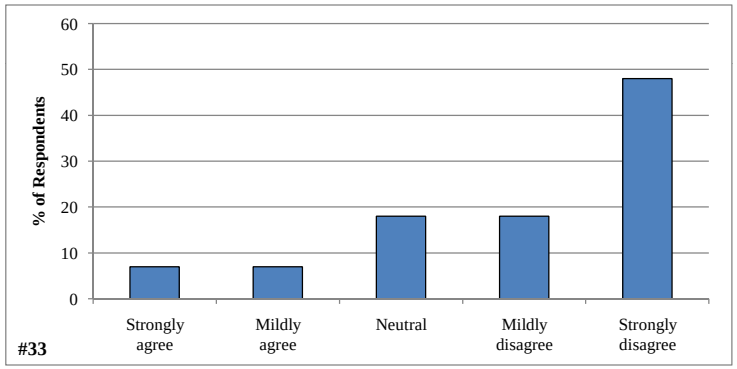
#32 Removal of native aquatic plants increases shoreline erosion.

	%
Definitely true	30.0
Probably true	43.0
Unsure	13.0
Probably false	13.0
Definitely false	0.0



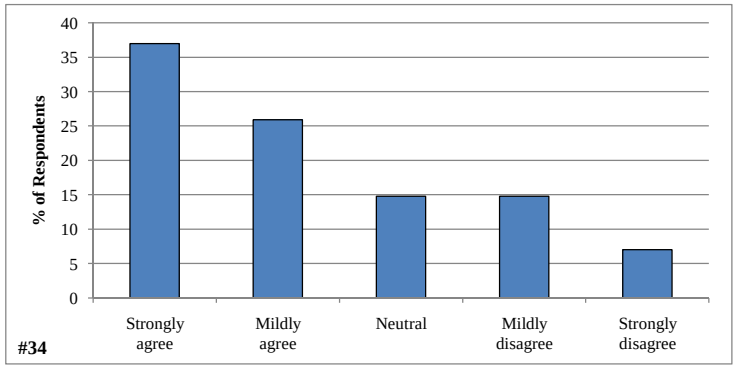
#33 Pond shorelines are more beautiful when lawns are turf grass and mowed to the edge.

	%
Strongly agree	7.0
Mildly agree	7.0
Neutral	18.0
Mildly disagree	18.0
Strongly disagree	48.0



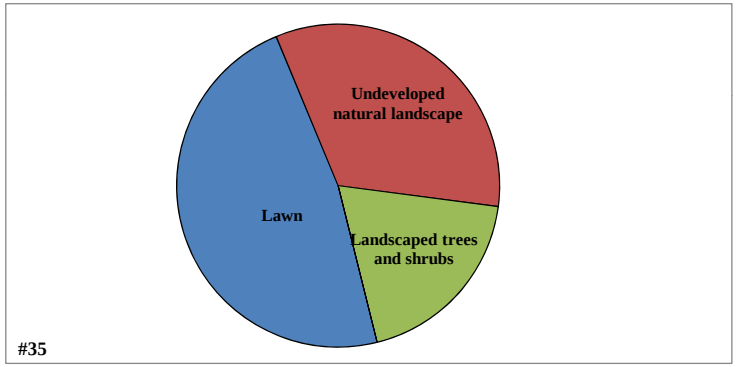
#34 Pond shorelines are more attractive when they have an abundance of native vegetation.

	%
Strongly agree	37.0
Mildly agree	25.9
Neutral	14.8
Mildly disagree	14.8
Strongly disagree	7.0



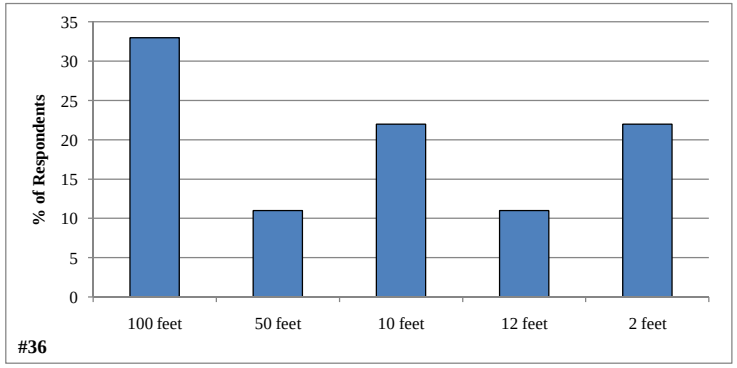
#35 What best describes the location where your property meets the pond?

	%
Lawn	37.0
Undeveloped natural landscape	25.9
Landscaped trees and shrubs	14.8
Rock riprap	0.0
Retaining wall	0.0



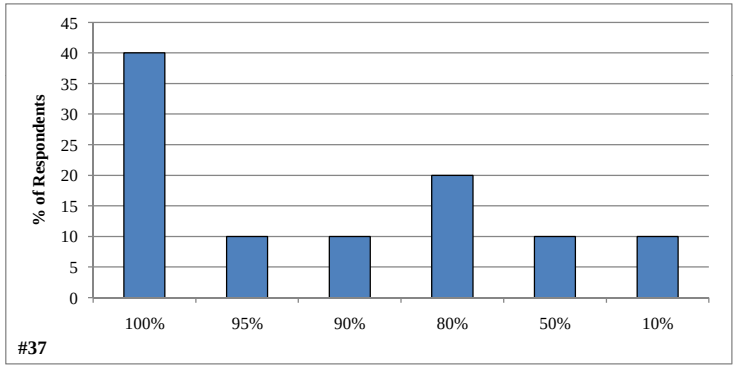
#36 If you have undeveloped natural landscape or a combination of un-mowed vegetation with trees and shrubs, how far from the edge of the pond on to the property does it extend?

	%
100 feet	33.0
50 feet	11.0
10 feet	22.0
12 feet	11.0
2 feet	22.0



#37 About what percent of your shoreline property is mowed?

	%
100%	40.0
95%	10.0
90%	10.0
80%	20.0
50%	10.0
10%	10



#38 Do you use fertilizer?

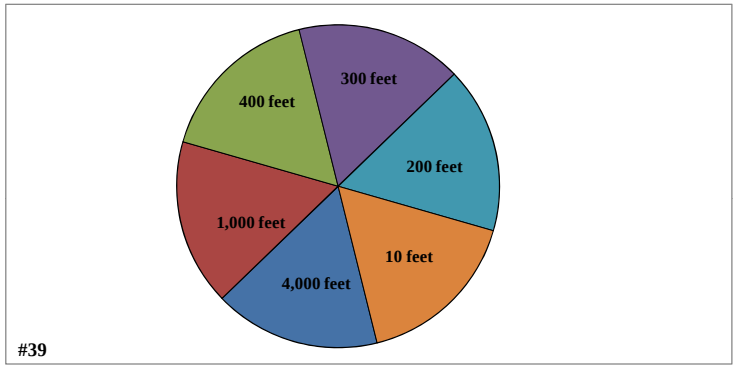
	%
Yes	30.0
No	70.0

#39 What is the closest distance from the pond to the area that is fertilized?

	%
4,000 feet	16.0
1,000 feet	16.0
400 feet	16.0
300 feet	16.0
200 feet	16.0
10 feet	16.0

If you answered "Yes" to #38, where do you use fertilizer?

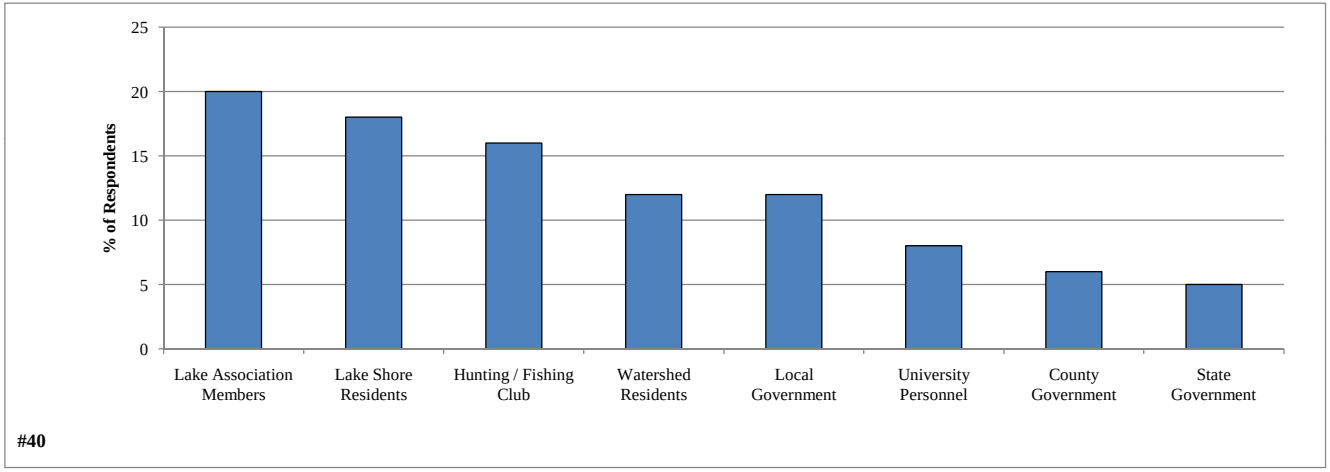
	%
Garden	58.0
Lawn	42.0
Other	33.0



Your Opinion

#40 Who should be involved in making management decisions for Harris Pond?

	%
Lake Association Members	20.0
Lake Shore Residents	18.0
Hunting / Fishing Club	16.0
Watershed Residents	12.0
Local Government	12.0
University Personnel	8.0
County Government	6.0
State Government	5.0



#40

#41 In your opinion, what should be done to restore, maintain, or improve the pond? Fill in the space below with your opinion

# of Responses	Response
22	Maintain water flow and or levels
15	Weed control and or removal
14	Silt and or sediment removal
9	Wild rice control
4	No draw down
2	Farming and fertilization
2	Minimal or no chemical use
2	Better education or communication on the part of the Lake Association, telling the community and/or sporsmant's club what is really happening
1	No large boats allowed on pond
1	Remove silt through compacting
1	Perform studies and follow DNR proposal
1	Restore natural landscape around water edge
1	Conduct a lake management plan and weed study
1	Pond needs a sandy beach area
1	Study native weeds versus exotic weeds
1	Maintain water level during spawning season
1	Practice catch and release of all large fish
1	Drain dredge and refill pond
1	Build an island in line with the dam to cause current to go around both sides of the island. Water going around island will cause better flow and help water clarity in bays.
1	Constant draining of pond by power plant had negative effect on wild life, pond ecosystem, and economy.
1	Declining water depth on pond is causing low oxygen. Surface weeds duck wort blocks sun to create low oxygen. Lake is very resilient and fish come back, but situation causes terrible odor because of rotting vegetation and dead fish.
1	Positive comments about exploring possibility to create a healthy environment that will be accepted by the majority for both people and wildlife.

#41 In your opinion, what should be done to restore, maintain, or improve the pond?
Fill in the space below with your opinion

# of Responses	Response
22	Maintain water flow and or levels
15	Weed control and or removal
14	Silt and or sediment removal
9	Wild rice control
4	No draw down
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1	Positive comments about exploring possibility to create a healthy environment that will be accepted by the majority for both people and wildlife.

C

APPENDIX C

Montello Watershed Study

Guidance for Improvement of Water Quality in the Montello River Watershed

Final Report to Montello Lake District and Wisconsin Department of Natural Resources

N. Turyk, M. Bruenig, P. McGinley



College of Natural Resources

Center for Watershed Science and Education

Acknowledgements

This study was a cooperative effort between the Marquette County Land and Water Conservation Department, the Montello River Watershed Task Force, the Harris Pond Lake Association, the Lawrence Lake Association, the Montello Lake District, the Wisconsin Department of Natural Resources (WDNR), the United States Geological Survey (USGS) and the University of Wisconsin-Stevens Point (UWSP) Center for Watershed Science and Education (CWSE).

We would like to acknowledge the support provided by our partners who provided input to guide this study, dissemination of information, implemented a Lake Fest, collected data, provided information about their land management practices, and participated in a number of meetings. We sincerely appreciate the time, energy, and funds contributed to this effort.

I would like to dedicate this report to Bob Cunningham, in recognition for his years of service as President of the Lawrence Lake Association, and for his assistance with this study. Bob was a very enjoyable person to be around, and I always looked forward to our outings on Lawrence Lake. The community lost not only a good, kind hearted man, but an active water quality advocate. Bob, you will be sincerely missed.
-Mark Breunig

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Executive Summary

This report summarizes the results of water quality study conducted in the Montello River Watershed between January 2008 and January 2010. The impetus for the study was to identify sources of water quality problems in Montello River and Montello Lake by evaluating lake, stream, and river quality at 11 sites throughout the watershed, including Lawrence and Montello Lakes, Harris Pond, Taggitz, Westfield (2), Klawitter (2), and Unnamed Creeks, and the Montello River (3). During this study period samples were collected throughout the year and during a variety of flow conditions so this dataset provides a valuable representation of nutrient water quality in the Montello River watershed. A significant flood occurred during this study which resulted in poor water quality that enters our lakes and rivers during heavy events. Although this flood was not an average event, it is these large events that introduce a lot of sediments and nutrients to waterbodies; once in the aquatic system these sediments and nutrients have long-term effects. Where possible, historic water quality data were used to enhance this dataset.

Phosphorus was the nutrient of focus in this study. Based on DNR phosphorus criteria, the recommended average total phosphorus (TP) in shallow impoundments should be below 40 µg/L. Average TP concentrations above this level begin to affect the type and amount of aquatic plants, algae, dissolved oxygen, fish, and other aquatic biota. The average TP calculated in Montello Lake (74 µg/L) and Harris Pond (73 µg/L) were above the proposed threshold. The average at Lawrence Lake (31 µg/L) was slightly below the threshold. Efforts should be made to reduce phosphorus in and entering Montello Lake and Harris Pond. Conscious efforts should be made to maintain Lawrence Lake at TP concentrations below 40 µg/L.

Median baseflow TP concentrations in some of the streams exceeded the DNR phosphorus criteria for wadable streams (74 µg/L) and impoundments (40 µg/L). This occurred at both sites on Klawitter Creek KW02 (91 µg/L), KW03 (98 µg/L), and Unnamed Creek UN01 (98 µg/L). Not surprisingly, the highest median TP and soluble reactive phosphorus (SRP) concentrations occurred at all sites during runoff events. KW02, KW03, and UN01 had the highest median event concentrations (171 µg/L, 358 µg/L, 192 µg/L), and the highest maximum sampled event concentrations (596 µg/L, 865 µg/L, 1,088 µg/L), respectively.

Total phosphorus loads indicate which streams deliver the greatest mass of phosphorus to the downstream river or impoundments. (Calculation of a load includes the phosphorus concentration and volume of water). Westfield Creek site WC01 had a noticeably higher average growing season TP load (9,587 lbs/acre) than the other sites, and site WC02 had the second highest (5,773 lbs/acre). These sites both had the highest averaged growing season volumes of water (21, 317 ft^3 and 12,327 ft^3) which dwarf the remaining sites (4,042 ft^3 and less).

Since a significant percent of agriculture comprises the landscape in the Montello River watershed, it was useful to evaluate how much phosphorus is leaving the fields based on the soil type, slope, and management practices used in this watershed. Many producers across the state are using a tool called SNAP-Plus to help them manage their farm nutrients by identifying which fields may need additional phosphorus for a given crop and which fields do not need more phosphorus. Reducing phosphorus applications helps to save the producers money and is good for groundwater, lake, and river water quality. Soil phosphorus was measured in samples that were collected from fields located in areas of the watershed that are considered directly connected to the streams and river and where land

managers were willing to participate with this study. Although current regulations require that fields with PIs greater than 6 take steps to reduce phosphorus, all losses of phosphorus from fields to water can have a negative impact on water quality, so benefits to lakes, rivers, and groundwater can occur with any reduction in PI. Nearly all sub-watersheds (except TC01 and WC02) had some fields with PIs greater than 6.

In summary, each impacted creek had specific issues to be addressed. Westfield Creek had three main issues of concern, temperature, loads, and yields. The first issue of concern was temperature, especially at Westfield Creek at site WC02. According to DNR temperature classifications, this reach of Westfield Creek can only support warm water fish species. The second issue was the loads. Loads are important to consider when assessing the impact a stream has on a downstream lake or impoundment. Westfield Creek is the largest tributary to the Montello River and contributes more phosphorus, sediment, and chloride to downstream impoundments than any other stream. Yields, which are area-weighted loads, indicate which sub-watersheds are exporting the highest mass of phosphorus/sediment/chloride per unit area, and are used to focus management efforts on areas of greatest concern. Westfield Creek had the second highest total suspended sediment yield and the highest chloride yield.

In contrast to Westfield Creek, Unnamed Creek is the smallest tributary to the Montello River, and flows directly into Montello Lake. It had the lowest loads of any site and hence, the least impact on downstream impoundments. The greatest issues of concern at Unnamed Creek were the phosphorus concentrations and yield, total suspended sediment yield, and nitrate concentrations. Although Unnamed Creek contributes a relatively low mass of phosphorus and sediment to Montello Lake, this sub-watershed was exporting a higher mass of phosphorus and sediment per area than any other sub-watershed. The biotic integrity of Unnamed Creek may also be hindered by high phosphorus concentrations. Nitrate concentrations at Unnamed Creek were also elevated.

Klawitter Creek, which has more flow than Unnamed but less than Westfield, also had water quality issues. The reach above the monitoring site KW03 had elevated phosphorus concentrations similar to that of Unnamed Creek, which may be impacting biotic integrity. Water temperature does not appear to be impacted, as this reach is considered to support cold water species. Elevated nitrate concentrations were observed in this reach of Klawitter Creek.

Tagatz Creek is the least impacted tributary to the Montello River. It supports cold water fish species and relative to other sites has no water quality issues of concern.

This study was a cooperative effort between the Marquette County Land and Water Conservation Department, the Montello River Watershed Task Force, the Harris Pond Lake Association, the Lawrence Lake Association, the Montello Lake District, the Wisconsin Department of Natural Resources (WDNR), the United States Geological Survey (USGS) and the University of Wisconsin-Stevens Point (UWSP) Center for Watershed Science and Education (CWSE). A number of citizens and landowners participated in collection and/or cooperation with this study, to which we are grateful.

Introduction

Project Summary

This report summarizes the results of water quality study conducted in the Montello River Watershed between January 2008 and January 2010. A diagram representing the project overview is shown in Figure 1. This study is a cooperative effort between the Marquette County Land and Water Conservation Department, the Montello River Watershed Task Force, the Harris Pond Lake Association, the Lawrence Lake Association, the Montello Lake District, the Wisconsin Department of Natural Resources (WDNR), the United States Geological Survey (USGS) and the University of Wisconsin-Stevens Point (UWSP) Center for Watershed Science and Education (CWSE). Community interaction and scientific data are equally important components of this study. This study uses an adaptive management approach that involves an active interchange of information and project direction.

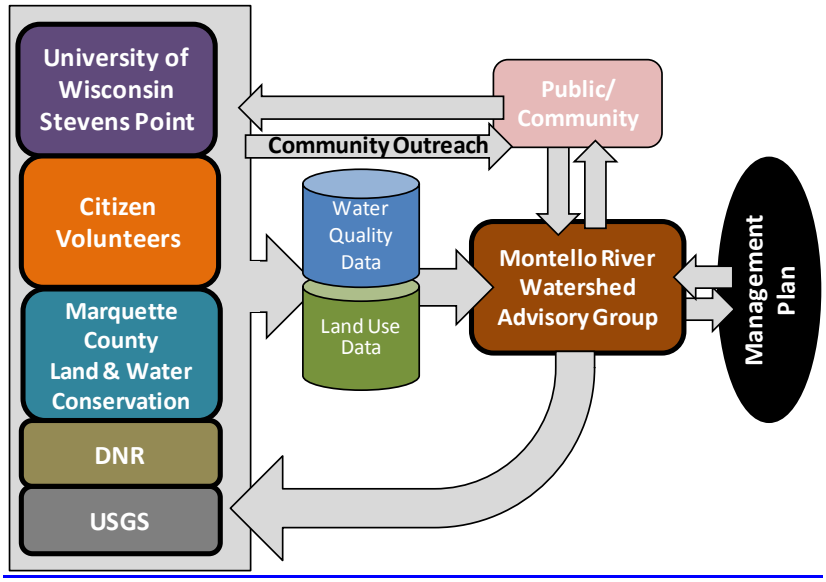


Figure 1. Project overview of the Montello River Watershed Study

This study was initiated because of a concern about water quality and excessive aquatic plant growth throughout the Montello River. In a previous study by Ramaker and Associates, Inc (2004), it was estimated that the Montello River accounted for the majority (81%) of the phosphorous loading to Montello Lake, while the remaining area around the lake contributed 19%. This general conclusion was based on limited monitoring data supplemented by rudimentary land use and water quality modeling results that were not fully validated by field observations. The current study provides a more in-depth analysis of water quality throughout the watershed.

Goals & Objectives

The overall goal of the study is to provide the Montello River Watershed Advisory Group, citizens, local municipalities, and agency staff with the necessary resources to protect and improve water quality in the Montello River, its tributaries, and impoundments. The objectives of this study are to:

1. Provide community outreach to the public.
2. Collect and analyze scientific data.
    a. Stream and impoundment water quality; precipitation
    b. Land Use & Management
3. Synthesize the study results and present them to Montello River Watershed Advisory Group.
4. Design and implement the management plan proposed by the Montello River Watershed Advisory Group.

General Background Information

Hydrologic Cycle

The hydrologic cycle describes the various ways water is exchanged from one form or location to another. In Wisconsin, precipitation, in the form of rain, snow, and everything in-between, falls onto the earth's surface. It either soaks into the ground or flows across the land. The water that soaks into the ground recharges the groundwater-table, or flows laterally through the ground into a lake or stream. The water that does not soak in, runoff, flows across the land until it reaches a lake or stream. Water moves from the land back into the air via evaporation and transpiration. Evaporation occurs when liquid water on the land changes into a gas in the atmosphere. Transpiration occurs when water evaporates from the leaves and stems of plants.

Understanding the hydrologic cycle is the first step in understanding water quality in streams, lakes, and impoundments. Raindrops that soak into the ground only carry soluble chemicals like nitrate, chloride, and reactive phosphorous. In contrast, runoff transports both dissolved chemicals and eroded soil. Nutrients that adsorb to soil, such as phosphorous, ammonia, and organic nitrogen, travel across the landscape with eroded soil during runoff events. A more specific discussion of these water quality parameters are found in the Stream Water Quality section.

Setting

The Montello River Watershed

The Montello River Watershed is located in south central Wisconsin. The watershed is within the wide valley of the Fox River, and ultimately drains to Lake Winnebago and Lake Michigan. A watershed is an area of land that drains water to a common outlet. A map of the Montello River Watershed (132 mi^2) is shown in Figure 2. There are four impoundments within the watershed, Lawrence Lake, the Westfield Millpond, Harris Pond, and Montello Lake.

The Montello River Watershed contains valuable stream resources. As shown in Figure 2, several streams are rated by the DNR as Class II trout streams or higher. Tagatz Creek features 13.5 miles of Class I trout waters, Caves Creek 9.4 miles, and Lawrence Creek 3.1 miles. A 3.5 mile reach of Klawitter Creek, between site KW02 and the confluence with the Montello River, is ranked as a Class II trout stream. According to the DNR, Class I trout streams have naturally reproducing trout at or near the maximum sustainable population. Class II trout streams have natural reproduction, but must be supplemented by stocking to achieve an optimal sport fishery.

The watershed was divided into smaller subwatersheds that drain to different stream monitoring locations. This permitted a site-specific evaluation of how and why water quality varies throughout the watershed. Many factors affect water quality. The shape of the land, geology, soils, land use, land management, and climate affect how much soil, nutrients, and chemicals are transported to water bodies within the Montello River Watershed. Data sets describing topography, land use and management, soil, and precipitation were combined with stream and lake monitoring to better understand and compare sub-watersheds.

Climate

The climate of the Montello River Watershed has influenced the characteristics of the current landscape. The humid continental climate type consists of varying weather patterns and significant seasonal temperature changes (USDA Soil Survey). Average annual precipitation is 29 inches. Most of the precipitation occurs between April and September. Winter precipitation usually occurs as snow, which is released back into groundwater or surface water during spring thaws (Poff and Thereinen 1963).

Topography, Geology, and Soils

Topography plays an important role in water quality by influencing runoff generation, erosion rates and groundwater recharge rates. Topography within the Montello River Watershed is gentle, with many flat areas and marsh belts. Elevations do not vary significantly, as they range from 750 ft to 1,326 feet above sea level. Estimated slopes within the watershed can be found in Figure 4**Error! Reference source not found.**. Glacial drumlins and kettles account for the steepest areas of the landscape, which are most common in the western part of the watershed. Many of the areas surrounding the kettle lakes are most likely internally drained depressions.

The last glaciations left this area covered by thick layer of glacial till, or terminal moraine. Underlying bedrock consists of Upper Cambrian sandstone, and areas of limestone associated with certain hilltops (Poff and Thereinen 1963).

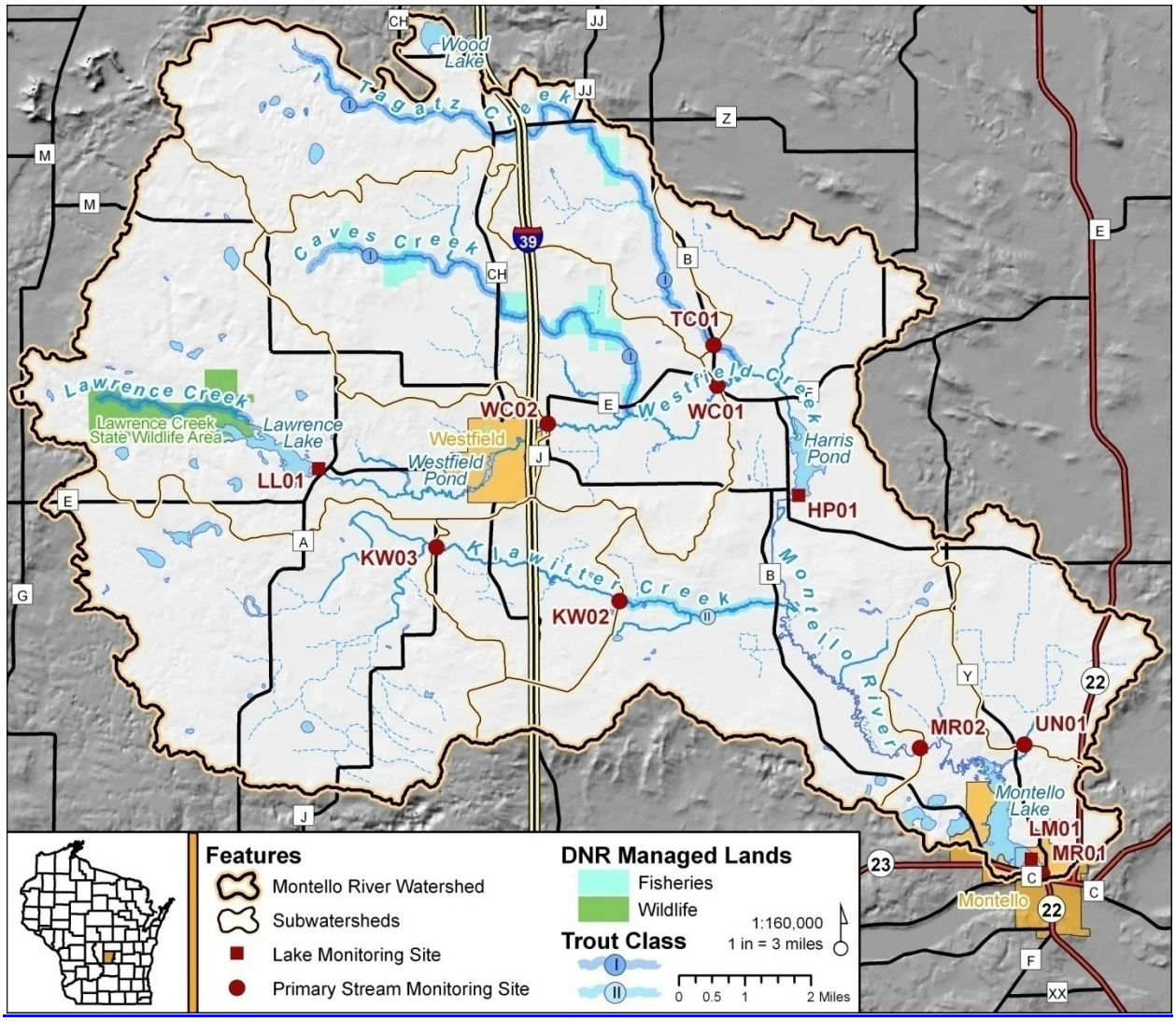


Figure 2. Water quality reservoir and stream monitoring sites in the Montello River Watershed.

Soils are also important to consider, as they influence erosion potentials, land use suitability, and land management strategies. Soils in the Montello River Watershed are generally sandy loams, as sandstone bedrock is incorporated into the glacial drift over the county (Poff and Thereinen 1963). Figure 5 **Error! Reference source not found.**provides an overview of the composite soil surface textures found within the watershed. Predominantly mucky soils are found along the lower reaches of the Montello River, and are associated with woody wetlands. Areas dominated by silt loams are also found in the central portion of the watershed.

Land Use

Land use and land management practices can have a strong influence on water quality. Development often leads to modifications of natural drainage patterns and changes in vegetative cover. Impervious surfaces, such as roads, rooftops, and compacted soils, and water diversions via culverts, drainage systems, and road cuts, can reduce or prevent the infiltration of runoff. This causes a decrease in groundwater recharge and an increase in the amount of stormwater flowing directly to lakes and streams. A possible long-term consequence from these changes is a decrease in stream baseflow, flashier stream response to rain events, an increase in stream temperatures, and greater transport of nutrient rich soil particles to the stream.

If not managed properly, application of fertilizers, pesticides, herbicides, and fungicides on residential, commercial, and agricultural land uses can significantly deteriorate water quality. Implementation of a variety of land management practices can reduce impacts to water bodies by helping to infiltrate water, reduce the total amount of nutrients on the landscape, timing of nutrients added to the landscape, etc. Some examples include the use of rain gardens, swales, manure storage facilities, following nutrient management plans, and restoring native vegetations.

The characteristics of the pathways taken by runoff, interflow, and groundwater travel and the land uses in route to a water body ultimately determine the water quality. For example, internally drained areas retain soil and soil-adsorbed nutrients but may contribute soluble chemicals to surface water. An example of an internally drained area within the Montello River Watershed is shown in Figure 3. Surface runoff from these areas does not reach the Montello River, or any of its tributaries and impoundments, so eroded soil and soil-adsorbed nutrients are deposited on the landscape. However, dissolved nutrients such as nitrate and soluble chemicals like chloride and pesticides can impact groundwater quality. Groundwater eventually discharges into surface waters, and plays a major role in determining water quality during baseflow (low flow) conditions.

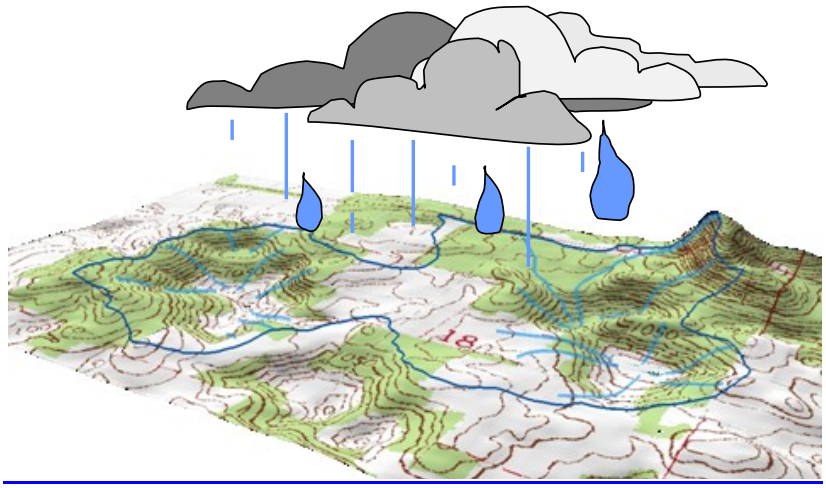


Figure 3. Example of an internally drained area in the Montello River Watershed (vertical scale is exaggerated).

Plots of land that have the same land use and land management will have different impacts if they have significantly different surface runoff pathway characteristics to surface water. Slope steepness, slope geometry, surface roughness, vegetative cover, flow distance, and travel time are examples of characteristics that influence how much soil and soil-absorbed nutrients actually reach the streams and

lakes in the Montello River watershed (Figure 4). Land use in the Montello Lake watershed primarily consists of deciduous forest (27.7%) and cultivated crops (27.2%). Pasture and hay accounts for 8.5%, woody wetlands 7.4%, and evergreen forest 6.5%. The remaining land uses each account for less than 5% of the total land use (Figure 6 and Figure 7).

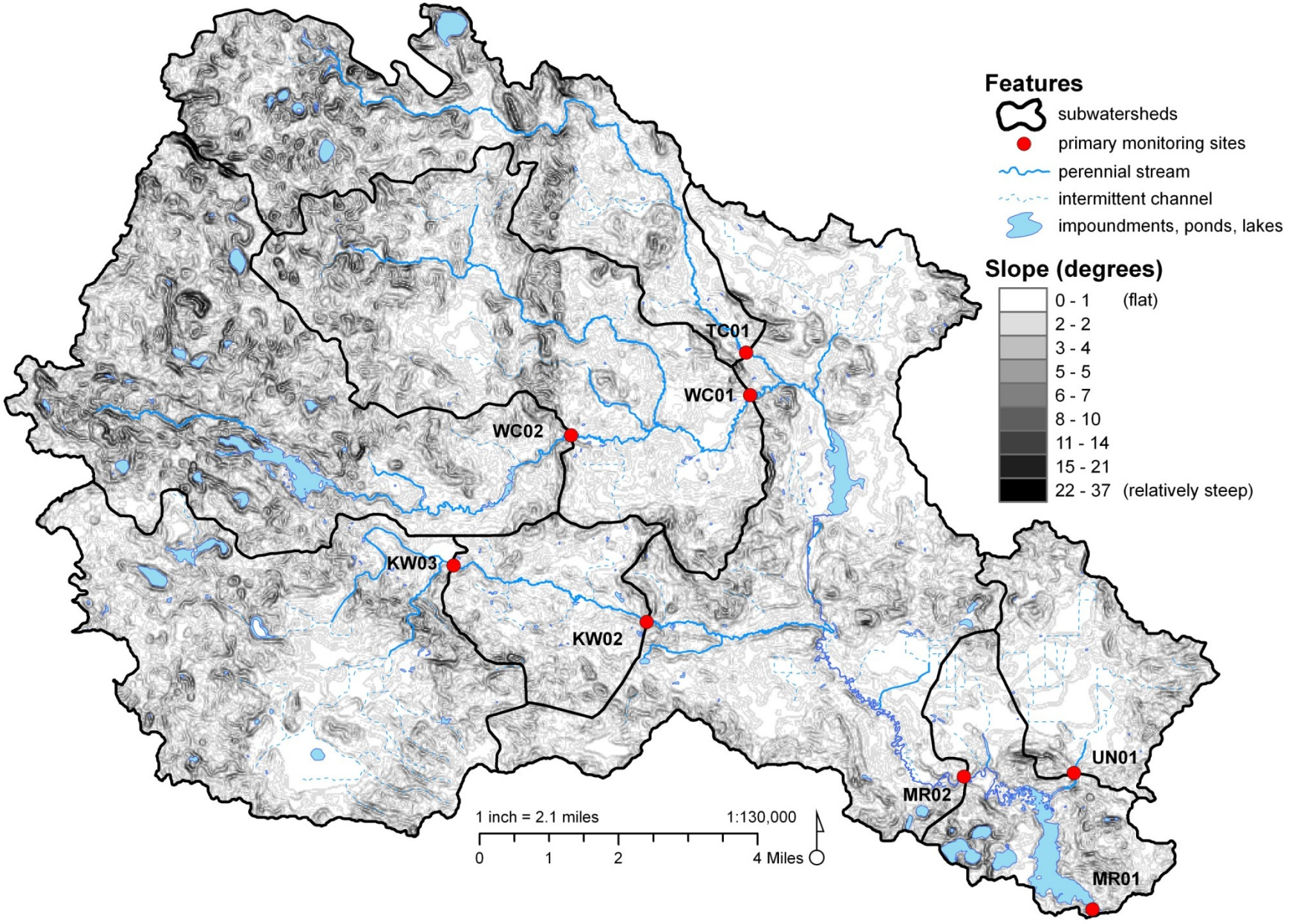


Figure 4. Estimated slopes within the Montello River Watershed.

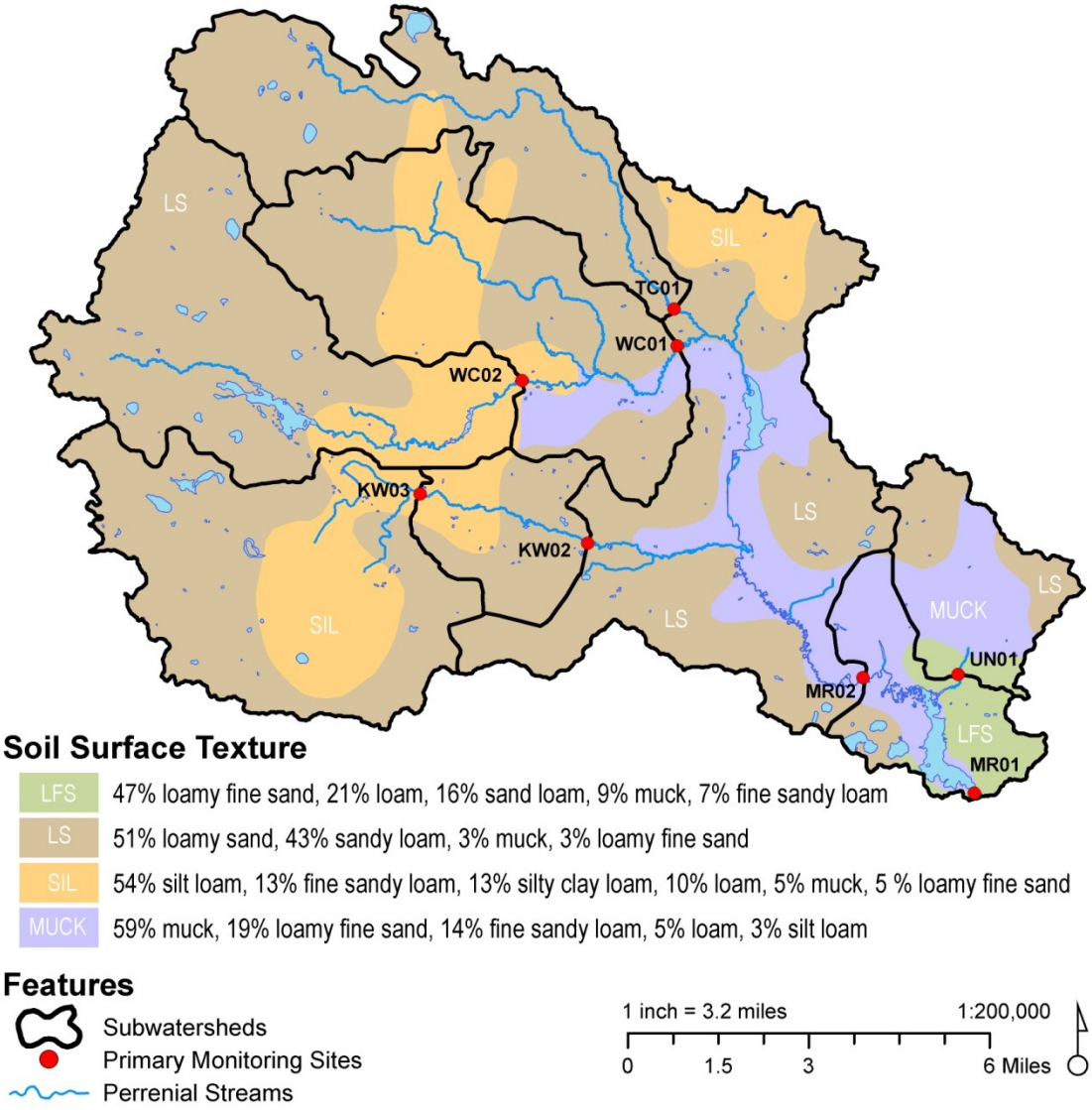


Figure 5. Composite soil surface textures within the Montello River Watershed (STATSGO).

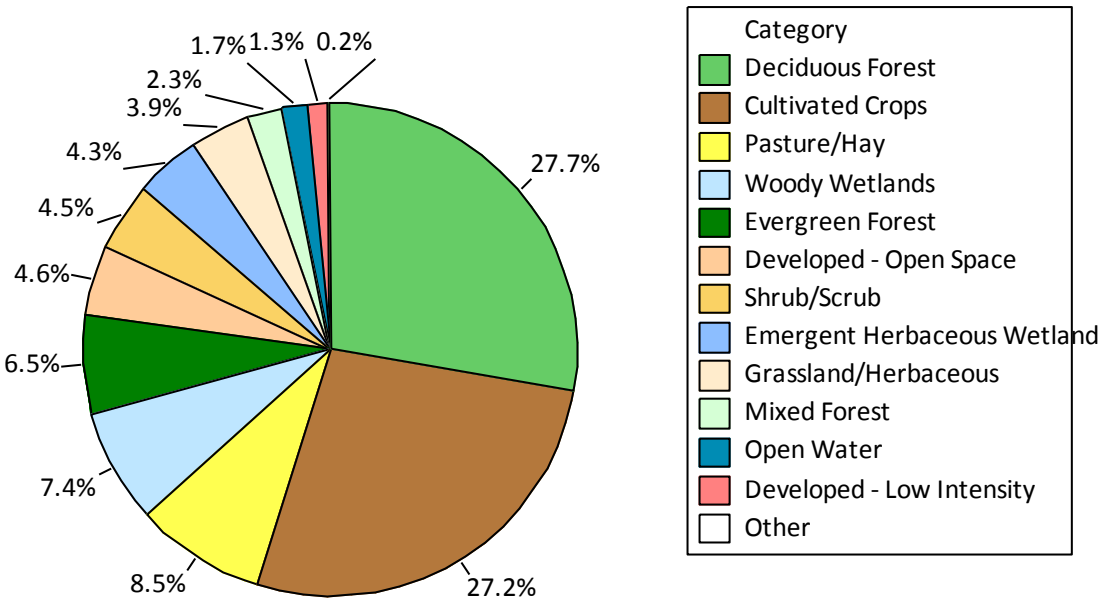


Figure 6. Land use within the Montello River Watershed (USGS NACD 2001).

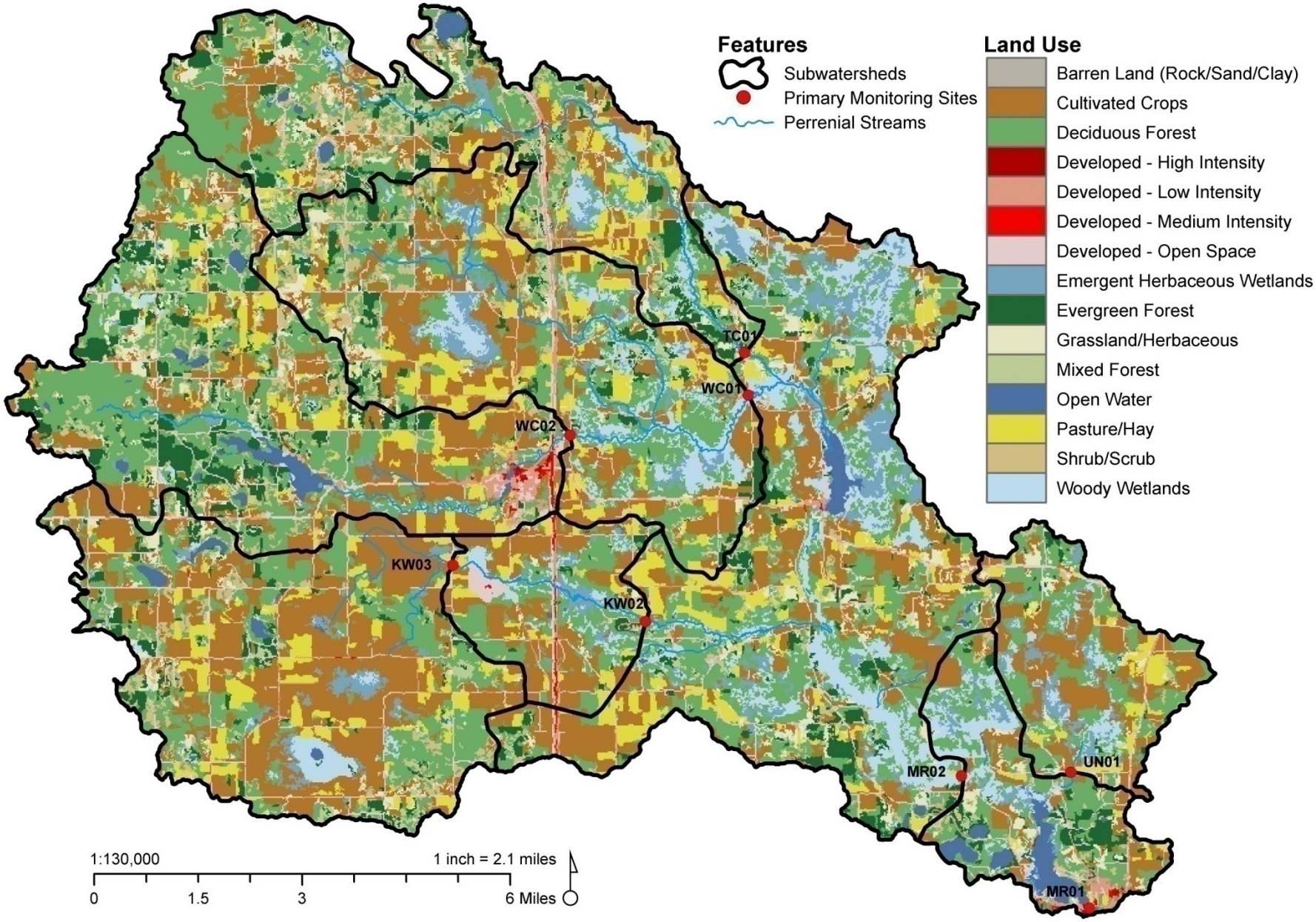


Figure 7. Land Use and primary stream monitoring sites in the Montello River Watershed (USGS NACLD 2001)

Methods

Sample Analysis

All water quality samples were analyzed at the state certified University of Wisconsin Stevens Point Water and Environmental Analysis Laboratory (UWSP WEAL). Appendix Table 6 provides analytical methods and detection limits for this laboratory. Soil samples were analyzed at the UW Soil & Plant Analysis Lab.

Impoundment Data Collection

Mid-Lake Sampling

Water quality data were collected from Lawrence Lake, Harris Pond, and Lake Montello from January 2008 to November 2009. This consisted of one site visit in the winter, spring, and fall. The sites were also visited four times during the summer, in approximately 1 month intervals. Mid-lake measurements were collected at the deepest point of the lake, which was based on historic bathymetric maps provided by the DNR and local knowledge. Secchi disk measures were collected during all the site visits except in the winter, and were made on the shaded side of the boat. For each site visit, in-situ vertical profiles were conducted. In-situ sampling involved the use of a Hydrolab Model 4600 data sonde to collect temperature, dissolved oxygen, conductivity, and pH data throughout the entire depth of the lake. A YSI data sonde was used to collect temperature and dissolved oxygen vertical profiles during some site visits. Water samples were collected during each visit with an integrated bailer. Samples were transferred to two 60 mL polypropylene bottles that contained sulfuric acid (H_2SO_4) as a preservative. One 60 mL bottle was unfiltered and the other was filtered through a 0.45 micron membrane filter. They were kept on ice until transferred to the UWSP WEAL to be analyzed for total phosphorus (TP), reactive phosphorus (RP), total Kjeldahl-N (TKN), ammonium-N (NH_4-N), nitrate+nitrite-N (NO_2+NO_3-N), and chloride (Cl). During the summer visits, chlorophyll a samples were collected from the lake, pumped through a 934/AH glass fiber filter, and placed in aluminum foil and kept on ice until received by the UWSP WEAL.

Historic Data

Additional historic data were downloaded from the DNR SWIMS database. These data consist of total phosphorus, chlorophyll a, and secchi disk results.

Sediment Samples

Sediment core samples were collected at Lake Montello and Harris Pond on 1/8/2008, Lawrence Lake on 1/10/2008, and Harris Pond on 7/21/2009. The cores were kept under aerobic conditions and were sampled about every 12 hours over the course of approximately 7 days. The water samples were extracted from the cores using a 60 mL syringe with a thin tube attached to the end. The extract was filtered through a 0.45 micron membrane filter and kept refrigerated until analyzed for reactive phosphorus. The cores were monitored to ensure aerobic conditions were maintained.

Stream Data Collection

Primary Monitoring Site Sampling Routine

Grab samples were collected at the primary monitoring sites KW02, KW03, TC01, UN01, WC01, WC02, and MR01 on a fixed interval basis of approximately 14 days from 2/22/2008 to 11/11/2008 and 3/9/2009 to 6/17/2009. Unlike the other primary monitoring sites, only fixed interval samples and in-situ water chemistry parameters were collected at MR01. In-situ water chemistry measures were made

with the same equipment as the impoundments. Samples were also collected at the primary monitoring sites during certain runoff events, which were either collected by siphon samplers or as manual grab samples. Discharge measurements and in-situ water chemistry were collected periodically throughout the entire study period. Velocities were measure using a Marsh McBirney Flo-Mate Model 2000 flow meter, and in-situ water chemistry conducted with the same equipment as the impoundments.

Continuous Stage Recorders

Solinst Levelogger Model 3001 Gold Series pressure transducers were used to obtain continuous measurements of stream temperature and stream depth, or stage, at the primary monitoring sites. Pressure transducers were installed to fence posts and secured to the stream bottom in areas of placid flow and at the same water surface elevation of the staff gauge. Recordings were made every 15 minutes. The pressure transducer data was adjusted for changes in barometric pressure by using a barometric (baro) logger exposed to the atmosphere. During the first year of the study, the baro logger was located in Stevens Point (8 hour intervals) and in Westfield during the second year (15 minute intervals).

Continuous Estimated Discharge

Staff gauges, essentially long rulers used to read water depth, were placed at stream monitoring sites near where flow was measured. Rating curves were developed based on the relationship between stream depth and stream flow. To estimate continuous flow values, the recorded pressure transducer stages were adjusted to the staff gauges. The flows were then calculated using the rating curves.

Growing Season Loads and Yields

The water quality computer model FLUX (Walker, 1999) was used to estimate 2008 and 2009 growing season total phosphorus, total suspended sediment, and chloride loads at each primary monitoring site. In this study, the 2008 growing season is defined as 4/1/2008 to 12/1/2008, and the 2009 growing season ranges from 3/14/2009 to 11/12/2009. FLUX is designed for the analysis and reduction of tributary monitoring data. This model estimates the mass of a particular constituent passing by a monitoring location per time period of interest, in this case pounds per growing season, through flow-concentration relationships developed using average daily flows and sample concentrations. Yields were calculated by dividing each load by its respective groundwatershed area.

Other Monitoring Sites

USGS Site 04072845

The DNR in cooperation with the USGS operates the gauging station at site MR02, which accounts for the vast majority of the flow entering Montello Lake. Similar to the UWSP primary monitoring sites, samples were collected on a 14 day fixed interval. Composite event samples were collected with an automated sampler.

Synoptic Sites

Samples were collected at additional sites throughout the watershed () on February 22 and 23, and August 20, 2008.

Sample Collection

Parameters Analyzed

All samples collected from primary stream monitoring sites and synoptic sites were analyzed for total phosphorus (TP), reactive phosphorus (RP), total Kjeldahl-N (TKN), ammonium-N (NH4-N), nitrate+nitrite-N (NO2+NO3-N), chloride (Cl) and total suspended solids (TSS). A Hydrolab Model 4600

data sonde to collect temperature, dissolved oxygen, conductivity, and pH at the time of sample collection.

Obtaining Samples and Preparation for Lab Analysis

Manual grab samples were collected at mid-depth of the stream from the stream thalweg using a 500 ml polyethylene bottle. Siphon samples were collected in 500 ml high-density polyethylene bottles, which were placed inside siphon samplers. They were set to fill within the range of stages of anticipated runoff events, and filled when the stream stage exceeded the siphon sampler height. The bottles were retrieved as soon as logistically possible; in some cases flooding prevented retrieval within 24 hours of filling. The 500 ml bottle used to obtain the sample was then used to fill two 60 ml bottles both preserved with 1 molar H_2SO_4. The 500 ml bottle was always well mixed prior transferring to the other 60 ml bottles in order to maintain consistency between all bottles. One of the 60 ml bottles was filled with filtered sample and the other with unfiltered sample. Filtration was conducted by transferring the sample to a 60 ml syringe which was attached to an in-line filter cassette. The cassette contained a 934/AH glass fiber pre-filter and a 0.45 micron membrane filter. The three bottles were kept on ice and delivered to the lab for analysis.

GIS Analysis

Watershed Delineation

The Montello River Watershed and subwatersheds were delineated using a combination of the automated watershed delineation tools available in ERSI ArcMap 9.3.1 ArcHydro tools and manual digital delineation using USGS 1:24k topographic maps and other supplementary layers.

Contributing Area

The contributing area was estimated based on surface overland flow distance to any waterbody that flows into the Montello River or impoundments. The parts of the Montello River Watershed that have a flow distance less than or equal to 1,650 feet were included in the contributing area.

Surface Overland Flow Distance

Surface overland flow distance to waterbodies that flow into the Montello River or impoundments was estimated by using a weighted flow length calculation (ERSI ArcMap 9.3.1). The stream network that feeds into the Montello River and its impoundments, and the Montello River itself, were assigned values of “0” in the weight grid. All other pixels within the watershed were assigned a value of “1” in the weight grid.

Inventory of Agricultural Management Practices

Overview

Agricultural management practices were evaluated using field-scale agricultural management tool SNAP-Plus at the basin scale. UWSP Center for Watershed Science and Education (CWSE) worked in cooperation with the Marquette County Land and Water Conservation Department (LWCD), and the SNAP-Plus software designers throughout this process.

Extent of Inventory

The first step of this process was to define the extent of the data collection effort within Montello River Watershed. In order to prioritize sampling efforts, UWSP determined that croplands (as defined by the USGS NALCD 2001 30m raster) within 1,650 feet of estimated surface overland flow of the stream network connected to the Montello River would be included in the inventory. The Marquette County LWCD performed several on site investigations to validate the original inventory area established by

CWSE. Based on their observations and pre-existing knowledge, some fields from the original area of interest were excluded, while others were added.

Data Acquisition

Once the inventory area was quality controlled, the process of data acquisition began. SNAP-Plus data was gathered by the LWCD via interviews, or from preexisting SNAP-Plus databases. The nature of the data acquired was subject to the discretion of the operator, consisting of no cooperation, partial data, and complete data.

Unique Identifier Naming System

For those farmers that cooperated, each field was assigned a unique identifier that consisted of the concatenation of the operator's identification number and the field name. The operator identification number was assigned by CWSE staff, and was unique for each operator. The original field names assigned by the operator, which were unique within an operator, were combined with the operator identification to form an identifier that was unique for all fields within the study area. The concatenated unique identifier was entered into the corresponding record of the field shapefile.

SNAP-Plus Database Merging

The SNAP-Plus data originally existed as independent SNAP-Plus databases, one for each cooperating operator. SNAP-Plus software engineers made a custom test version of SNAP-Plus that facilitated the merging of these databases. The software performed successfully, and allowed UWSP and the LWCD to efficiently perform multiple iterations of quality controlling the SNAP-Plus data collected by the LWCD.

Connecting SNAP-Plus and Access

The merged SNAP-Plus database was queried using Microsoft Access 2007 as the client application and FlashFiler Server as the server application. This was done by establishing the merged SNAP-Plus database folder as an alias in FlashFiler Server. FlashFiler Server's ODBC driver was used to facilitate Access as the client application.

Making the Data Spatial

ERSI ArcMap 9.3.1 was used to join the field shapefile and the Access query using the concatenated unique identifier.

Assessing Status of Data

Several fields had nearly complete data, and were only missing soil tests. These fields were prioritized and the LWCD collected 82 additional soil test samples, accounting for an increase in the ability to calculate phosphorus index values on 120 more fields within the inventory area. Some fields that were shown as separate were actually being managed as the same field, thus allowing the use of a single soil test on two or more fields.

Potential Bias

The greatest setback of this process was the potential introduction of bias with the subsample of fields. Since the process is voluntary, operators of more poorly managed fields may have been more inclined to not cooperate with the LWCD.

Impoundment Water Quality

Understanding Impoundments

The path water takes before reaching a lake or impoundment has a strong influence on water quality. Lawrence Lake, Harris Pond, and Montello Lake receive the majority of their water from their respective tributaries. Lawrence Creek feeds Lawrence Lake, while Westfield Creek and Tagatz Creek flow into Harris Pond. The Montello River collects all of this water which flows into Montello Lake.

Water quality in impoundments is predominately controlled by upstream factors. While streams and rivers act as highways that transport sediment and nutrients, impoundments and lakes should be considered sinks. Water that is in motion has the capacity to carry more sediment than stationary water. When a stream "slows down" it deposits the materials it is carrying.

Shoreline activities can also be an important factor influencing water quality in a lake or impoundment. For example, lawn fertilizer applied on a lakeshore property can easily make its way into the pond. The addition of impervious surfaces (roofs, paved driveways and roads, etc) quickly route water to the pond instead of infiltrating to groundwater, and removal of near shore native vegetation eliminates the filtration of particles and uptake of nutrients from deep roots before runoff and/or groundwater enter the pond.

Water quality in lakes is assessed by measuring different characteristics including temperature, dissolved oxygen, water clarity, chlorophyll a, and water chemistry. In this study samples were collected from Lawrence Lake, Harris Pond, and Montello Lake once in the spring, fall, and winter and five times between May and September 2008 and 2009.

Dissolved Oxygen and Temperature

Dissolved oxygen is important in aquatic ecosystems since aerobic aquatic organisms depend on it for survival. Just as we use our lungs to absorb oxygen from the atmosphere into our bloodstream, an *aerobic* aquatic organism obtains oxygen from the water. These organisms come in a variety of sizes, from a single-celled bacteria to a "trophy" fish. Oxygen enters lake water by diffusion from the air and photosynthetic activity from algae and aquatic plants. Greater wind and wave interaction with the atmosphere causes greater diffusion of oxygen into the water and increases the rate that oxygen is transferred.

Increased biological activity in a lake can also result in reduced dissolved oxygen concentrations. Decaying organic material in the lake reduces oxygen as decomposers use oxygen to drive their respiration. As the amount of aquatic plants and algae increase in a lake, oxygen increases during the summer, but in the fall and winter oxygen is reduced as it is consumed by decomposers breaking down the plant tissue. Nutrient additions to the lake often result in increased plant and algal growth. These nutrients come off the land from fertilizers, soil, and vegetation that are carried to the lake during runoff events, groundwater, and from wetland sediment that is buried below water when a river is impounded.

Dissolved oxygen concentrations are also affected by water temperature. Cold water can hold more oxygen than warmer water. Temperature variation throughout the year affects how water mixes with the atmosphere because the density of water changes with temperature changes

A good example of a fully mixed lake was observed May 2008 at Lawrence Lake (A). The temperature and dissolved oxygen are similar from top to bottom resulting in similar water density throughout the lake which allows wind to easily mix the water with the atmospheric oxygen. In 2008 Harris Pond and Lake Montello experienced fall mixing (overturn) prior to Lawrence Lake. Since Lawrence Lake has a deeper maximum depth than the others, it takes longer to mix in the spring.

As surface water warms in late spring layers of warm and cooler waters have differing densities which creates layering or stratification. During stratification, surface water remains in contact with atmospheric oxygen, while the lower layers do not. When layering exists for extended periods of time, dissolved oxygen begins to be depleted in the bottom layer as decomposers consume oxygen. If enough material decomposes, almost all the oxygen can be consumed.

Summer stratification is very subtle in Montello Lake, Lawrence Lake, and Harris Pond. It only occurs at the deepest depths and does not appear to be problematic to the fishery. Evidence of the stratifying and mixing that occurs during the summer at each site can be found in Figure 8. For example, the temperature profile collected on 5/19/2008 at Montello Lake exhibits some degree of stratification while the profile collected on 6/21/2008 shows the lake is completely mixed. The periodic mixing and stratification that occurs throughout the summer allows phosphorous that is liberated from bottom sediments during stratified periods to be circulated into upper water when the lake mixes. During the summer aquatic plants and algae can use this phosphorous for growth.

During the fall, lake temperatures become uniform as the season cools the water from the top down (Figure 8). The vertical profile of temperature collected at Montello Lake on 3/1/2008 exhibits the reverse stratification pattern that occurs in winter (B).

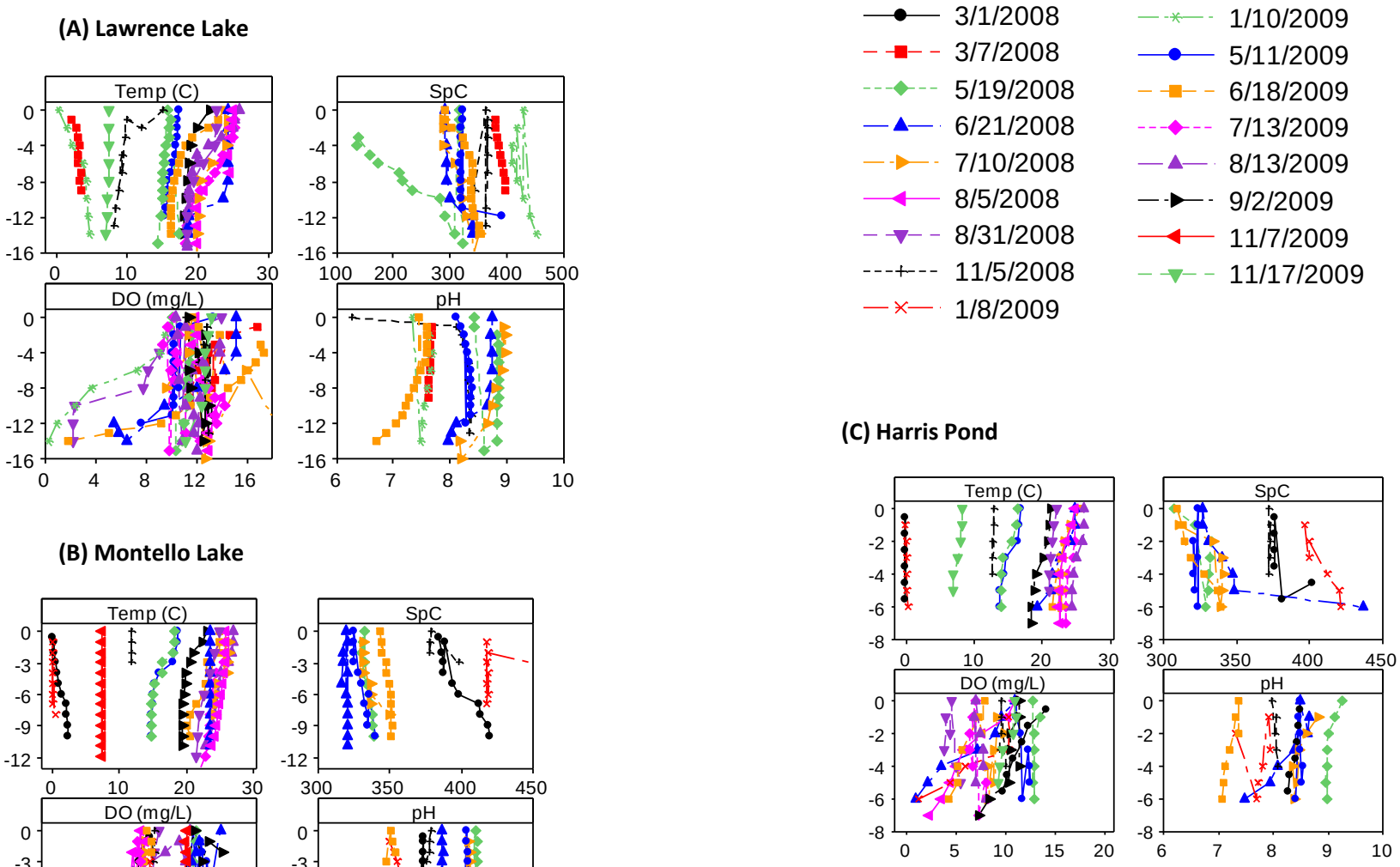


Figure 8. Vertical profiles of temperature (°C), dissolved oxygen (mg/L), conductivity (µs/s), and pH sampled 3/1/2008 – 11/17/2009 at (A) Lawrence Lake, (B) Montello Lake, and (C) Harris Pond.

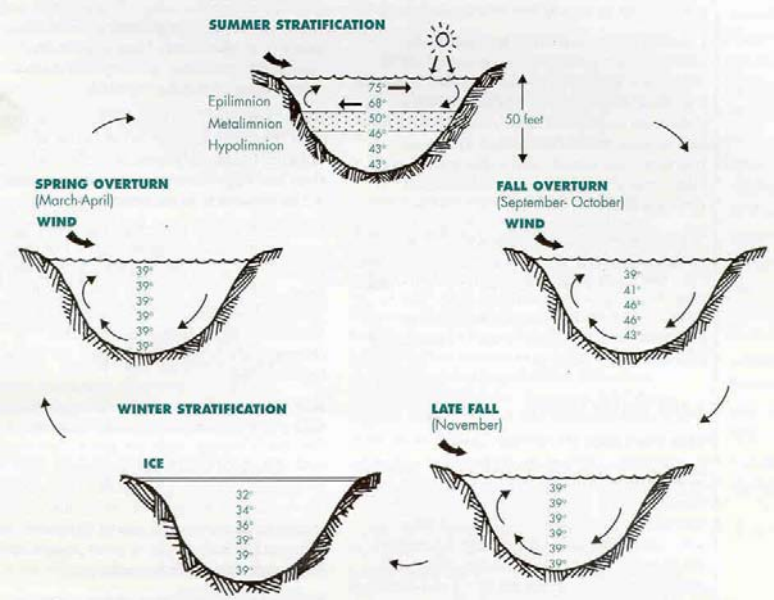


Figure 9. Seasonal temperature variation causing the stratification and mixing of many Wisconsin lakes (Shaw et al., 2002).

Nutrients in Lakes and Impoundments

TP:TN Ratio

The amount of aquatic plants and algae that can grow in a lake depends on the amount of nutrients that are available. The major nutrients of concern for surface waters in Wisconsin are phosphorus and nitrogen. In a given body of water, a plant community's requirement for phosphorus is usually different than for nitrogen. The total nitrogen (TN) to total phosphorus (TP) ratio indicates whether nitrogen or phosphorus is the limiting nutrient for plant growth. When the TN:TP ratio is greater than approximately 15:1, plant growth is generally restricted by the amount of phosphorus available. When the ratio is less than 10:1, this indicates nitrogen could be the limiting nutrient. The average TN:TP ratios for Harris Pond was 35, Lawrence Lake 77, and Montello Lake 26. These data indicate phosphorous is the limiting nutrient in these three impoundments.

Phosphorous

Phosphorus is the most significant nutrient in the lakes in the Montello River Watershed. This is similar to most Wisconsin lakes where phosphorus is the primary element that leads to the development of nuisance algae (Wetzel 2002; Cogger 1988). Phosphorus is present naturally throughout the watershed in soil, plants, and animals. It is transferred to the lake with the erosion of soil, runoff of animal waste and fertilizers, effluent from septic systems, nutrients and sediments released from wetlands and plants, groundwater, and atmospheric deposition.

The most common mechanism for the transport of phosphorus from the land to the water is surface runoff. Phosphorus adheres to soil/sediment particles and can travel with solids. If those particles (soil, organic material, etc.) are disturbed or if water containing phosphorus is conveyed directly to the lake, phosphorus is transferred from land to water. Phosphorus also travels in dissolved form, but this is usually a less significant source. Once in the lake, a portion of the phosphorus becomes part of the aquatic system in the form of plant and animal tissue, sediments, and in solution in the water. The phosphorus continues to cycle within the system, and is very difficult to remove once it enters.

In some cases, phosphorus can also travel to the lake in groundwater. In central Wisconsin phosphorus in groundwater is a result of a large continuous source of phosphorus such as an earthen or unguttered barnyard or septic drainfield.

In this study, two forms of phosphorus were measured: soluble reactive phosphorus (SRP) and total phosphorus (TP). SRP is dissolved phosphorus that is readily available for use by aquatic plants and algae. It is usually present in low concentrations (Wetzel 2002). TP is a measure of the dissolved phosphorus plus particulate phosphorus in the water.

TP is used as a measure of overall lake phosphorus because its concentrations are more stable than SRP. Phosphorus concentrations can vary within a lake seasonally, annually, and spatially. Total phosphorous varied during the past year in Harris Pond, Lawrence Lake, and Montello Lake (Figure 10). The impact of the flood events that occurred in June 2008 can be distinctly seen. Montello Lake experienced the greatest increase in total phosphorous concentrations, as it received an immense input of nutrients from the entire watershed during the flooding. The three lakes experienced similar increases and decreases throughout the year, but total phosphorous concentrations were usually greatest in Montello Lake. At the final summer sampling in August, Harris Pond had the highest total phosphorous concentration. Lawrence Lake consistently ranked as the lowest concentration of total phosphorous throughout the year.

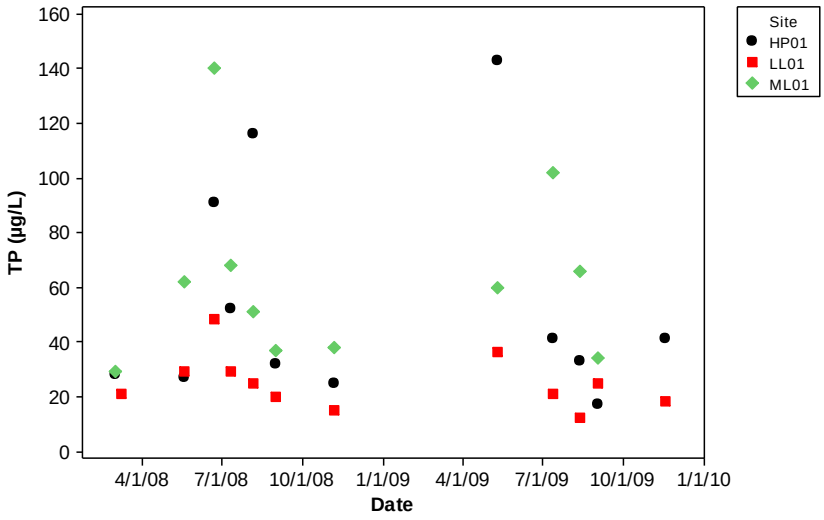


Figure 10. Total phosphorous concentrations (µg/L) observed during the 2008-2009 sampling seasons at Harris Pond, Lawrence Lake, and Montello Lakes in the Montello River Watershed.

Generally, TP concentrations above 30µg/L are enough to stimulate algae blooms and excessive aquatic plant growth. At each site, summer concentrations were high enough to stimulate algae blooms and excessive plant growth. Lawrence Lake only exceeded 30 µg/L during two monitoring visits, while Harris Pond and Montello Lake were exceeded this concentration multiple times. Although concentrations at Lawrence Lake are lower than the other two impoundments, algae blooms occur a few times a year. Since the rooted aquatic plant community is currently being managed with the application of chemicals, the resulting plant community at Lawrence Lake consists of more algae than if rooted plants were present to use the phosphorus. At Harris Pond, rooted aquatic plants dominate, but excessive algal growth is common. TP concentrations at Montello Lake are typically above 30 µg/L, and algae and

rooted aquatic plants have a constant presence.

Based on DNR phosphorus criteria, the recommended average TP in shallow impoundments (calculated from samples collected between June 1st and September 15th) should be below 40 µg/L. The average TP calculated in Montello Lake (74 µg/L) and Harris Pond (73 µg/L) were above the proposed threshold. The average at Lawrence Lake (31 µg/L) was slightly below the threshold.

Shaw, et al. (2002) suggests that reactive phosphorous concentrations following spring overturn should be 10 µg/L or less to prevent summer algae blooms. The concentrations measured at each lake in March 2008 exceeded this threshold. Similar to total phosphorous, reactive phosphorous concentrations rise and fall over time in a similar pattern at each lake (Figure 11).

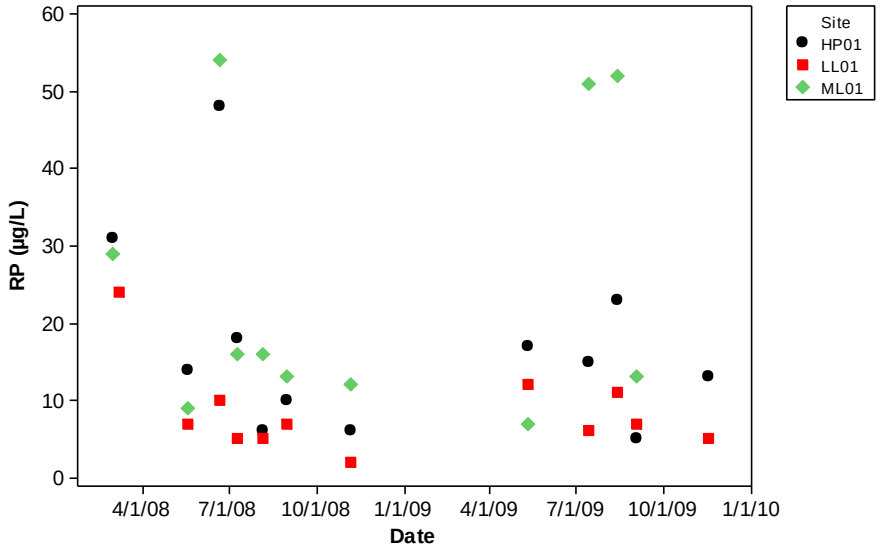


Figure 11. Reactive Phosphorous concentrations (µg/L) observed during the 2008-2009 sampling seasons in Harris Pond, Lawrence Lake, and Montello Lakes in the Montello River Watershed.

Nitrogen

Nitrogen is an important biological element. It is second only to phosphorus as a key nutrient that influences aquatic plant and algal growth in lakes. Nitrogen is a major component of soil, all plant and animal tissue, and therefore organic matter. It is also found in precipitation and can be the primary nitrogen source in some seepage and drainage lakes. Nitrogen travels in groundwater and surface runoff; therefore, it can enter a lake in both soluble and particulate forms. Sources of nitrogen are often directly related to land uses including agricultural, lawn, and garden fertilizers, animal waste, nutrients in septic system effluents, sewage treatment plants.

During this study the majority of nitrogen in Harris Pond and Lawrence Lake existed as nitrate and nitrite (Figure 12). At Montello Lake, nitrate and nitrite concentrations were usually similar to organic nitrogen concentrations. Ammonium comprised a very small proportion of the total nitrogen at each lake.

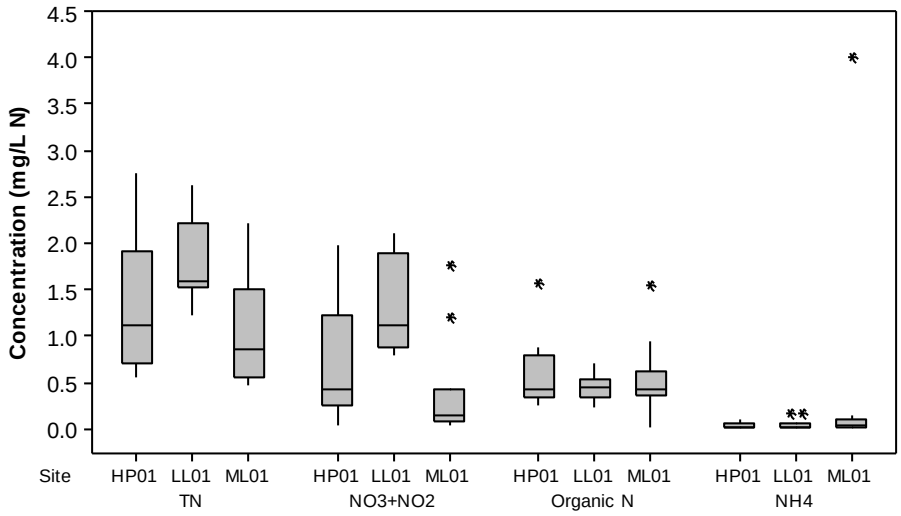


Figure 12. Total nitrogen (mg/L), nitrate and nitrite (mg/L), organic nitrogen (mg/L), and ammonium concentrations (mg/L) measured in Harris Pond (HP), Lawrence Lake (LL), and Montello Lake (ML) during the 2008 and 2009 sampling years.

Water Clarity and Chlorophyll a

Water clarity is a measure of light penetration which can be associated with algal growth, turbidity, and/or color. It is an aesthetic measure and is related to how deep rooted aquatic plants can grow. The Secchi disc is a tool used to measure water clarity by lowering this black and white disc into the water and measuring the depth where it is no longer visible. Secchi disc measurements give a value of water clarity at the time of reading. These measurements can vary from month to month or day to day. Variations can result from storm and wind events, sunny versus cloudy days, time of day and year, abundance of algae, and/or boat traffic. Collecting routine water clarity and chemistry measures provide a long term data record and help to enhance the interpretation of this data and changes in water clarity in the ponds.

Historic and recent Secchi depths are shown in Figure 13**Error! Reference source not found.**. Overall, water clarity in Montello Lake is poorer than Lawrence Lake. The day to day variations in water clarity can clearly be seen in the historic data for both lakes. Despite this, an overall trend of decreasing water clarity over time was observed in both lakes. Secchi depth measurements were not recorded at Harris Pond because the full water clarity measurements were limited by the maximum depth of the pond.

Chlorophyll *a*, which is used as a measure of algal abundance, can also vary daily, seasonally, and annually. Since they are both a measure of water clarity, chlorophyll *a* often correlates with Secchi disc values. As shown in Figure 13**Error! Reference source not found.**, this correlation was stronger at Harris Pond and Lawrence Lake than Lake Montello.

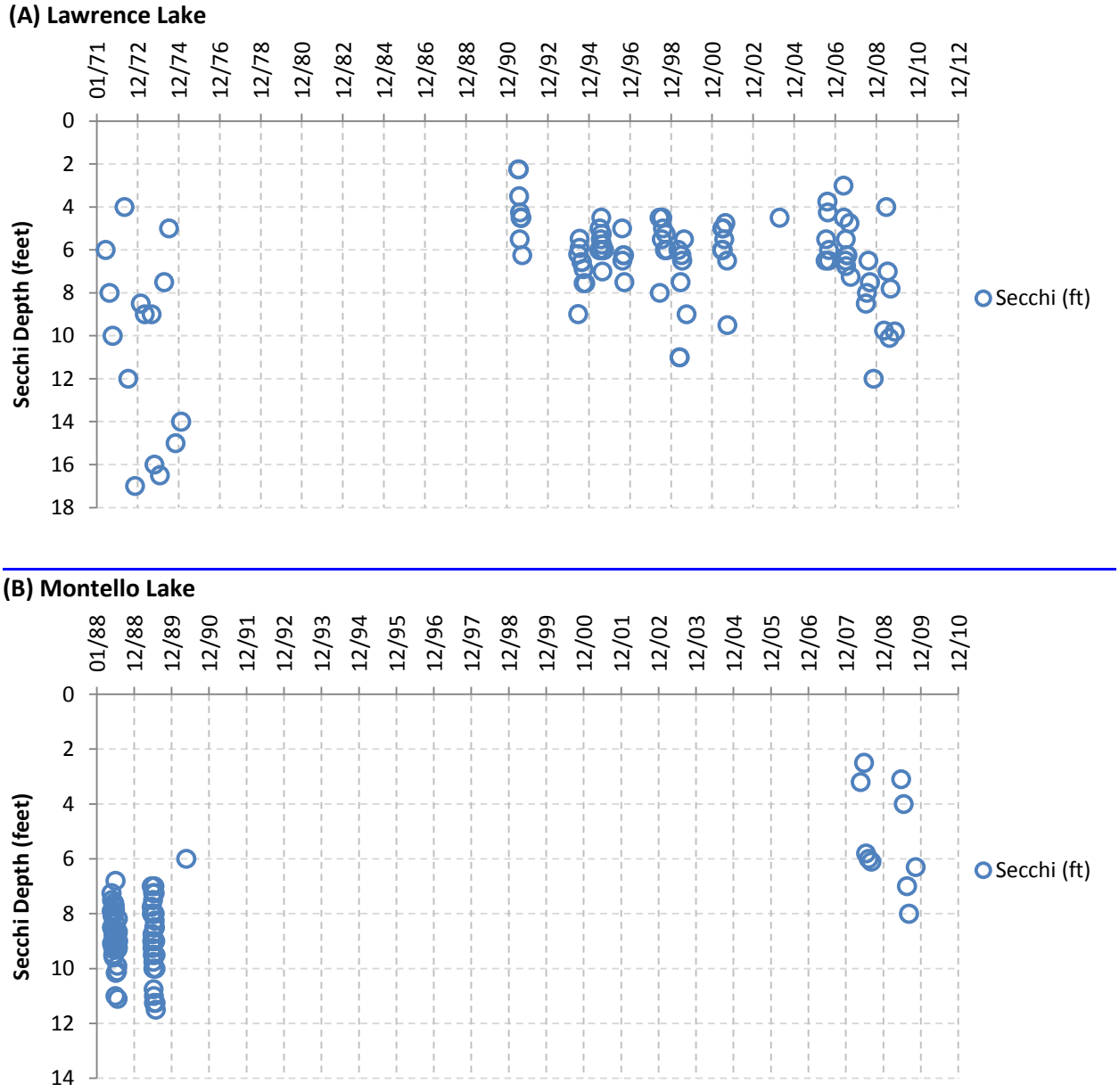
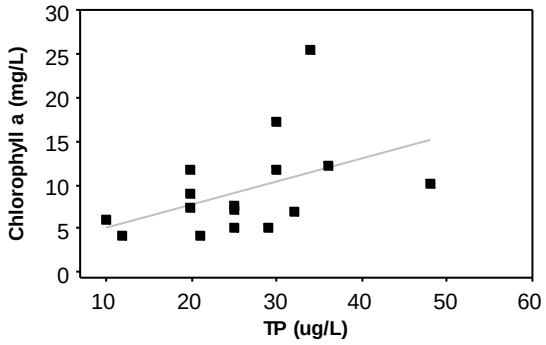
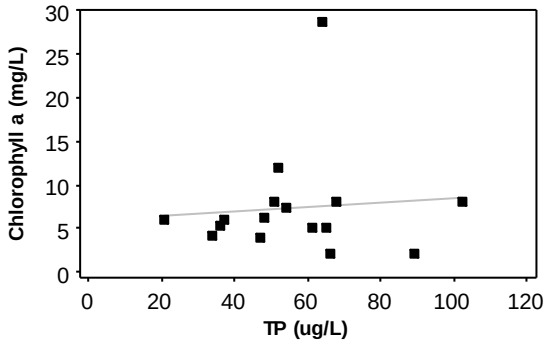


Figure 13. Historic and recent Secchi depth (ft) measures in (A) Lawrence Lake (B) Montello Lake (Harris Pond omitted, Secchi depth was greater than the maximum pond depth).

(A) Lawrence Lake



(B) Montello Lake



(C) Harris Pond

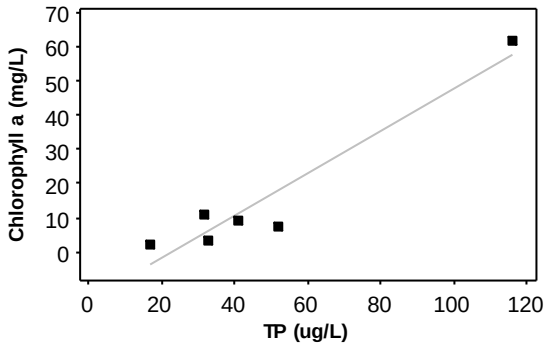


Figure 14. Historic and recent (2008-2009) total phosphorus and chlorophyll a measures from (A) Lawrence Lake (historic 1994), (B) Lake Montello (historic 1995-1998), and (C) Harris Pond (No historic data) (SWIMS 2009).

Internal Loading

Internal loading is the amount of phosphorus that is released to the water column. It is often greatest during periods where bottom waters lack oxygen, but can occur, to a lesser extent, when oxygen is present in the overlying water. Sediment cores were collected from the bottom of the ponds and set up at UWSP for analysis of phosphorus release. At the majority of the sites, results from sediment core lab trials suggest that the impoundment sediments are not releasing phosphorus under aerobic (oxygen rich) conditions. The cores collected near the Lake Montello swimming beach suggest sediments in Lake Montello are releasing phosphorus at about 0.09 mg/m^2/day. This adds up to 27,926 lbs of phosphorus in the typical growing season. The samples taken from Westfield Millpond suggest a similar release rate of 0.07 mg/m^2/day, and 1,810 lbs in a typical growing season. The estimated phosphorus release from Westfield Millpond is 31% of the phosphorus load at monitoring site WC02, which is located just a few miles downstream. Internal release of phosphorus from sediment cores collected in Harris and Lawrence Ponds did not release measurable amounts of phosphorus. Impoundment internal loading estimates are found in Table 1.

Table 1. Estimated impoundment sediment phosphorus release rates.

Water Body	Site	Release Rate ($mg/m^2/day$)	Area (m^2)	Growing Season P Release (lbs)
Harris Pond	HP01SP	Below detect.	-	-
	HP01T	Below detect	-	-
Lawrence Lake	LL01L	Below detect	-	-
	LL01SP	Below detect	-	-
Lake Montello	LM01B	0.09	938,618	27,936
	LM01MR	Below detect	-	-
Westfield Millpond	WMP	0.07	78,193	1,810

Stream Water Quality Monitoring

Sampling Overview

During 2008, stream samples were collected within the Montello River Watershed between February 22 and November 11 at the eight primary monitoring sites shown in Figure 2. Samples were collected every two weeks in addition to during certain storm events. Event samples were either collected by siphon samplers or as manual grab samples. Discharge measurements and in-situ water chemistry were collected periodically throughout this time period. Stage recorders measured stream height every 15 minutes at sites KW02, KW03, TC01, UN01, WC01, and WC02 between April 4 and November 30 2008. The DNR in cooperation with the USGS operated site MR02, which accounts for the majority of the flow entering Montello Lake. Samples were collected at additional sites throughout the watershed on February 22 and 23, and August 20, 2008.

Interpreting Stream Data

Conditions in a stream can change rapidly with rain or snow melt or very dry conditions. Conditions also change with season, from one year to the next year, and with changes in land management activities on the landscape. These changes necessitate looking at the water quality data from various perspectives. The data in this section will be presented in various viewpoints; the following summarizes the differences in flow conditions and instantaneous measures versus annual estimates.

Baseflow and Runoff

Water quality measured in samples collected during baseflow can be quite different then the water quality of runoff event samples. These differences were taken into account with the interpretation of the stream water quality data in this study. Baseflow water quality represents the combination of groundwater discharging into the stream and some phosphorus release from stream sediments, while runoff event samples are primarily composed of baseflow plus surface overland flow. Baseflow concentrations typically exhibit seasonal variations, but do not change rapidly. In contrast to baseflow, runoff event concentrations of particulate constituents can change continuously, especially in small, flashy streams (Figure 15).

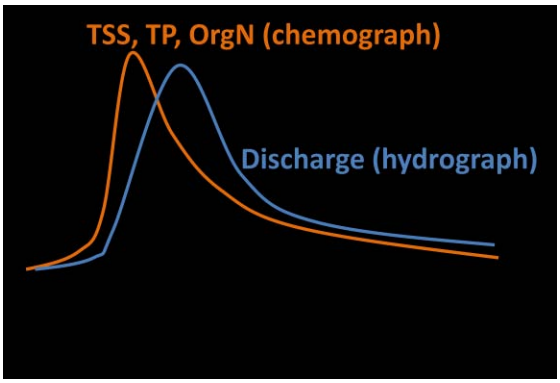


Figure 15. Example of the typical response of the amount of water (discharge) and water quality concentrations during a theoretical runoff event.

Concentrations, Loads, and Yields

Water quality parameters are expressed in different ways. It is important to distinguish between *concentrations*, *loads*, and *yields*. Water quality *concentrations* are expressed as a mass per volume. Common units include milligram per liter (mg/L), and microgram per liter (µg/L). Understanding the *loads* and *yields* helps to prioritize where corrective efforts should be targeted within a watershed.

A ***load*** considers the concentration and the volume of water in the stream resulting in a mass per time. The time period of a load can range from one single instant (instantaneous) to a long-term annual average. The load allows us to compare the amount of a nutrient or other water quality measure from one site to another. For instance, a stream with a high concentration of a nutrient but a small volume of water may have less impact to the downstream waterbody than a stream with a lower concentration of the nutrient with a greater volume of water.

A ***yield*** is calculated to determine the average mass of nutrient per acre within a sub-watershed. It is calculated by dividing the load at a monitoring site by the watershed area of the monitoring site.

Summary of Stream Water Quality Results

A summary of preliminary water quality results at primary monitoring sites in the Montello River watershed, the implications of the results, and the potential sources of water quality degradation can be found in Table 2. Unnamed Creek, Klawitter Creek, and Westfield Creek had the most impacted water quality, while Tagatz Creek was the least impacted.

Each impacted creek has specific issues to be addressed. Westfield Creek has three main issues of concern, temperature, loads, and yields. The first issue of concern is temperature, especially at WC02. According to DNR temperature classifications, this reach of Westfield Creek can only support warm water fish species. The second issue is the loads. Loads are important to consider when assessing the impact a stream has on a downstream lake or impoundment. Westfield Creek is the largest tributary to the Montello River and contributes more phosphorus, sediment, and chloride to downstream impoundments than any other stream. Yields, which are area-weighted loads, indicate which sub-watersheds are exporting the highest mass of phosphorus/sediment/chloride per unit area, and are used to focus management efforts on areas of greatest concern. Westfield Creek had the second highest total suspended sediment yield and the highest chloride yield.

In contrast to Westfield Creek, Unnamed Creek is the smallest tributary to the Montello River, and actually flows directly into Montello Lake. It had the lowest loads of any site, and hence the least impact

on downstream impoundments. The greatest issues of concern at Unnamed Creek are the phosphorus concentrations and yield, total suspended sediment yield, and nitrate. Although Unnamed Creek contributes a relatively low mass of phosphorus and sediment to Montello Lake, this sub-watershed is exporting a higher mass of phosphorus and sediment per area than any other sub-watershed. The biotic integrity of Unnamed Creek may also be hindered by high phosphorus concentrations. Nitrate concentrations at Unnamed Creek were also elevated.

Klawitter Creek, which has more flow than Unnamed but less than Westfield, also has water quality issues. The reach above the monitoring site KW03 has elevated phosphorus concentrations similar to that of Unnamed Creek, which may be impacting biotic integrity. Water temperature does not appear to be impacted, as this reach is considered to support cold water species. Elevated nitrate concentrations were observed in this reach of Klawitter Creek.

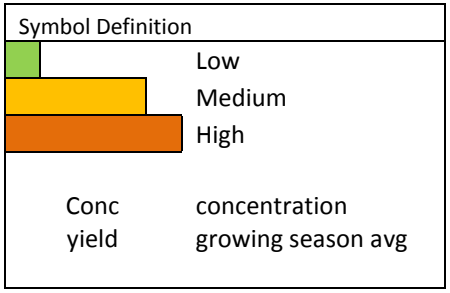
Tagatz Creek is the least impacted tributary to the Montello River. It supports cold water fish species and relative to other sites has no water quality issues of concern.

Table 2. Summary of water quality from samples collected at primary monitoring sites in the Montello River Watershed between 2/22/2008 and 11/13/2009..

		water quality measures of interest										
Stream	Site	Temp-erature	TP Conc	TP Load	TP yield	Cl Conc	Cl Load	Cl yield	TSS Conc	TSS Load*	TSS Yield*	NO_3NO_2 Conc
Klawitter Creek	KW02											
	KW03											
Tagatz Creek	TC01											
Unnamed	UN01											
Westfield Creek	WC01											
	WC02											
Implications of Water Quality Measure		Fish and macroinvertebrate communities	Stream biologic integrity	Eutriphication of downstream lakes & Impoundments	Mass of phosphorus exported per area	Can be used as a tracer of human activity but not harmful at concentrations measured in this study	Mass of chloride potentially delivered to downstream lakes & impoundments	Mass of chloride exported per area	Stream clarity	Soil deposition to downstream lakes & impoundments	Mass of particulate matter exported per area	Drinking water quality
Sources of concern in Montello River Watershed		Runoff from impervious surfaces, impoundments	Runoff from impervious surfaces, human & animal waste, fertilizers			Road salt, some fertilizers, human and animal waste			Erosion of disturbed soil			Groundwater leaching from fertilizers, human & animal waste

Note: Upstream sites are indicated by higher site numbers

*These values are reported with a low confidence



Summary of Stream Water Quality Issues

Westfield, Klawitter, and Unnamed Creek have the most impacted water quality within the Montello River Watershed. Table 2 provides a guide for interpreting the most important water quality measures in this study. It is essential to consider what each parameter indicates, and what the sources within the watershed are contributing to the problem.

Water temperature is a very important factor that in conjunction with habitat characteristics determines what type of species may potentially exist in a stream. WC02 has the most impacted water temperatures of the tributaries, and is classified as a warm water stream. This stream has unsuitable temperatures for cold water species like brook trout.

Total phosphorus concentrations can be used as an indicator of the impact to the biotic integrity of the stream. Streams with lower total phosphorus concentrations will typically have a more diverse biological community of fish, aquatic plants, and aquatic macroinvertebrates. No biological surveys were conducted in this study, but the water quality data gathered in this study suggest that the biologic communities at KW02, KW03, and UN01 are likely the most impacted. KW02, KW03, and UN01 had the highest median fixed interval concentrations (99 µg/L, 103 µg/L, 106 µg/L), the highest median baseflow concentrations (90 µg/L, 98 µg/L, 98 µg/L), the highest median event concentrations (171 µg/L, 358 µg/L, 192 µg/L), and the highest maximum sampled event concentrations (596 µg/L, 865 µg/L, 1,088 µg/L), respectively.

Total phosphorus loads indicate the impact of eutrophication on downstream lakes and impoundments. WC01 had a noticeably higher average growing season total phosphorus load (9,587 lbs/acre) than the other sites, and WC02 had the second highest (5,773 lbs/acre). These sites both had the highest averaged growing season volumes of water (21, 317 ft^3 and 12,327 ft^3) which dwarf the remaining sites (4,042 ft^3 and less).

Chloride concentrations indicate the presence of human activity, as it is found at very low concentrations in undisturbed landscapes of this region. Concentrations were similar across sites, however were slightly higher at WC02 during events and at KW02 during baseflow. The concentrations measured in this study are not known to be harmful to biota.

Discussion focusing on Tributaries with Water Quality Issues

Westfield Creek

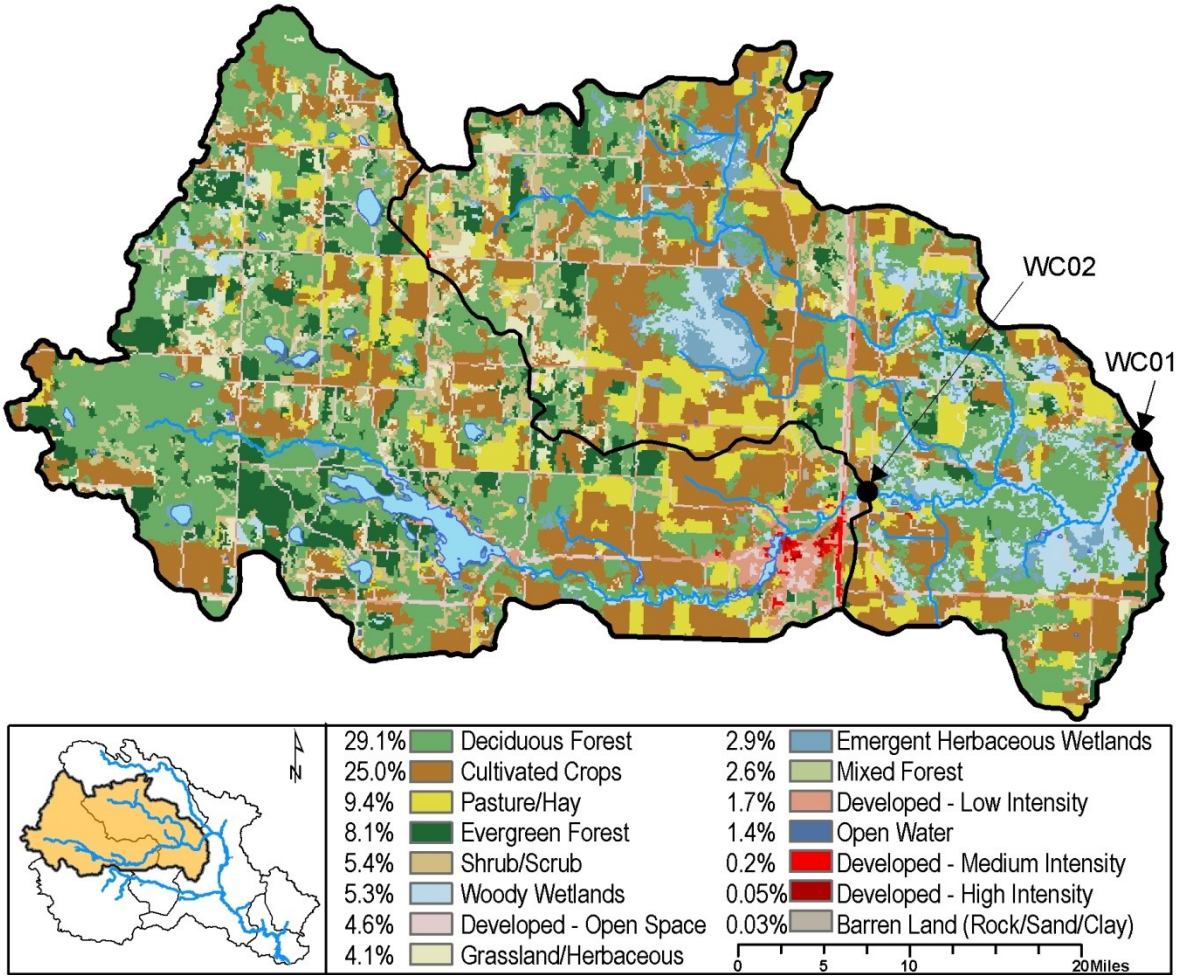


Figure 16. Land use types and monitoring sites in the Westfield Creek surface watershed.

The Westfield Creek surface watershed is 43.7 square miles, and consists primarily of loamy sand and silt loam soil textures (Figure 5). The groundwater watershed is estimated to be 57.7 square miles and extends beyond the surface watershed to the west (Figure 19). The areas to the north and south of Lawrence Creek and Lawrence Lake are internally drained. These internally drained areas contain several small ponds. Westfield Creek originates at the outflow of Lawrence Lake.

The surface watershed downstream of Lawrence Lake is likely the source of a large proportion of the phosphorus, chloride, and total suspended sediment observed at monitoring site WC02. The WC02 sub-watershed has several water quality issues of concern (temperature, phosphorus load, sediment load/yield, and chloride load/yield), all of which involve surface runoff as the main method of transport from the source on the landscape to the stream. Runoff from impervious surfaces in Westfield, the Westfield Millpond, and effluent from the Westfield sewage treatment plant are all likely causes for the warmer stream temperatures observed at WC02. Total phosphorus loads indicate the impact of eutrophication on downstream lakes and impoundments. WC01 had a noticeably higher average growing season total phosphorus load (9,587 lbs/acre) than the other sites, and WC02 had the second highest (5,773 lbs/acre). These sites both had the highest average growing season volumes of water (21, 317 ft^3 and 12,327 ft^3) which dwarf the remaining sites (4,042 ft^3 and less). While the majority of the

water in Westfield Creek is coming from groundwater, the primary source of phosphorus observed at WC02 is likely from a combination of the agriculture located in the surface watershed downstream of Lawrence Lake, the Westfield sewage treatment plant, and lawns in Westfield. The relatively high chloride yield is most likely from road salt from Westfield and I-39, and the Westfield sewage treatment plant effluent.

The overall water quality improves between WC02 and WC01, as phosphorus, total suspended solids, chloride concentrations, and temperature all decrease from the upstream site to downstream.

Unnamed Creek

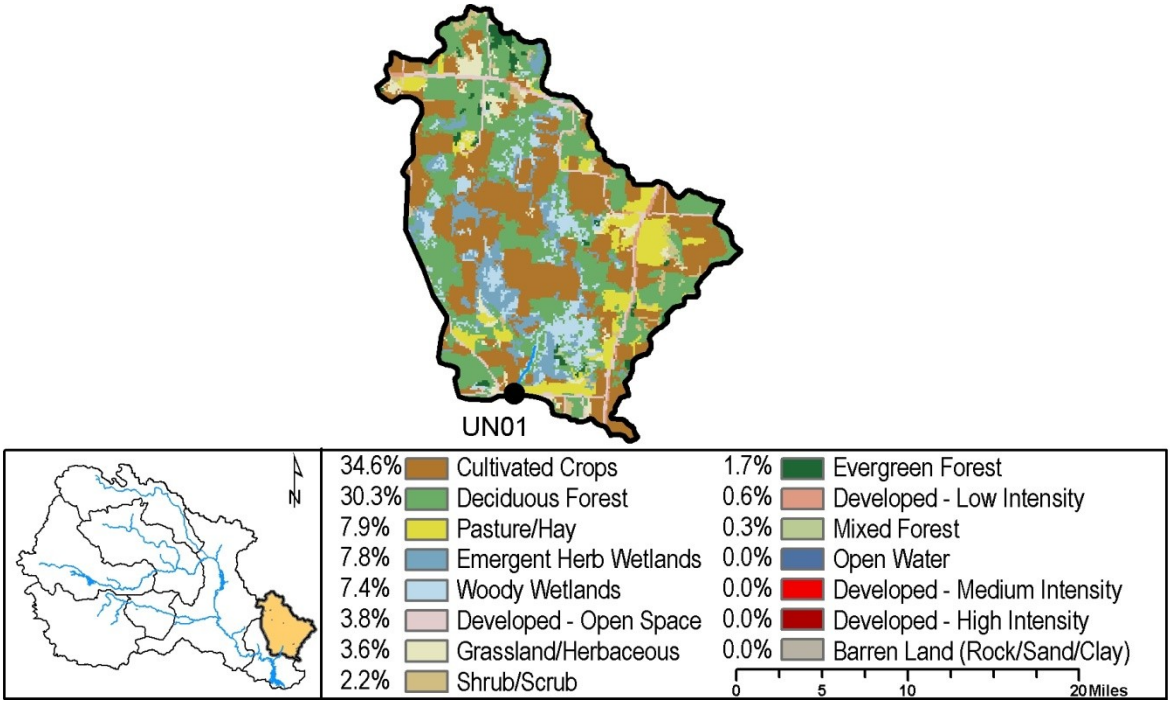


Figure 17. Land use types and monitoring site in the Unnamed Creek surface watershed.

Unnamed Creek has a relatively small surface watershed (7.3 square miles) and consists primarily of muck and loamy sand (Figure 5). The groundwater watershed appears to be very similar to the surface watershed. This is one of the flashier tributaries in the Montello River Watershed, as it responds quickly to rain events and has little flow during dry periods.

Surface runoff is the issue of concern for Unnamed creek, as it has the highest phosphorus yield (0.35 lb/acre) and ranks among the highest total suspended sediment yields (54.8 lb/acre) of any site Although Unnamed Creek has the highest mass of phosphorus and sediment exported per watershed area, it is contributing a small amount of phosphorus and sediment to Lake Montello relative to what is delivered by the Montello River.

Klawitter Creek

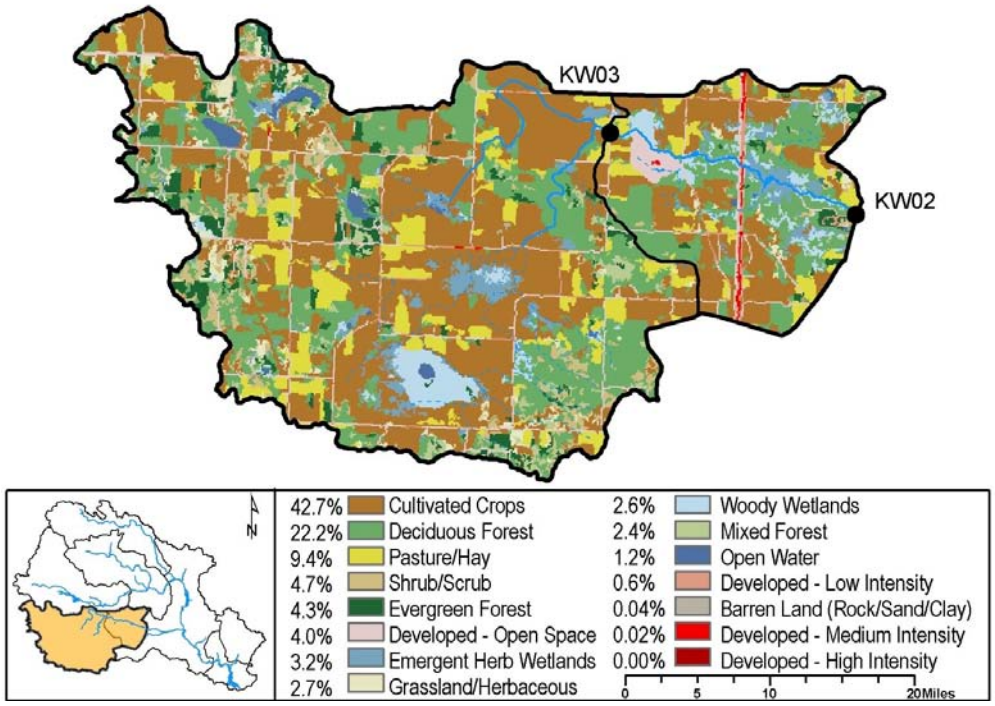


Figure 18. Land use and monitoring sites in the Klawitter Creek surface watershed.

The Klawitter Creek watershed, as defined in this study, consists of the watershed above monitoring site KW02, and does not include the reach between KW02 and the Montello River. Klawitter Creek has a 27.5 square mile surface watershed and consists primarily of loamy sand and silt loam soil textures (Figure 5). The groundwater watershed is estimated to be only slightly larger (28.8 square miles) than the surface watershed, and extends to the northwest (Figure 19). The northwest portion of the surface watershed is internally drained and contains a few small ponds. There is a golf course just downstream of monitoring site KW03. The majority of the KW03 sub-watershed is cultivated cropland, but the reach between KW03 and KW02 is more forested.

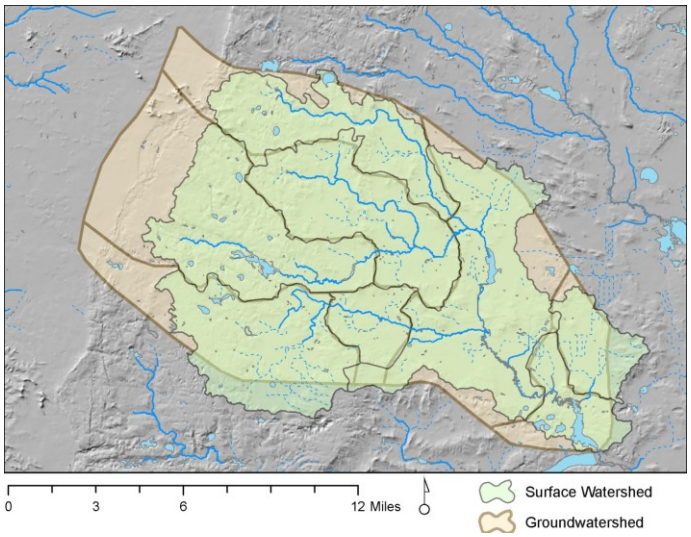


Figure 19. Groundwater and surface watersheds for the Montello River and tributaries.

Temperature and Dissolved Oxygen

Stream temperature has a large influence on aquatic life because many aquatic organisms require temperature specific conditions for successful growth and reproduction. Colder waters can hold more dissolved oxygen (DO) than warmer waters. Some aquatic organisms, such as macro-invertebrates and fish, can be more tolerant of varying DO concentrations, while other organisms can only survive within specific ranges of DO.

Dissolved oxygen can be produced and consumed in various ways. Water receives dissolved oxygen from direct contact with the atmosphere. Oxygen is also produced by algae and rooted aquatic plants during photosynthesis. Dissolved oxygen can become depleted when the rate of dissolved oxygen consumption is higher than the rate of production. DO depletion occurs in streams which have excessive aquatic plant life and slow moving water. When the plants die, oxygen is consumed during decomposition of the plant material.

Average daily water temperatures at primary monitoring sites in the Montello River Watershed are shown in Figure 20 (2008) and Figure 21 (2009). A summary of the 2008 and 2009 maximum average daily thresholds, the summer average, and July average are shown in Table 3. These temperatures may be subject to some degree of error, since on occasion the temperature sensors were buried in sediment at some sites. This was most significant at UN01.

The maximum average daily temperature is the primary criteria for determining the classification of a stream (e.g. warm, cool, cold water). The summer average and July average are used as supplementary information in cases where the maximum average daily temperature is very near a threshold between classes. Using this approach and considering the data from both 2008 and 2009, an overall classification was determined. The site TC01 on Tagatz Creek, which is classified as a Class I trout stream by the DNR, is considered a cold water stream and had noticeably cooler temperatures than the other sites. The site KW03 near the headwaters of Klawitter Creek is also classified as a cold water stream but is considered a Class III trout stream. UN01 located on Unnamed Creek and KW02, located in the middle reach of Klawitter Creek, fall into the cool-cold transition category. WC01, located on the lower reach of Westfield Creek, is considered a cool-warm transition stream reach. WC02, located in the middle reach of Westfield Creek, has the highest temperatures and is considered a warm stream reach.

Shallow, slower moving water in the Westfield Millpond, effluent from the Westfield sewage treatment plant, and warm runoff from impervious surfaces (pavement, roofs, etc) increases water temperatures at both downstream sites. This effect is most pronounced at WC02 because it is only a couple of miles downstream of the Millpond, and there are no incoming tributaries between the two points. Colder water from Caves Creek, which feeds into Westfield Creek between WC02 and WC01, explains the slightly cooler temperatures at WC01.

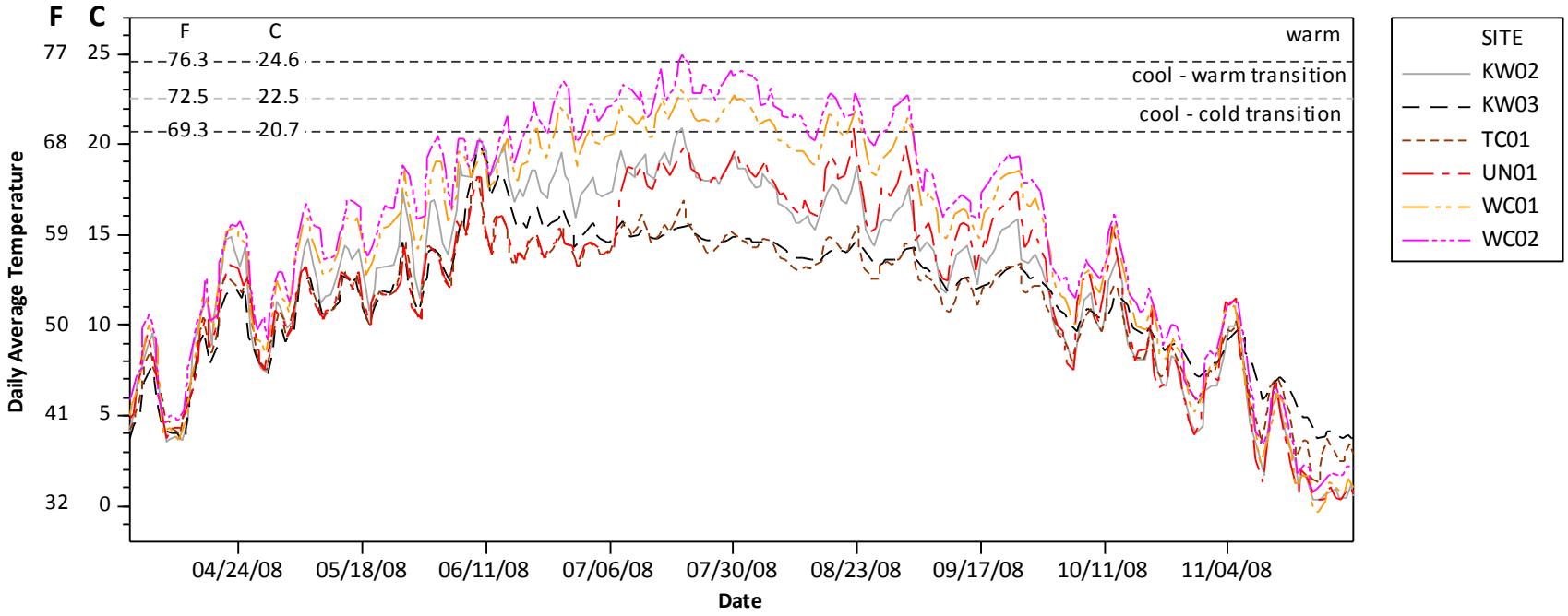


Figure 20. 2008 Average daily water temperature calculated from continuous temperature data recorded at primary stream monitoring sites in the Montello River Watershed.

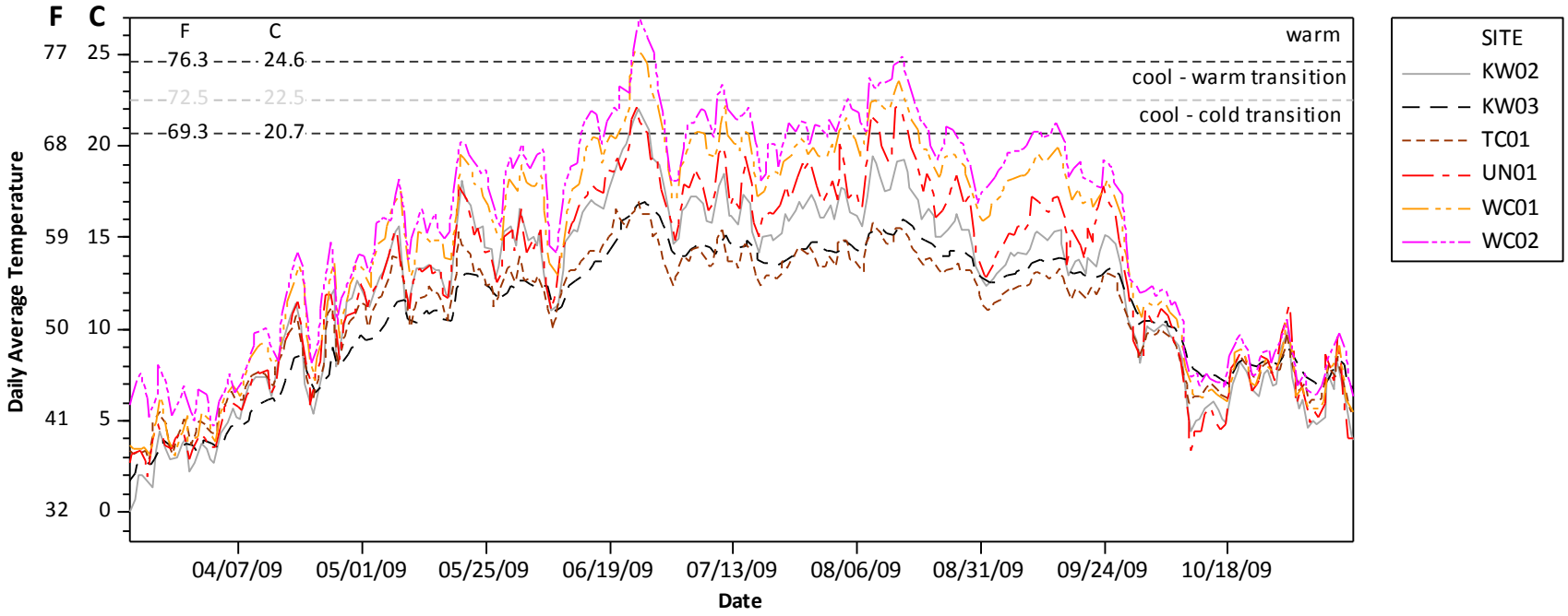


Figure 21. 2009 Average daily water temperature calculated from continuous temperature data recorded at primary stream monitoring sites in the Montello River Watershed

Table 3. Summary of average daily stream temperature calculated from continuous temperature records at primary monitoring sites during 2008, 2009, and overall.

	Metric	Maximum daily average				Summer Average (6/1 – 8/31)				July Average			
Thresholds (*C* and F)	lower (>=)		*20.7* 69.3	*22.5* 72.5	*24.6* 76.3		*17.0* 62.6	*18.7* 65.7	*20.5* 68.9		*17.5* 63.5	*19.5* 67.1	*21.0* 69.8
	upper (<)	*20.7* 69.3	*22.5* 72.5	*24.6* 76.3		*17.0* 62.6	*18.7* 65.7	*20.5* 68.9		*17.5* 63.5	*19.5* 67.1	*21.0* 69.8	
2008													
Stream	**Site**												
Klawitter Creek	KW02		20.90				17.70				18.62		
	KW03	19.91				15.00				15.00			
Tagatz Creek	TC01	18.16				14.49				14.96			
Unnamed	UN01		20.88			16.66					17.60		
Westfield Creek	WC01			23.04				20.36					21.49
	WC02				24.94				21.73				22.97
2009													
Klawitter Creek	KW02		22.03			16.57				16.88			
	KW03	16.95				14.29				13.92			
Tagatz Creek	TC01	16.99				13.89				14.02			
Unnamed	UN01		22.15				17.59			17.05			
Westfield Creek	WC01				25.26			19.77				19.56	
	WC02				26.92				21.03			20.92	

		Overall				Symbol	DNR Classification
Klawitter Creek	KW02		CT			Cd	Cold
	KW03	Cd				CT	Cool – cold transition
Tagatz Creek	TC01	Cd				WT	Cool – warm transition
Unnamed	UN01		CT			W	Warm
Westfield Creek	WC01			WT			
	WC02				W		

Note: Upstream sites are indicated by higher site numbers, continuous temperature data are not available for the Montello River sites

Total Suspended Solids

Total suspended solids (TSS) provide a measure of how much eroded soil and organic matter is in the water. TSS can affect water clarity, limiting the amount of sunlight penetrating the river bottom and visibility for predatory fish. The suspended particles may eventually settle to the bottom of a river/impoundment as velocity slows. Excessive deposition of fine particles such as silt can alter reproductive habitat of some fish species and decrease the quality of macro-invertebrate habitat. In extreme cases, water temperature increases can result from the darker water absorbing more sunlight than normal. In extreme cases this may cause cold water fisheries to change to cool or even warm water fisheries.

Sources of TSS may include soil, leaves and other vegetation which can travel across the landscape during runoff events. Exposed soil such as those found on construction sites and cultivated fields is most susceptible to erosion. Exposed soil is also most susceptible to wind erosion, which is not uncommon in the sandy soil of this region. The transport of TSS to a stream during a runoff event is heavily influenced by the distance from the stream and the characteristics of the landscape along a flow path. The amount of material that is transported can be decreased by intercepting runoff using a combination of vegetative buffer strips, silt fences, constructed or restored wetlands, raingardens, and settling ponds or altering the slope of the landscape. Water may also be captured and diverted (e.g. gutters on buildings in conjunction with one or more of the above practices) or used at a later time (rain barrel).

Stream bank erosion is another source of TSS in a stream. Bank erosion is a natural occurrence that takes place mostly during periods of high flow. However, alterations within the watershed that increase runoff can make streams more flashy will increase streambank erosion. The most severe forms of unnatural bank erosion are caused by channel alteration with construction equipment, washouts from poorly constructed culverts and or road crossings, and trampling from concentrated agricultural stock access. Removal of shoreland vegetation and routine use by large animals will also result in increased stream erosion.

A summary of TSS concentrations sampled in this study is found in Figure 22. During low flow, the median TSS concentrations were very similar across all sites, ranging from 3 mg/L at KW03 to 12 mg/L at WC02. These median values are considered low, and indicate streambed and streambank erosion are not significant during these conditions. As would be expected, low flow TSS concentrations did not exhibit seasonal variation.

Most runoff total suspended sediment concentrations observed in this study were relatively low. High concentrations were observed during the intense flood on 6/8/2008 with the highest observed concentration, 242 mg/L, which occurred at KW03. The highest sampled concentrations at the other sites were 152 mg/L at WC02, and 123 mg/L at UN01.

Average growing season loads are found in Figure 23. Based on the calculations done in FLUX, these data are reported with some uncertainty. Despite this, the data still provide useful estimates. Westfield Creek contributes the vast majority of the flow to Montello River, so it is no surprise it also contributes the most total suspended sediment (2,080,387 lbs/year at WC01 and 1,489,799 lbs TSS/year at WC02). Unnamed Creek UN01), which contributes the least flow to Montello Lake, contributed 257,103 lbs TSS/year. It appears the 2008 TSS load at KW02 (149,221 lbs) may have been underestimated and the 2008 KW03 load was overestimated (582,837 lbs) to some degree (Appendix, Table 5). KW03 was the only site that had a higher TSS load in 2008 than 2009.

The yields, found in Figure 24, offer a valuable area-weighted comparison of each sub-watershed. Based on this, it appears the Unnamed Creek and Westfield Creek watersheds are exporting about twice the mass of sediment per area than the other sites. TC01 and KW02 stand out as the lowest TSS yields (15 lbs/acre and 21 lbs/acre, respectively).

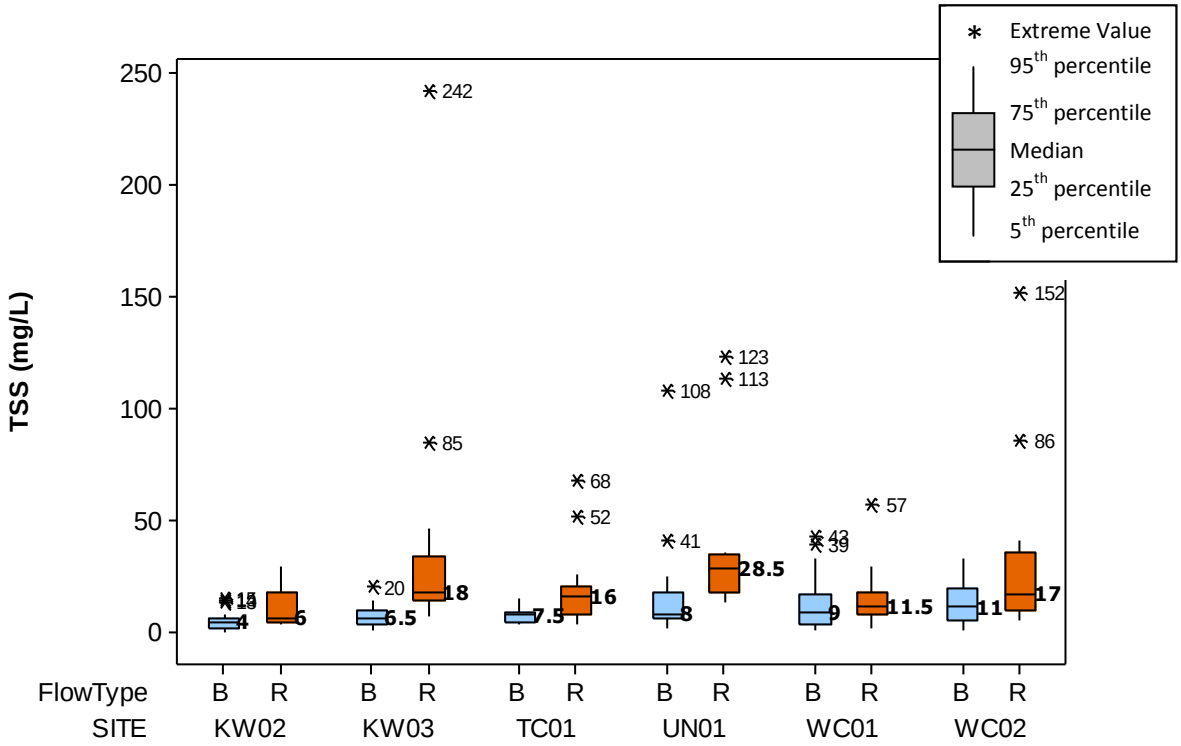


Figure 22. Total Suspended Solids concentrations (mg/L) sampled at primary monitoring sites in the Montello River Watershed between 2008-2009. (B=Baseflow, R=Runoff)

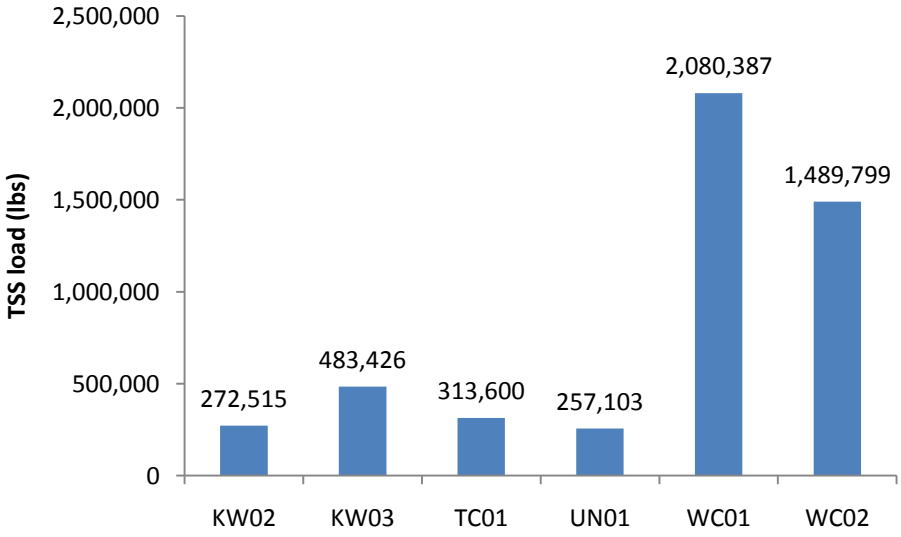


Figure 23. Total suspended solids 2008-2009 growing season (4/1/2008-12/1/2008, 3/14/2009-11/12/2009) average loads at primary monitoring sites in the Montello River watershed.

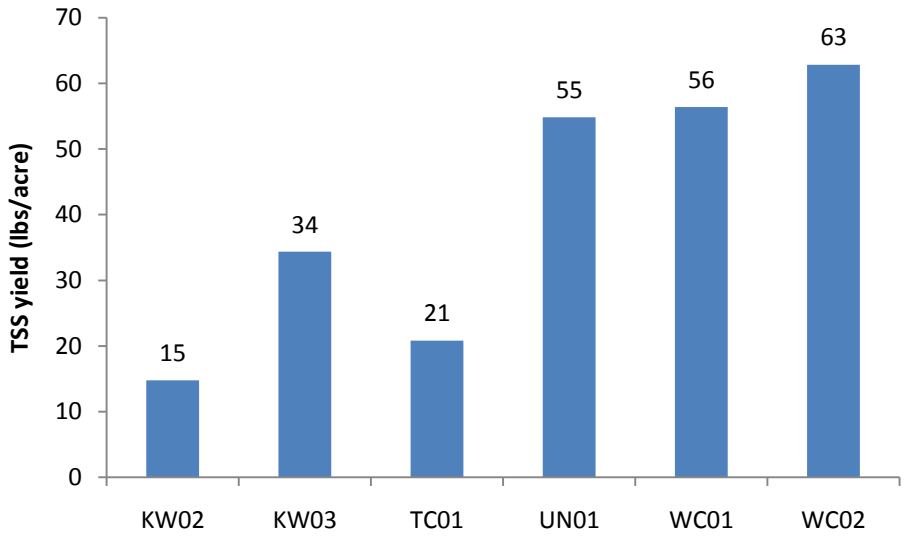


Figure 24. Total suspended solids 2008-2009 growing season (4/1/2008-12/1/2008, 3/14/2009-11/12/2009) average yields at primary monitoring sites in the Montello River watershed.

Phosphorous

Phosphorous (P), has a significant impact on aquatic ecosystems. Just as phosphorous increases plant growth on land, it also increases aquatic algae and rooted aquatic plants. Just as phosphorous was the limiting nutrient in the lakes in this study it is also the most important nutrient to manage in the Montello River Watershed.

Soil-adsorbed phosphorous and soluble reactive phosphorous are transported across the land to surface water during runoff events. Total phosphorous (TP) is a measure of both the soil-adsorbed and soluble reactive component. Soluble reactive phosphorous (SRP) is readily used by algae and aquatic plants. Phosphorus sources include human and animal wastes, organic material, soil erosion, detergents and other household products, septic systems, fertilizers, and runoff from farmlands, lawns, and construction (Shaw et al., 2002).

Baseflow and Runoff Event Concentrations

Phosphorus concentrations during runoff events were distinctly higher at Klawitter Creek and Unnamed Creek (Figure 25). Unnamed Creek had the highest sampled phosphorus concentration (1,008 µg/L) of the entire study, which occurred during the flood of 6/8/2008. The next highest concentrations (685 and 665 µg/L) were observed at Klawitter Creek at the KW03 monitoring site. Tagatz Creek had the lowest median baseflow total phosphorus concentration of any site (39 µg/L), and also had consistently low runoff event concentrations. Both Westfield Creek sites are downstream from two impoundments, Lawrence Lake and the Westfield Millpond. This makes the stream less responsive to runoff events, as incoming water, soil, and phosphorus are slowed and possibly retained rather being transported directly downstream. This is one possible explanation for the somewhat low event concentrations in Westfield Creek. Another potential explanation is dilution from the massive amount of groundwater that feeds this stream. WC01, the downstream site on Westfield Creek, had similar runoff concentrations to TC01. Runoff event concentrations at the upstream site, WC02, were consistently higher than that of WC01.

Median baseflow TP concentrations exceeded the DNR phosphorus criteria for wadable streams (74 µg/L) and impoundments (40 µg/L) at both sites on Klawitter Creek KW02 (91 µg/L), KW03 (98 µg/L), and Unnamed Creek UN01 (98 µg/L). TP concentrations during baseflow showed seasonal variability. As would be expected, the highest concentrations were observed after the major flood and early June, which steadily decreased until the end of the sampling season in November (Figure 26). Phosphorous release rates from streambed sediments deposited in the flood were higher directly after the event; the release rate decreased over time. Seasonality may have also influenced this trend, as biologic activity is higher in the summer. Sites on Klawitter Creek, KW02 and KW03, also had higher concentrations in early spring, which decreased until the flood in early June. Phosphorous enriched soil was deposited into the stream during spring runoff, and release rates decreased until the next major input in June. Samples representing winter baseflow concentration were collected 2/22/08, which were quite a bit lower at KW02 and KW03 than the spring baseflow concentrations.

Soluble reactive phosphorus concentrations were strongly correlated with TP concentrations (Figure 27), which is commonly observed.

Impact of Phosphorus on the Biotic Integrity of a Stream

The DNR has phosphorous criteria for streams, rivers and lakes. Based on the results of a recent study by the USGS (Robertson *et al.* 2006), median stream concentrations above 74 µg/L and median river concentrations above 103 µg/L have a greater impact on the overall biotic integrity of a water body. The sites on Klawitter Creek, Tagatz Creek, Unnamed Creek, and Westfield Creek are classified as streams. Reference concentrations throughout Wisconsin, which represent the natural condition of a water body, were estimated to be between 30 and 40 µg/L (Robertson 2006). Using a different statistical method, the United States Environmental Protection Agency (USEPA) estimated reference conditions in the north central hardwood forest sub-ecoregion, which spans across central Wisconsin, to be 29 µg/L (2000). Median TP concentrations for each site, which represent random conditions and include no more than one sample per 30 day period, are shown in (Figure 25). Randomly sampled median concentrations at KW02, KW03, and UN01 were above the DNR P criteria for wadable streams of 74 µg/L. Concentrations at WC01 were slightly below the threshold, and are suggested to have minimum effects on the overall biotic integrity of the stream. Values at WC02 were within the proposed range of total phosphorous concentrations that have the least impact on the overall biotic integrity of the stream. The site on Tagatz Creek, which is classified as a Class I trout stream by the DNR, was considered to have natural phosphorous concentrations. All of the sites except TC01 were above the proposed standard for impoundments (40 µg/L). Since all the sites are located upstream of impoundments, it is suggested that stream concentrations should not exceed the impoundment standard.

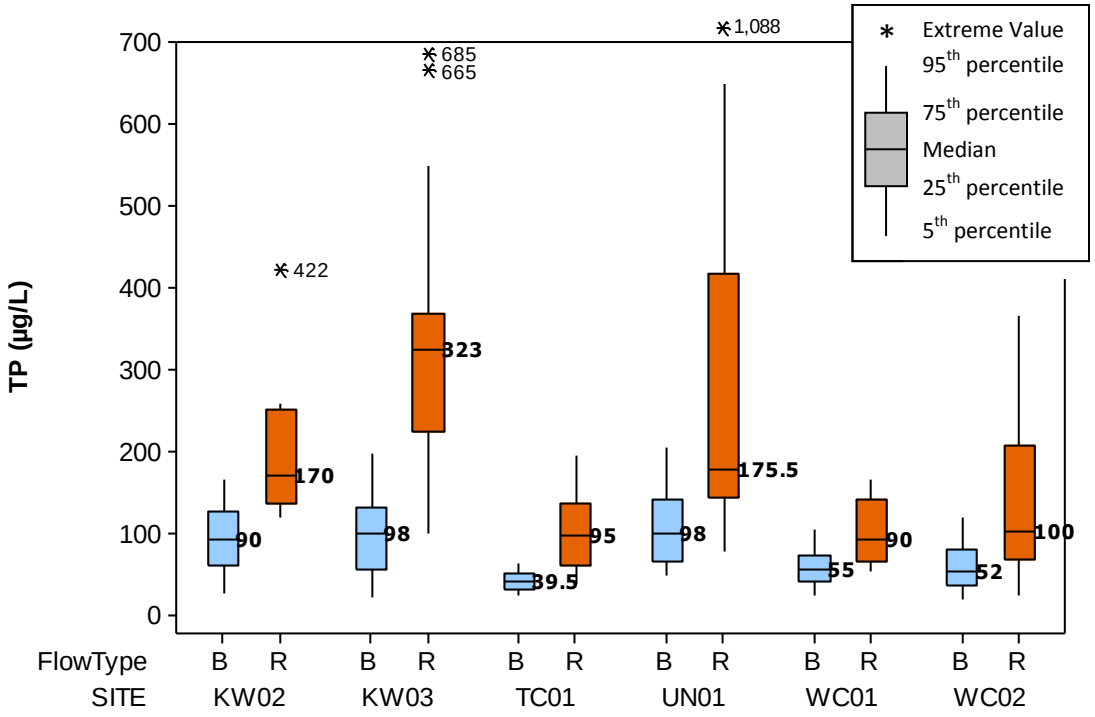


Figure 25. Total Phosphorous concentrations (mg/L) sampled at primary monitoring sites in the Montello River Watershed between 2/22/2008 and 11/11/2008.

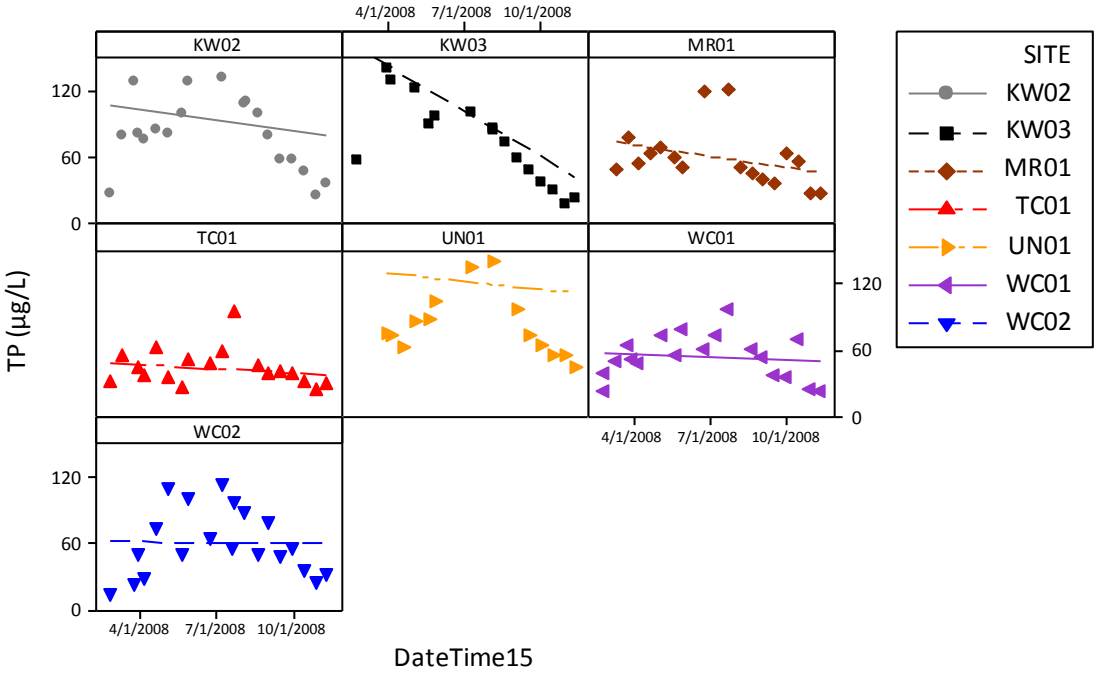


Figure 26. Baseflow total phosphorous concentrations (µg/L) sampled at primary monitoring sites in the Montello River Watershed between 2/22/2008 and 11/11/2008.

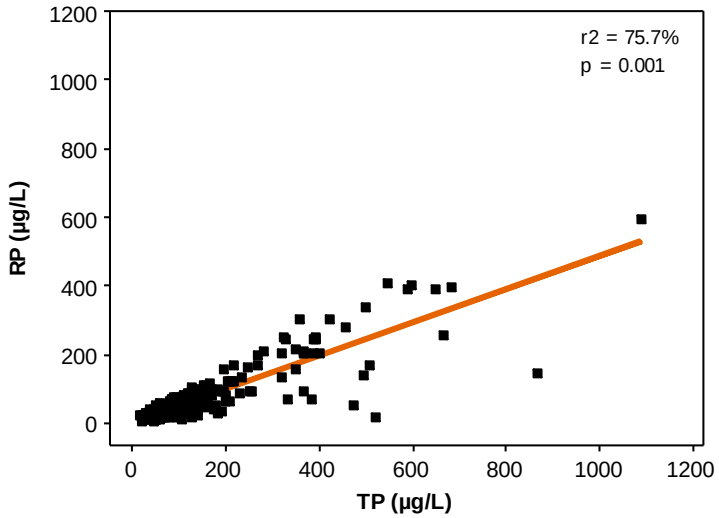


Figure 27. Total phosphorous vs Soluble reactive phosphorous concentrations sampled at primary monitoring sites in the Montello River Watershed between 2008-2009.

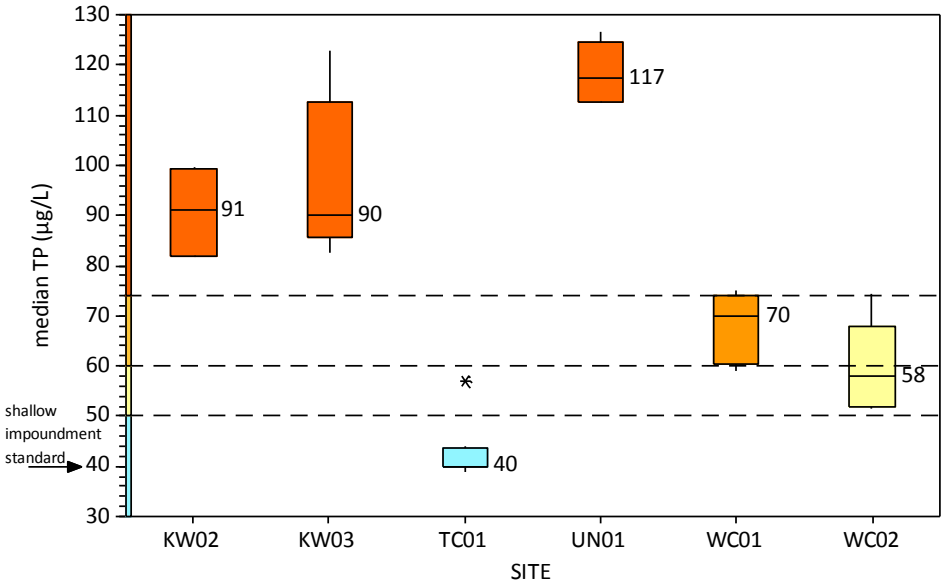


Figure 28. Box plot of total phosphorous (µg/L) concentrations in the study streams 2008-9. The lines show the DNR phosphorus criteria (impoundments, 40 ug/L, red line) and (streams, 74 ug/L, green line). (B=Baseflow, R=Runoff)

A Closer Look at the June 2008 Flood

Instantaneous TP loads were calculated from samples collected during the intense flooding in early June 2008 which presented an opportunity to compare the hydrographs and water quality samples across sites (Figure 29). In order of highest to lowest instantaneous TP loads, the sites ranked as follows: WC02, KW03, WC01, UN01, KW02, and TC01. Sites WC02, UN01, and KW03 had significant increase in TP load as flow increased. Flood event instantaneous TP loads at sites TC01, KW02, and WC01 showed little change despite increases in flow. It appears that the first two rounds of samples were collected during the rising limb of the total phosphorous chemograph, and the final round occurred on the falling limb.

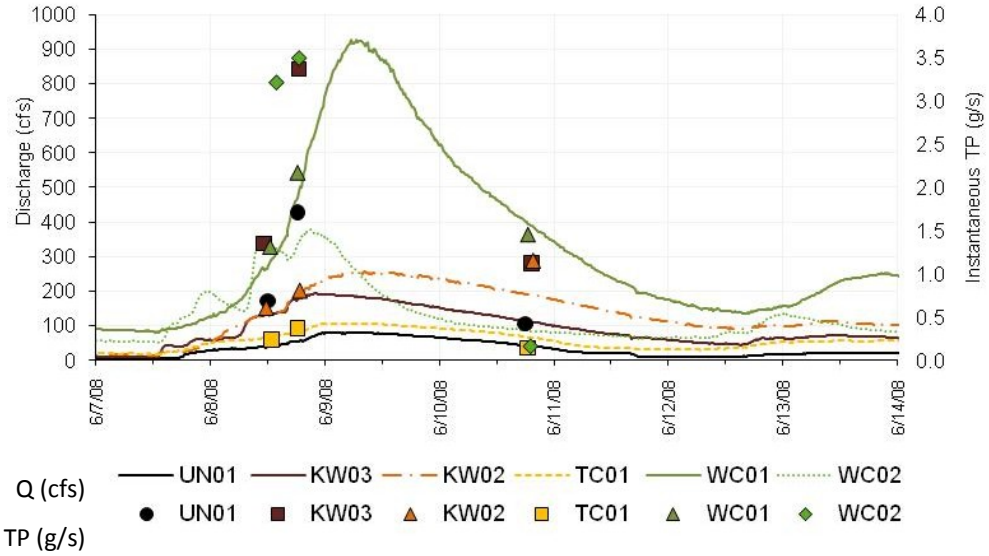


Figure 29. Instantaneous TP loads and continuous discharge between June 7 and June 14, 2008.

Loads and Yields

The total phosphorus loads (Figure 30) and yields (Figure 31) offer valuable insight on the Montello River tributaries. The more phosphorus transported downstream, the more eutriphication of downstream impoundments occurs. Westfield Creek, which contributes the greatest amount of water to the Montello River (Appendix, Table 4), also contributes the greatest amount of phosphorus (average growing season load of 9,587 lbs at WC01 and 5,773 lbs at WC02). In contrast, Tagatz Creek and Unnamed Creek contribute only a fraction of the phosphorus Westfield Creek does (1,703 lbs and 1,627 lbs respectively). When weighted by the area that contributes water to the each respective monitoring site, the sites rank much differently (Figure 31). The average growing season yield was the greatest at UN01, and lowest at TC01 (0.11 lbs/acre). The yields at Klawitter Creek and Westfield Creek were similar.

It is important to consider that although a very large area contributes water to Westfield Creek, much of this area is internally drained. An internally drained area contributes a negligible amount of phosphorus to receiving water bodies. Increasingly best management practices throughout the groundwatershed of Westfield Creek would not result in an increase of water quality in Westfield Creek or any downstream impoundments. Rather, areas that are known to directly contribute surface runoff to Westfield Creek promise to reduce eutriphication of downstream impoundments.

Although UN01 exported more mass of phosphorus per area than any other sites, focusing management efforts here are likely to have only a minor increase on the eutriphication of Montello Lake, as it is already contributing the least of any subwatershed. The ideal candidate to focus management efforts would have both the highest yield and load.

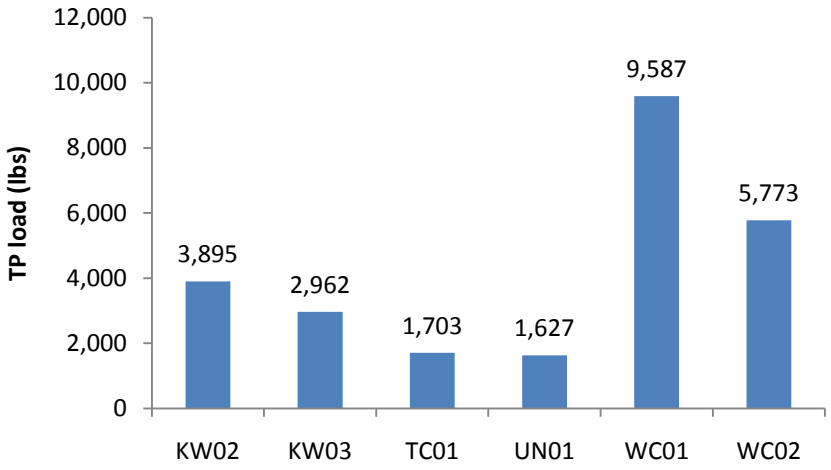


Figure 30. Total phosphorus 2008-2009 growing season (4/1/2008-12/1/2008, 3/14/2009-11/12/2009) average laods at primary monitoring sites in the Montello River watershed.

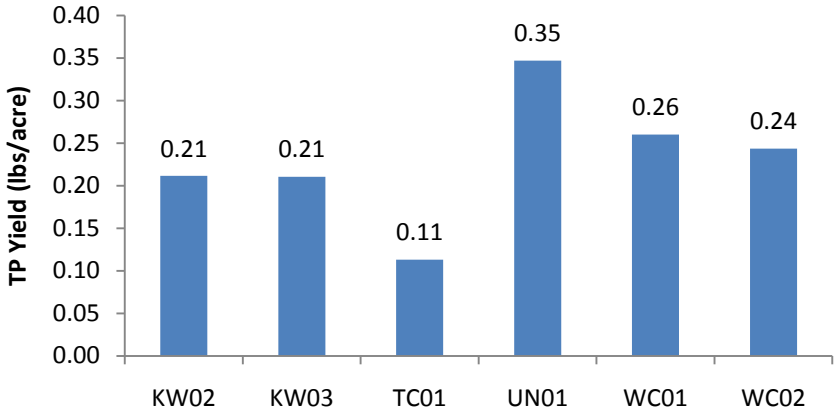


Figure 31. Total phosphorus 2008-2009 growing season (4/1/2008-12/1/2008, 3/14/2009-11/12/2009) average yields at primary monitoring sites in the Montello River watershed.

SNAP-Plus Phosphorus Modeling

There are many sources of phosphorus in the Montello River watershed; many described earlier in this document. Since a significant percent of agriculture comprises the landscape in the watershed, it was useful to evaluate how much phosphorus is leaving the fields based on the soil type and management practices used in this watershed. Many producers across the state are using a tool called SNAP-Plus to help them manage their farm nutrients by identifying which fields may need additional phosphorus for a given crop and which fields do not need more phosphorus. Reducing phosphorus applications helps to save the producers money and is good for groundwater, lake, and river water quality.

The field-scale nutrient management software SNAP-Plus was used to estimate phosphorus exports from some of the farm fields within the Montello River watershed. Using a field-scale tool such as SNAP-Plus offers many improvements over a basin-scale model such as SWAT. SNAP-Plus accounts for variations in management on a field-by-field basis, whereas SWAT only considers the landscape in generalized regions. This prioritization helps to identify where best management practices (BMP's), are most needed within the watershed. The downside of SNAP-Plus is that participation in the data collection process is voluntary, so complete data sets for the watershed were difficult to acquire;

however, using SNAP-Plus allows a agricultural producer to more efficiently manage their land, and it is gaining popularity as producer's learn about the benefits it offers.

Figure 34 provides a comparison of the Phosphorus Index (PI) calculated by SNAP-Plus and the phosphorus loads and yields estimated from the data collected in this study. The Phosphorus Index is calculated in units of pounds per acre per year, and represents the estimated amount of phosphorus that reaches a nearby waterbody based on specific management practices on the field and its distance to the waterbody. Median PI's for each sub-watershed correlated somewhat with the estimated TP yields, with the median PI explaining 64% of the variation of the yields.

Areas most directly connected to the tributaries and rivers within the Montello River watershed were identified by creating a model which included soil type, slope, and distance to water (Figure 32). We hoped to evaluate fields that fell within the most directly connected regions of the watershed; however, the actual participants in this study were voluntary so we were not able to get full coverage.

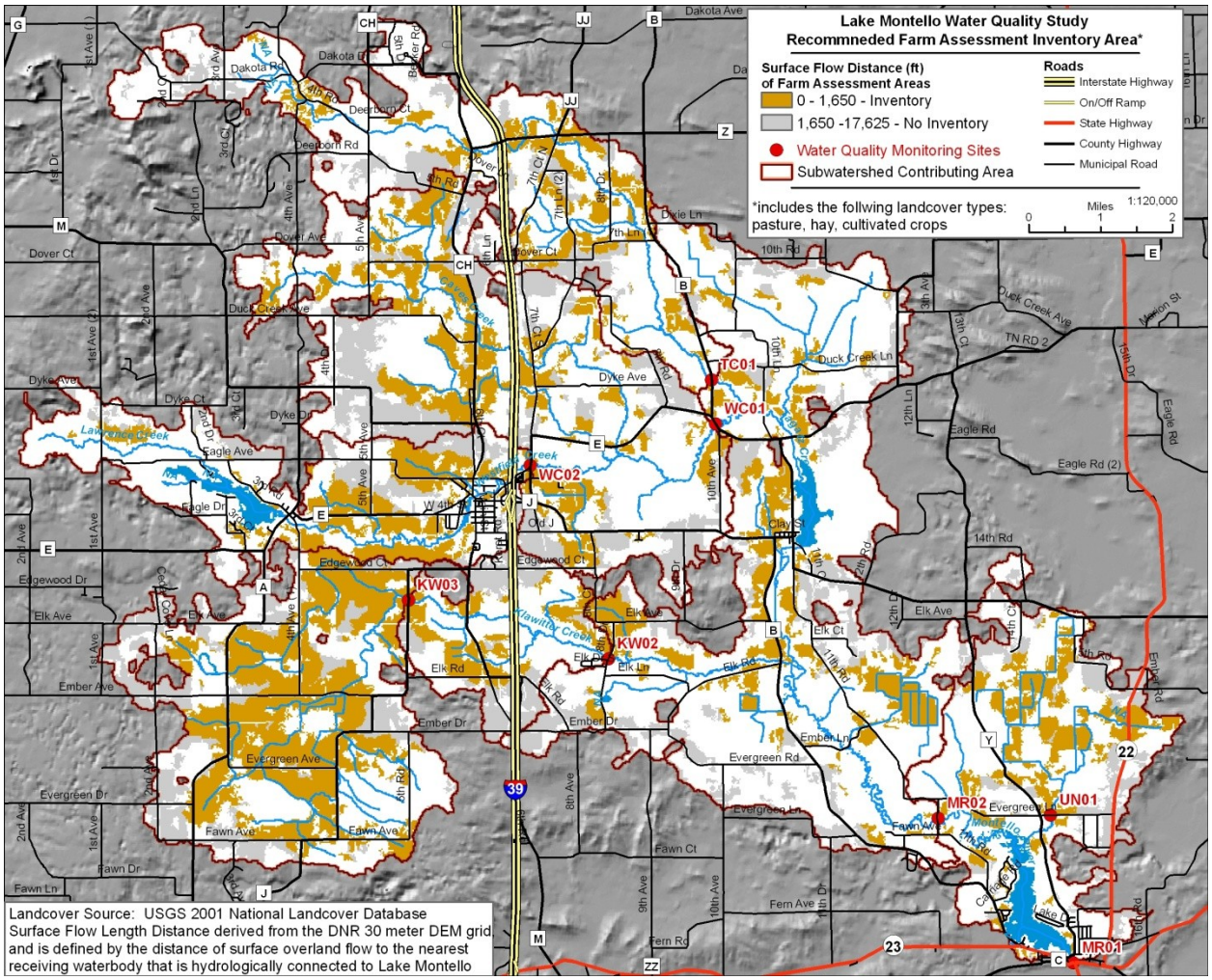


Figure 32 Fields within the Montello River watershed identified as being most directly connected to streams and rivers.

PI by sub-watershed is displayed in Figure 33. This information can be used to prioritize efforts to reduce phosphorus within the Montello River watershed. Fields with the highest PIs should have

practices put into place to reduce phosphorus in the field. This reduction, along with implementation of best management practices that reduce soil loss should reduce in stream phosphorus concentrations. Although current regulations require that fields with PIs greater than 6 take steps to reduce phosphorus, all losses of phosphorus from fields to water can have a negative impact on water quality so benefits to lakes, rivers, and groundwater can occur with any reduction in PI. Nearly all sub-watersheds (except TC01 and WC02) had fields with PIs greater than 6.

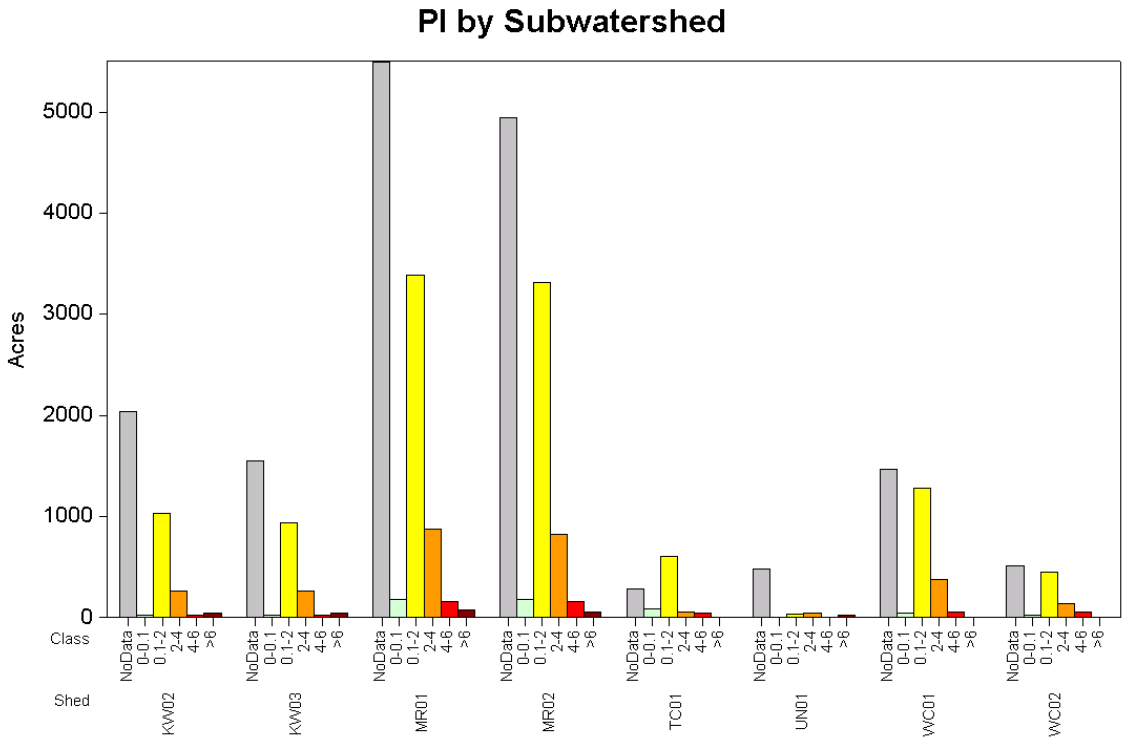


Figure 33. PIs of fields by sub-watershed in acres with PIs ranging from 0 to greater than 6 and acreage of fields lacking sufficient data for SNAP-Plus.

This study only represents the first step forward in using SNAP-Plus at the basin scale. The correlation between median PI and average TP yield suggests SNAP-Plus can be used effectively at the basin scale. Future studies can improve the quality of their results by getting more producers to participate, and finding the best way to derive useful summary statistics from the data.

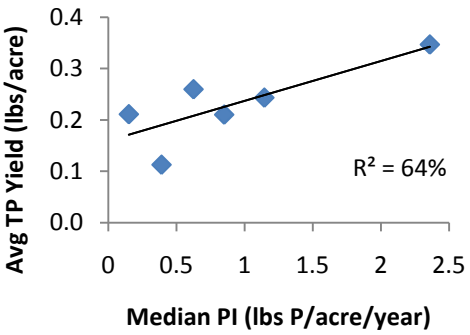


Figure 34. Comparison of SNAP-Plus phosphorus estimates and estimated yields based on observed data (2008-09).

Chloride

Chloride is neither a nutrient nor toxin on its own, but because the natural concentrations of chloride in Wisconsin are relatively low, it is an indicator of cultural inputs to the river system. Microorganisms do not degrade chloride and it does not react with soil as it moves to the river making it a good "tracer" of man-made sources. Common sources of chloride include septic systems, animal waste, potassium fertilizer, pesticides, and road-salting chemicals (Shaw et al., 2002). These chloride sources may have other contaminants (such as nutrients, pesticides, pharmaceuticals, etc) associated with them. In general, when chloride is moving to the river primarily via groundwater, the concentrations tend to be higher during baseflow (low flow) conditions and if chloride is moving to the system through overland flow, concentrations will be elevated during runoff events and lower during baseflow.

Chloride concentrations can be observed in Figure 35. WC02 had the highest concentrations of any site. Runoff concentrations were higher than baseflow concentrations at WC01 and WC02, suggesting that chloride is being transported from the landscape to Westfield Creek via surface runoff. Road salt applied to streets and sidewalks in Westfield and I-39 are likely sources of the chloride being transported via surface runoff. Effluent from the Westfield sewage treatment plant is also likely to be contributing to the chloride concentrations observed in Westfield Creek. At monitoring site UN01, chloride concentrations decreased during runoff events, suggesting groundwater as the primary transport path. The remaining sites had similar concentrations during runoff events and baseflow.

Similar to phosphorus and total suspended sediment, Westfield Creek also had the highest average growing season chloride load (851,561 lbs at WC01 and 627,801 lbs at WC02). Westfield Creek also had the highest yields of any stream (23.1 at WC01 and 26.5 at WC02). Management efforts aimed at reducing chloride in the Montello River Watershed would be best focused on the WC02 sub-watershed, but since chloride itself poses no direct harm to aquatic ecosystems, managing to reduce chloride alone is a poor utilization of resources.

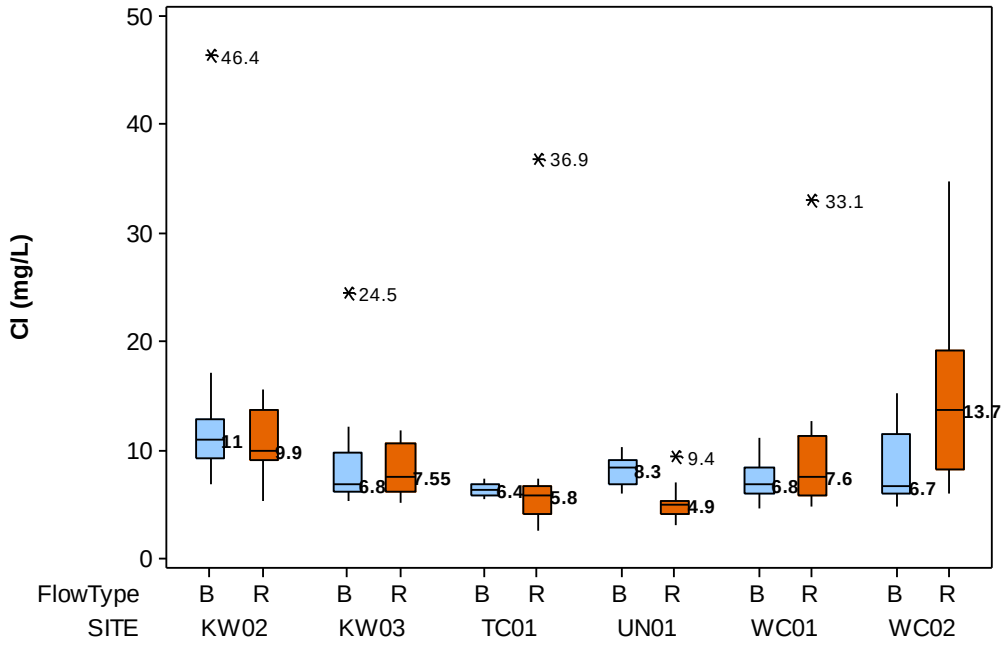


Figure 35. Chloride concentrations sampled at primary monitoring sites in the Montello River watershed between 2008-2009.

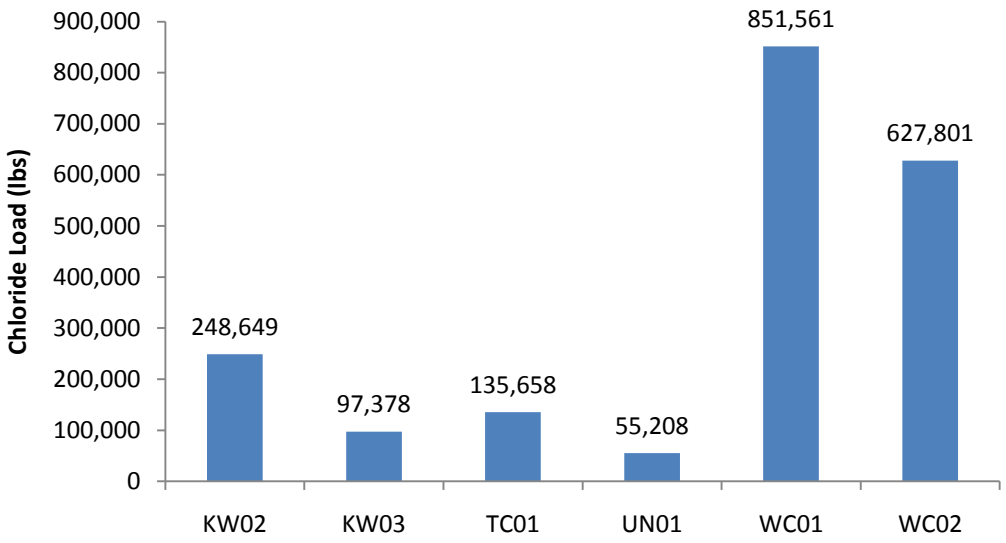


Figure 36. Chloride 2008-2009 growing season (4/1/2008-12/1/2008, 3/14/2009-11/12/2009) average loads at primary monitoring sites in the Montello River watershed.

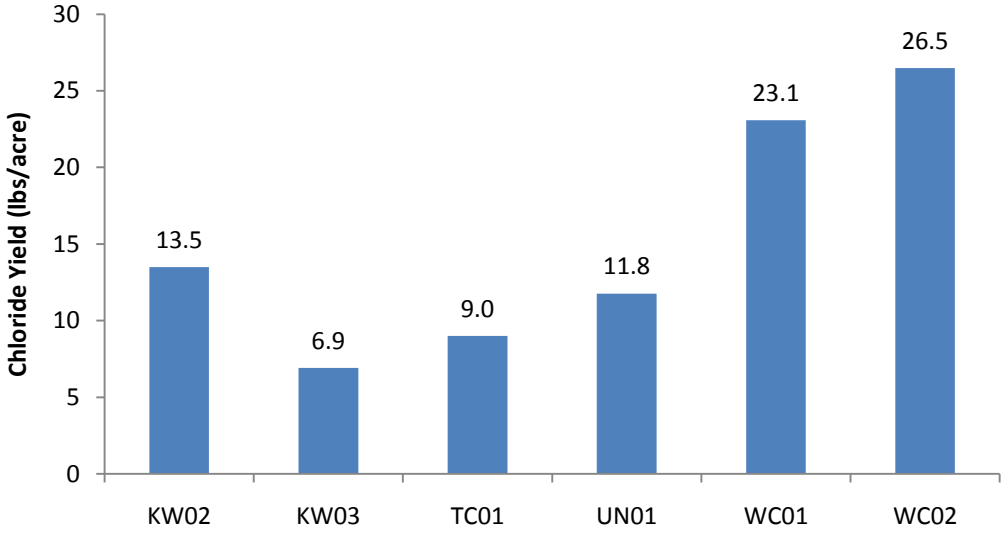


Figure 37. Chloride 2008-2009 growing season (4/1/2008-12/1/2008, 3/14/2009-11/12/2009) average yields at primary monitoring sites in the Montello River watershed.

Nitrogen

Nitrogen is an important nutrient for plant and animal survival and growth. Elevated nitrogen concentrations can lead to abundant plant growth which can have negative effects on stream and lake ecosystems, affecting algae, aquatic plants, invertebrates, and fish. The increase in plant growth can affect the types of plants and ecological communities that are present. The decomposition of excess plant material may also deplete available oxygen. Depending on the form, excess nitrogen can be transported to rivers through groundwater and/or surface runoff.

The forms of nitrogen discussed in this study included nitrate + nitrite (NO_2+NO_3 -N), ammonium (NH_4), organic nitrogen (OrgN), and total nitrogen (TN). The different forms of nitrogen are produced through

both biological and physical processes and may be transported in the watershed by different means. Common sources of nitrate include fertilizers, animal waste, and septic systems. In the sandy soils of the Montello River Watershed nitrate not taken up by plants or degraded by microorganisms in the soil can leach to groundwater with relative ease. Nitrate can be transported great distances by groundwater until it is discharged to surface water. Organic nitrogen is often a particulate form of nitrogen that is associated with soil, sediment, and vegetation.

Ammonium is another form of nitrogen important to water quality and is readily available for use by algae and aquatic plants. Surface runoff and release from wetlands are the primary sources of ammonium to lakes and stream because ammonium adsorbs to soil particles. The major sources of ammonium include animal waste, fertilizers, and degraded septic systems and wastewater infiltration ponds. A natural source of ammonium is from wetland soils.

The most prominent form of nitrogen in the Montello River Watershed samples was nitrate followed by organic nitrogen. Following are observations by the various forms.

The United States Environmental Protection Agency (USEPA) estimated reference conditions for TN in streams in central Wisconsin to be between 0.46 and 0.71 mg/L. Median values at all the sites in the Montello River Watershed are well above natural conditions for this region with concentrations at UN01 more than four times higher than natural conditions. Median total nitrogen concentrations are shown in Figure **38**.

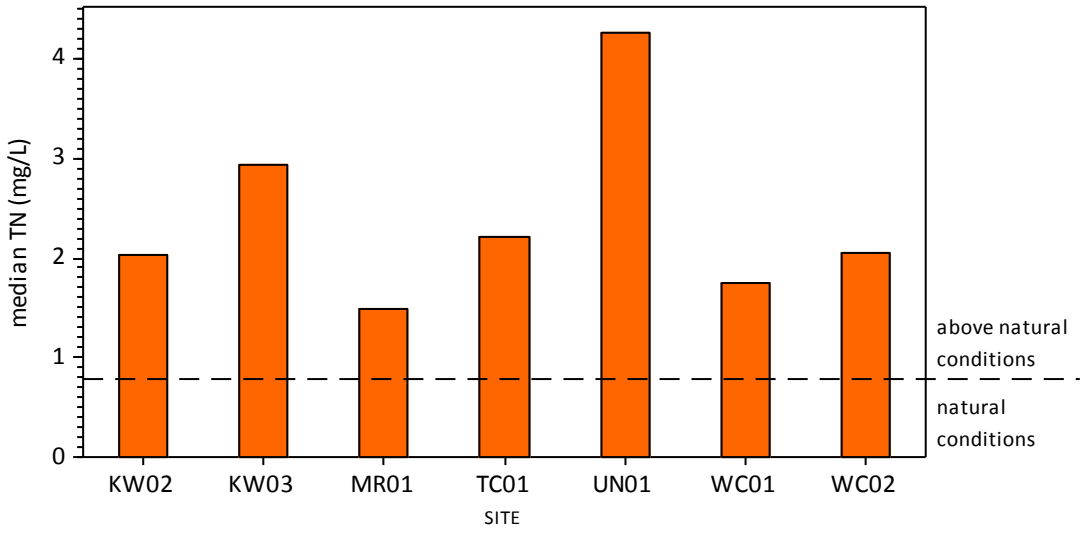


Figure 38**. Median total nitrogen concentrations (mg/L) in samples collected at primary monitoring sites in the Montello River Watershed between 2/22 and 11/11/2008.**

Since nitrate plus nitrite account for the majority of the forms of nitrogen that make up TN in the Montello River Watershed samples, the concentrations shown in Figure 38 are very similar to those for TN. UN01 had higher maximum baseflow nitrate and nitrite concentrations (9.3 mg/L N, 8.6 mg/L N). These concentrations are very high for surface water and warrant concern for the private drinking water wells in this sub-watershed. Concentrations at WC01, WC02, and MR01 were low relative to the other sites. At monitoring site UN01, the median runoff concentration (2.6 mg/L and 5.0 mg/L respectively) was higher than the median baseflow concentrations at KW02, MR01, UN01, WC02. At every site but

KW03, the maximum observed baseflow concentration was greater than the maximum runoff concentration, suggesting that nitrates are moving to the streams via groundwater. To reduce nitrogen transport to groundwater, in agricultural systems nutrient management that addresses the form and timing of nitrogen application should be developed and adhered to. Nitrogen should only be applied to lawns when indicated by soil tests and septic systems should be sighted as far from water bodies as possible.

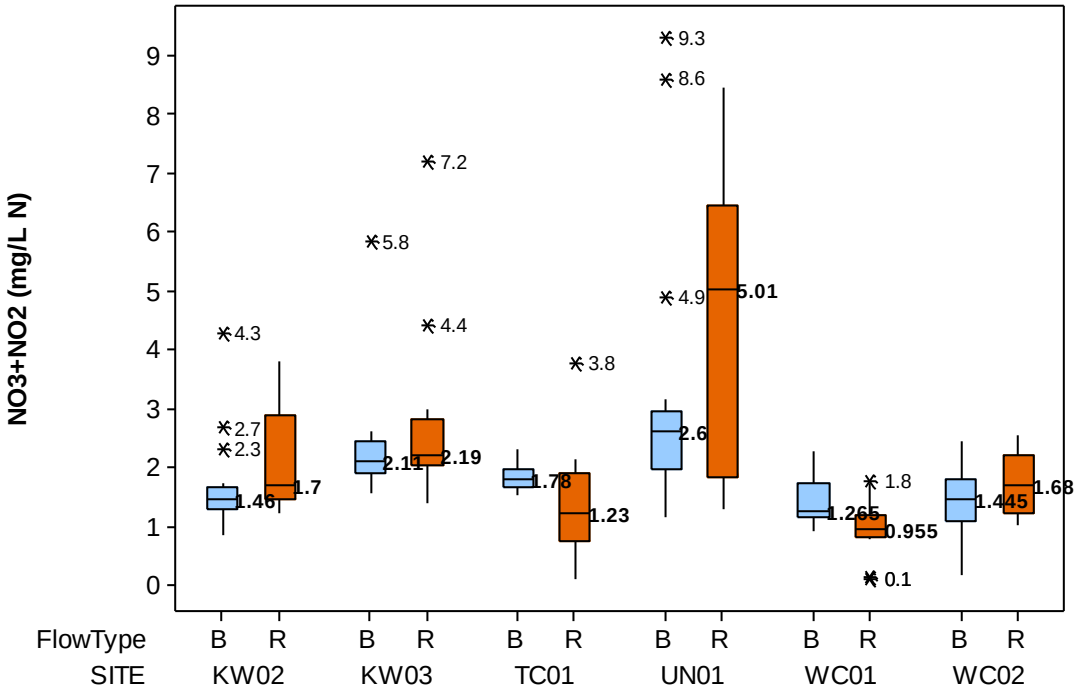


Figure 39. Nitrate-Nitrite concentrations sampled at primary monitoring sites in the Montello River watershed 2008-2009.

Ammonium does not comprise a large component of nitrogen in the Montello River Watershed. Runoff event concentrations were higher at KW02 and KW03 than the other sites. Across all sites, the majority of the values were below 0.10 mg/L. Most of the samples at TC01 were under the detection limit (Figure 40).

Organic nitrogen concentrations are found in Figure 41. At all sites, organic nitrogen increased during runoff events. Most of the runoff event concentrations at UN01 were higher than that of any other site. The highest sampled runoff event organic nitrogen concentration (3.88 mg/L) occurred at this site. Runoff event concentrations at KW02 and KW03 were higher than the other sites, excluding UN01. The median baseflow organic nitrogen concentration observed at UN01 (1.70 mg/L) is also distinctly higher than the other sites.

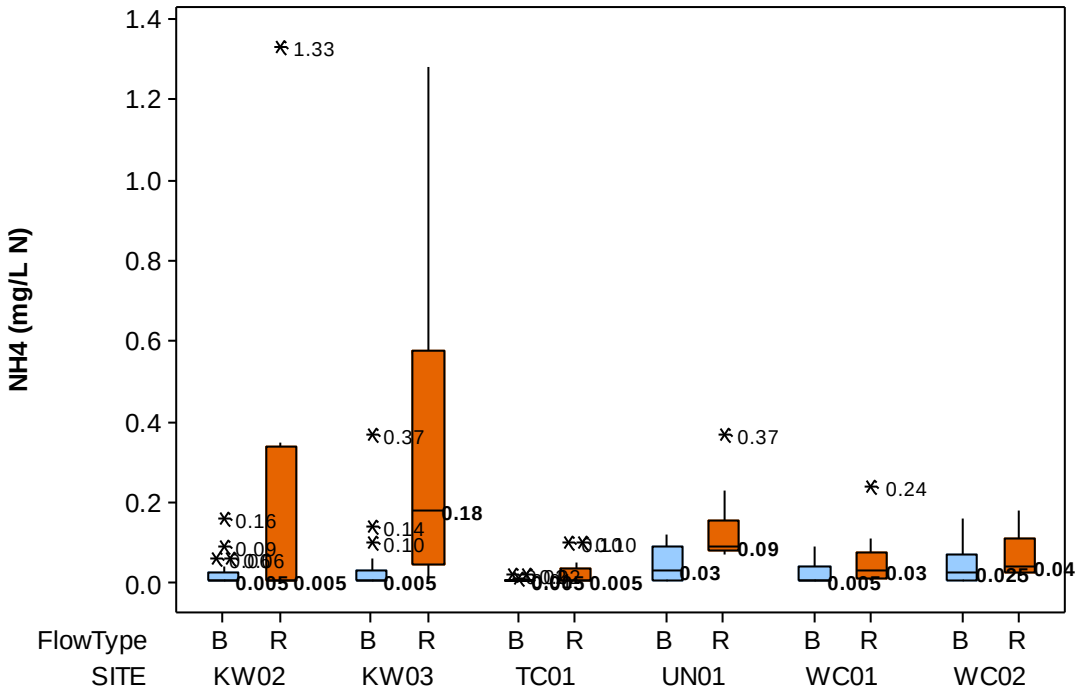


Figure 40. Ammonium concentrations sampled at primary monitoring sites in the Montello River watershed 2008-2009.

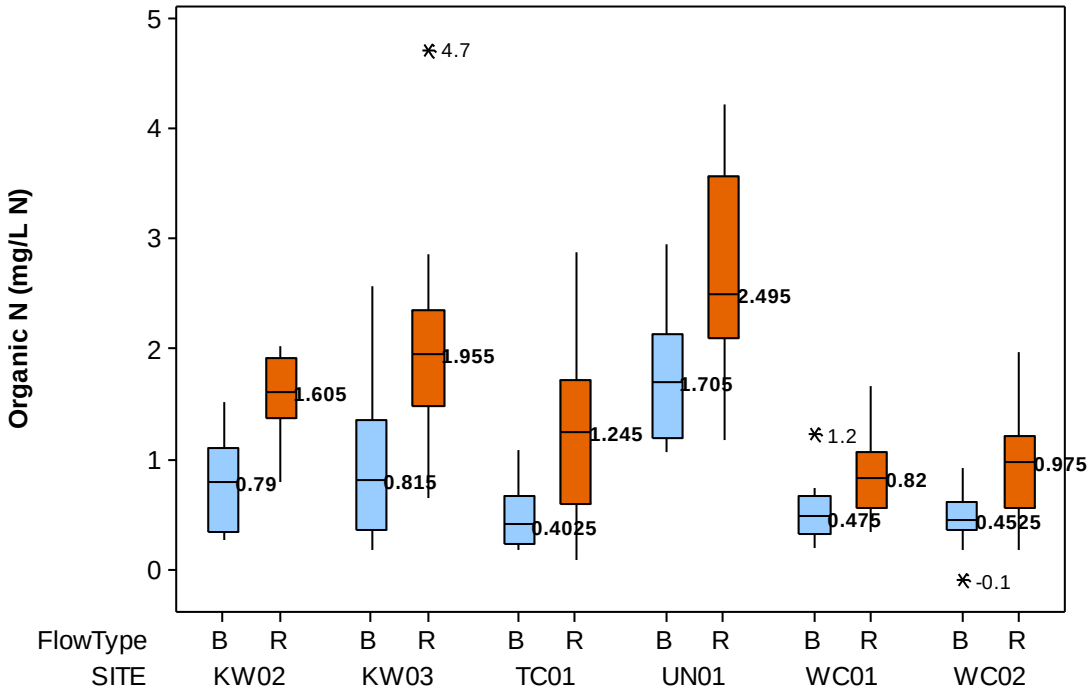


Figure 41. Organic nitrogen concentrations sampled at primary monitoring sites in the Montello River watershed between 2008-2009.

Conclusions and Recommendations

During this study period samples were collected from 11 sites in reservoirs (3), streams (6), and the Montello River (2) throughout the year and during a variety of flow conditions so this dataset provides a valuable representation of nutrient water quality in the Montello River watershed. A significant flood occurred during this study which resulted in poor water quality that enters our lakes and rivers during heavy events. Although this flood was not an average event, it is these large events that introduce a lot of sediments and nutrients to waterbodies; once in the aquatic system these sediments and nutrients have long-term effects.

Phosphorus was the nutrient of focus in this study. It was analyzed in samples collected from Lawrence Lake, Harris Pond, and Montello Lake. It was also analyzed at two sites in Klawitter Creek, two sites in Westfield Creek, Taggets Creek, un-named creek, and two sites in the Montello River. Soil phosphorus was measured in samples that were collected from fields located in areas of the watershed that are considered directly connected to the streams and river and where land managers were willing to participate with this study.

Based on DNR phosphorus criteria, the recommended average total phosphorus (TP) in shallow impoundments (calculated from samples collected between June 1st and September 15th) should be below 40 µg/L. Average TP concentrations above this level begin to affect the type and amount of aquatic plants, algae, dissolved oxygen, fish, and other aquatic biota. The average TP calculated in Montello Lake (74 µg/L) and Harris Pond (73 µg/L) were above the proposed threshold. The average at Lawrence Lake (31 µg/L) was slightly below the threshold. Efforts should be made to reduce phosphorus in and entering Montello Lake and Harris Pond. Conscious efforts should be made to maintain Lawrence Lake at TP concentrations below 40 µg/L.

Total phosphorus (TP) concentrations are one measure of the impact to the biotic integrity of the stream. Streams with lower TP concentrations will typically have a more diverse biological community of fish, aquatic plants, and aquatic macroinvertebrates. No biological surveys were conducted in this study, but the water quality data gathered in this study suggest that the biologic communities in Klawitter Creek at sites KW02, KW03, and Unnamed Creek site UN01 are likely the most impacted.

Median baseflow TP concentrations in some of the streams exceeded the DNR phosphorus criteria for wadable streams (74 µg/L) and impoundments (40 µg/L). This occurred at both sites on Klawitter Creek KW02 (91 µg/L), KW03 (98 µg/L), and Unnamed Creek UN01 (98 µg/L). Not surprisingly, the highest median TP and soluble reactive phosphorus (SRP) concentrations occurred at all sites during runoff events. KW02, KW03, and UN01 had the highest median event concentrations (171 µg/L, 358 µg/L, 192 µg/L), and the highest maximum sampled event concentrations (596 µg/L, 865 µg/L, 1,088 µg/L), respectively.

Total phosphorus loads indicate which streams deliver the greatest mass of phosphorus to the downstream river or impoundments. (Calculation of a load includes the phosphorus concentration and volume of water). Westfield Creek site WC01 had a noticeably higher average growing season TP load (9,587 lbs/acre) than the other sites, and site WC02 had the second highest (5,773 lbs/acre). These sites both had the highest averaged growing season volumes of water (21, 317 ft^3 and 12,327 ft^3) which dwarf the remaining sites (4,042 ft^3 and less).

Since a significant percent of agriculture comprises the landscape in the Montello River watershed, it was useful to evaluate how much phosphorus is leaving the fields based on the soil type, slope, and management practices used in this watershed. Many producers across the state are using a tool called SNAP-Plus to help them manage their farm nutrients by identifying which fields may need additional phosphorus for a given crop and which fields do not need more phosphorus. Reducing phosphorus applications helps to save the producers money and is good for groundwater, lake, and river water quality. SNAP-Plus results include Phosphorus Indices (PI) which is related to a level of phosphorus in the field. Fields with the highest PIs should have practices put into place to reduce phosphorus in the field. This reduction, along with implementation of best management practices that reduce soil loss should reduce in-stream phosphorus concentrations in the Montello River watershed. Although current regulations require that fields with PIs greater than 6 take steps to reduce phosphorus, all losses of phosphorus from fields to water can have a negative impact on water quality, so benefits to lakes, rivers, and groundwater can occur with any reduction in PI. Nearly all sub-watersheds (except TC01 and WC02) had some fields with PIs greater than 6.

Nitrogen can also fuel algae and aquatic plant growth in an aquatic system. The United States Environmental Protection Agency (USEPA) estimated reference conditions for TN in streams in central Wisconsin to be between 0.46 and 0.71 mg/L. At all of the sample sites, nitrate+nitrate comprised that largest component of TN. Median values at all the sites in the Montello River watershed are well above natural conditions for this region with concentrations at Unnamed Creek UN01 more than four times higher than natural conditions. UN01 had higher maximum baseflow nitrate+nitrite concentrations (9.3 mg/L N, 8.6 mg/L N). These concentrations are very high for surface water and warrant concern for the private drinking water wells in this sub-watershed. At every site but KW03, the maximum observed baseflow nitrate concentrations were greater than the maximum runoff concentration, suggesting that nitrates are moving to the streams via groundwater. To reduce nitrogen transport to groundwater, in agricultural systems nutrient management that addresses the form and timing of nitrogen application should be developed and adhered to. Nitrogen should only be applied to lawns when indicated by soil tests and septic systems should be sighted as far from water bodies as possible.

Chloride concentrations indicate the presence of human activity, as it is found at very low concentrations in undisturbed landscapes in this region of Wisconsin. Concentrations were similar across sites; however, were slightly higher in Westfield Creek at site WC02 during events and at Klawitter Creek at site KW02 during baseflow. The concentrations measured in this study are not known to be harmful to biota.

Water temperature is a very important factor that, in conjunction with habitat characteristics, determines what type of fish and other species may potentially exist in a stream. Westfield Creek at site WC02 had the most impacted water temperatures of the tributaries, and is classified as a warm water stream. This stream has unsuitable temperatures for cold water species like brook trout.

In summary, each impacted creek has specific issues to be addressed. Westfield Creek has three main issues of concern, temperature, loads, and yields. The first issue of concern is temperature, especially at Westfield Creek at site WC02. According to DNR temperature classifications, this reach of Westfield Creek can only support warm water fish species. The second issue is the loads. Loads are important to consider when assessing the impact a stream has on a downstream lake or impoundment. Westfield Creek is the largest tributary to the Montello River and contributes more phosphorus, sediment, and chloride to downstream impoundments than any other stream. Yields, which are area-weighted loads, indicate which sub-watersheds are exporting the highest mass of phosphorus/sediment/chloride per

unit area, and are used to focus management efforts on areas of greatest concern. Westfield Creek had the second highest total suspended sediment yield and the highest chloride yield.
In contrast to Westfield Creek, Unnamed Creek is the smallest tributary to the Montello River, and actually flows directly into Montello Lake. It had the lowest loads of any site, and hence, the least impact on downstream impoundments. The greatest issues of concern at Unnamed Creek are the phosphorus concentrations and yield, total suspended sediment yield, and nitrate concentrations. Although Unnamed Creek contributes a relatively low mass of phosphorus and sediment to Montello Lake, this sub-watershed was exporting a higher mass of phosphorus and sediment per area than any other sub-watershed. The biotic integrity of Unnamed Creek may also be hindered by high phosphorus concentrations. Nitrate concentrations at Unnamed Creek were also elevated.

Klawitter Creek, which has more flow than Unnamed but less than Westfield, also had water quality issues. The reach above the monitoring site KW03 had elevated phosphorus concentrations similar to that of Unnamed Creek, which may be impacting biotic integrity. Water temperature does not appear to be impacted, as this reach is considered to support cold water species. Elevated nitrate concentrations were observed in this reach of Klawitter Creek.

Tagatz Creek is the least impacted tributary to the Montello River. It supports cold water fish species and relative to other sites has no water quality issues of concern.

This study reveals the locations of problem concentrations and sources of phosphorus and nitrogen in the Montello River watershed. There is no reason to believe that these problems could not be mitigated with the implementation of best management practices. Agricultural inputs should be addressed throughout the watershed, with priority in the directly contributing areas and fields with high phosphorus indices (PIs). At a minimum, management of the fields that were input into SNAP-Plus should adhere to practices that reduce phosphorus, erosion, and ultimately runoff. It would be advantageous to run SNAP-Plus of all fields within this area to identify nutrient management needs and reduce unnecessary costs due to over use of fertilizers. Municipalities and residences should only use fertilizer if soils tests are conducted and fertilizer is deemed beneficial. When possible, mowed lawns should be replaced with native vegetation that does not need fertilizer.

Near shore development should also install best management practices that are designed to reduce surface runoff from impervious surfaces, reduce erosion, reduce/eliminate nutrient addition to the landscape, especially properties located on Montello Lake where phosphorus concentrations need to be reduced if less aquatic plant growth is desired. The nature of this impoundment lends itself to abundant aquatic plant growth but efforts to reduce nitrogen and phosphorus to the system should mitigate some of the problems.

Appendix

Table 4. Hydrologic summary for 2008 and 2009 growing season (4/1/2008-12/1/2008, 3/14/2009-11/12/2009).

SITE	YEAR	Flow (cfy)	Direct Runoff (cfy)	Baseflow (cfy)	BFI
KW02	2008	3,995	1,423	2,572	0.64
KW02	2009	3,936	770	3,166	0.80
KW03	2008	2,765	853	1,912	0.69
KW03	2009	2,031	265	1,765	0.87
TC01	2008	4,896	748	4,148	0.85
TC01	2009	3,188	622	2,566	0.80
UN01	2008	1,821	375	1,446	0.79
UN01	2009	1,071	247	824	0.77
WC01*	2008	24,292	3,029	21,262	0.88
WC01*	2009	18,343	1,985	16,358	0.89
WC02*	2008	14,733	1,396	13,337	0.91
WC02*	2009	9,920	1,123	8,797	0.89
MR02*	2008	39,008	9,697	29,311	0.75
MR02*	2009	34,305	8,179	26,126	0.76

*Downstream of 1 or more impoundments

Table 5. Estimated 2008 and 2009 growing season (4/1/2008-12/1/2008, 3/14/2009-11/12/2009).

SITE	GW Shed (acres)	YEAR	TSS (lb)	TP (lb)	Cl (lb)	TSS (lb/acre)	TP (lb/acre)	Cl (lb/acre)
KW02	18,432	2008	149,221	2,998	218,753	8.10	0.16	11.87
KW02	18,432	2009	395,808	4,791	278,545	21.47	0.26	15.11
KW03	14,076	2008	582,837	3,685	111,734	41.41	0.26	7.94
KW03	14,076	2009	384,014	2,239	83,022	27.28	0.16	5.90
TC01	15,056	2008	203,458	1,626	179,728	13.51	0.11	11.94
TC01	15,056	2009	423,742	1,780	91,588	28.14	0.12	6.08
UN01	4,691	2008	238,553	2,000	70,034	50.86	0.43	14.93
UN01	4,691	2009	275,653	1,253	40,382	58.77	0.27	8.61
WC01	36,899	2008	1,417,164	9,796	885,125	38.41	0.27	23.99
WC01	36,899	2009	2,743,609	9,379	817,996	74.35	0.25	22.17
WC02	23,711	2008	1,258,956	6,501	700,443	53.10	0.27	29.54
WC02	23,711	2009	1,720,642	5,045	555,160	72.57	0.21	23.41

Table 6. Analytical Methods and Corresponding Detection Limits for Water Quality Analyses Performed at the UW-Stevens Point Water and Environmental Analysis Lab.

Analyses	Method	Method Detection Limit
Chloride	Automated Ferricyanide 4500 C1 E	0.5 mg/L
Nitrogen, Ammonia	Automated Salicylate 4500-NH_3 G	0.01 mg/L
Nitrogen, Nitrate + Nitrite	Automated Cadmium Reduction 4500-NO_3 F	0.021 mg/L
Nitrogen, Total Kjeldahl	Block Digester; Auto Salicylate 4500-NH_3 G	0.05 mg/L
Phosphorus, Reactive	Automated Colorimetric 4500 P F	0.002 mg/L
Phosphorus, Total	Block Digestor, Automated 4500 P F	0.006 mg/L
Total Suspended Solids	Gravimetric 2540 D	2.0 mg/L
Volatile Suspended Solids	Gravimetric 2540 E	2.0 mg/L
N/P Pesticides	EPA Method 8270	Varies

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D

APPENDIX D

Aquatic Plant Survey Data

Point Number	Latitude	Longitude	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Notes	Total Rake Fullness	Potamogeton crispus	Lemna turionifera	Wolffia columbiana	Wolffia borealis	Spirodela polyrhiza	Ceratophyllum demersum	Elodea canadensis	Potamogeton zosteriformis	Heteranthera dubia	Potamogeton amplifolius	Vallisneria americana	Zizania palustris	Chara spp.	Ranunculus aquatilis	Potamogeton nodosus	Myriophyllum sibiricum	Sagittaria rigida	Potamogeton friesii	Stuckenia pectinata	Lemna trisulca	Myriophyllum verticillatum	Nuphar variegata	Schoenoplectus tabernaemontani	Carex comosa
1	43.8892056	-89.4042491	3	M	P		1		1	1	1	1	1	1								1									
2	43.8888365	-89.4042527	3	M	P		1		1	1	1	1										1									
3	43.8884674	-89.4042564	3	M	P		1		1	1	1	1			1																
4	43.8877291	-89.4042638	2	M	P		1		1	1	1	1																			
5	43.8892030	-89.4037387				Unreachable																									
6	43.8888338	-89.4037423				Unreachable																									
7	43.8884647	-89.4037460	2	M	P		1		1	1	1	1	1						1					1							
8	43.8880956	-89.4037497	2	M	P		1		1	1	1	1		1										1							
9	43.8877264	-89.4037534	2	M	P		2						2		1				1												
10	43.8873573	-89.4037571	2	M	P		2		1	1	1	1	2																		
11	43.8869882	-89.4037607	3	M	P		1		1	1	1	1		1								1									
12	43.8866191	-89.4037644	2	M	P		1		1	1	1	1													1						
13	43.8862499	-89.4037681	2	M	P		1		1	1	1	1			1																
14	43.8777599	-89.4038528	5	M	P		1						1			1	1														
15	43.8773908	-89.4038565	8	M	P	No Vegatation																									
16	43.8770216	-89.4038601	6	M	P		3		1	1	1	1						3													
18	43.8936299	-89.4031840				Unreachable																									
19	43.8892003	-89.4032282				Unreachable																									
20	43.8888312	-89.4032319				Unreachable																									
21	43.8884620	-89.4032356				Unreachable																									
22	43.8880929	-89.4032393				Unreachable																									
23	43.8877238	-89.4032430	3	M	P		2		1	1	1	1	1	2	1						1										
24	43.8873547	-89.4032467	3	M	P		1		1	1	1	1	1	1	1																
25	43.8869855	-89.4032504	2	M	P		1		1	1	1	1																			
26	43.8866164	-89.4032540	3	M	P		1		1	1	1	1																			
27	43.8862473	-89.4032577	2	M	P		1		1	1	1	1																			
28	43.8858781	-89.4032614	5	M	P		1		1	1	1	1	1		1	1		1													
29	43.8781264	-89.4033388	6	M	P		1						1		1	1															
30	43.8777572	-89.4033425	6	M	P		1		1	1	1	1																			
31	43.8773881	-89.4033461	8	M	P	No Vegatation																									
32	43.8770190	-89.4033498	6	M	P		1						1																		
38	43.8766498	-89.4033535				Unreachable																									
39	43.8936272	-89.4026736				Unreachable																									
40	43.8932581	-89.4026772				Unreachable																									
41	43.8928889	-89.4026809				Unreachable																									
42	43.8925198	-89.4026846				Unreachable																									
43	43.8921507	-89.4026883	3	M	P		1		1	1	1	1	1	1	1				1												
44	43.8888285	-89.4027215	3	M	P		1		1	1	1	1	1	1	1																
45	43.8884594	-89.4027252	1	M	P		1						1		1									1							
46	43.8880902	-89.4027289	2	M	P		1	1	1	1	1	1		1	1				1	1											
47	43.8877211	-89.4027326	3	M	P		2		1	1	1	1		2						1											
48	43.8873520	-89.4027363	4	M	P		1		1	1	1	1																			
49	43.8869829	-89.4027400	3	M	P		1		1	1	1	1																			

Point Number	Latitude	Longitude	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Notes	Total Rake Fullness	Potamogeton crispus	Lemna turionifera	Wolffia columbiana	Wolffia borealis	Spirodela polyrhiza	Ceratophyllum demersum	Elodea canadensis	Potamogeton zosteriformis	Heteranthera dubia	Potamogeton amplifolius	Vallisneria americana	Zizania palustris	Chara spp.	Ranunculus aquatilis	Potamogeton nodosus	Myriophyllum sibiricum	Sagittaria rigida	Potamogeton friesii	Stuckenia pectinata	Lemna trisulca	Myriophyllum verticillatum	Nuphar variegata	Schoenoplectus tabernaemontani	Carex comosa
50	43.8866137	-89.4027437	4	M	P		1		1	1	1	1																			
51	43.8862446	-89.4027473	5	M	P	No Vegatation																									
52	43.8821841	-89.4027879	6	M	P		1						1																		
53	43.8818150	-89.4027916	6	M	P		1		1	1	1	1				1															
54	43.8814459	-89.4027953	7	M	P		1											1													
55	43.8799694	-89.4028100	7	M	P		2										1	2													
56	43.8796002	-89.4028137	1	M	P		1		1	1	1	1			1							1									
64	43.8781237	-89.4028285				Unreachable																									
65	43.8777546	-89.4028322				Unreachable																									
66	43.8773854	-89.4028358				Unreachable																									
67	43.8770163	-89.4028395				Unreachable																									
68	43.8766472	-89.4028432				Unreachable																									
69	43.8932554	-89.4021668				Unreachable																									
70	43.8928863	-89.4021705	3	M	P		1		1	1	1	1	1								1	1									
71	43.8925171	-89.4021742	2	M	P		1		1	1	1	1	1		1							1			1						
72	43.8921480	-89.4021779	4	M	P		2		1	1	1	1		1	2						1										
73	43.8917789	-89.4021816	4	M	P		2		1	1	1	1		1	2																
74	43.8914098	-89.4021853	4	M	P		1		1	1	1	1			1																
75	43.8910406	-89.4021890	1	M	P		1		1	1	1	1				1			1	1											
76	43.8906715	-89.4021927	4	M	P		1	1	1	1	1	1		1	1										1						
77	43.8888258	-89.4022111	5	M	P		1	1	1	1	1	1		1						1					1						
78	43.8884567	-89.4022148	5	M	P		2	1	1	1	1	1		1	1					2											
79	43.8880876	-89.4022185	4	M	P		1		1	1	1	1			1																
80	43.8877184	-89.4022222	2	M	P		1		1	1	1	1						1		1											
81	43.8873493	-89.4022259	5	M	P		1		1	1	1	1																			
82	43.8869802	-89.4022296	5	M	P		3		1	1	1	1		1	1		1			2											
83	43.8866111	-89.4022333	5	M	P		1		1	1	1	1																			
84	43.8862419	-89.4022370	5	M	P		1		1	1	1	1		1	1					1											
85	43.8851345	-89.4022480	5	M	P		1		1	1	1	1						1													
86	43.8847654	-89.4022517	5	M	P		2		1	1	1	1	1	2	1	1															
87	43.8843963	-89.4022554	6	M	P		2		1	1	1	1	1	1		2															
88	43.8825506	-89.4022739	6	M	P		1		1	1	1	1	1				1														
89	43.8821815	-89.4022776	6	M	P		1						1																		
90	43.8818123	-89.4022812	8	M	P		1										1	1													
91	43.8814432	-89.4022849	8	M	P		2						2					1													
92	43.8810741	-89.4022886	8	M	P		1						1	1	1	1															
93	43.8807050	-89.4022923	1	M	P	No Vegatation																									
101	43.8803358	-89.4022960				Unreachable																									
102	43.8799667	-89.4022997				Unreachable																									
103	43.8795976	-89.4023034				Unreachable																									
104	43.8792284	-89.4023071				Unreachable																									
105	43.8788593	-89.4023108				Unreachable																									
106	43.8784902	-89.4023145				Unreachable																									

Point Number	Latitude	Longitude	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Notes	Total Rake Fullness	Potamogeton crispus	Lemna turionifera	Wolffia columbiana	Wolffia borealis	Spirodela polyrhiza	Ceratophyllum demersum	Elodea canadensis	Potamogeton zosteriformis	Heteranthera dubia	Potamogeton amplifolius	Vallisneria americana	Zizania palustris	Chara spp.	Ranunculus aquatilis	Potamogeton nodosus	Myriophyllum sibiricum	Sagittaria rigida	Potamogeton friesii	Stuckenia pectinata	Lemna trisulca	Myriophyllum verticillatum	Nuphar variegata	Schoenoplectus tabernaemontani	Carex comosa
107	43.8781210	-89.4023181				Unreachable																									
108	43.8777519	-89.4023218	4	M	P		1		1	1	1	1																			
109	43.8773828	-89.4023255	3	M	P		1		1	1	1	1	1	1				1													
110	43.8770136	-89.4023292	3	M	P		1		1	1	1	1																			
111	43.8766445	-89.4023329	4	M	P		1		1	1	1	1	1																		
112	43.8762754	-89.4023366	4	M	P		1		1	1	1	1		1				1													
113	43.8928836	-89.4016601	5	M	P		2		1	1	1	1	1		1	1		2													
114	43.8925145	-89.4016638	5	M	P		1		1	1	1	1	1	1	1																
115	43.8921453	-89.4016674	5	M	P		1		1	1	1	1	1		1																
116	43.8917762	-89.4016711	4	M	P		1		1	1	1	1	1	1	1		1	1													
117	43.8914071	-89.4016748	4	M	P		1		1	1	1	1		1	1																
118	43.8910380	-89.4016785	4	M	P		1	1	1	1	1	1	1	1	1																
119	43.8906688	-89.4016822	5	M	P		1	1	1	1	1	1	1																		
120	43.8902997	-89.4016859	5	M	P		1		1	1	1	1		1	1																
121	43.8888232	-89.4017007	5	M	P		1		1	1	1	1		1	1					1											
122	43.8884540	-89.4017044	6	M	P		1		1	1	1	1			1																
123	43.8880849	-89.4017081	7	M	P		2		1	1	1	1		1			2														
124	43.8877158	-89.4017118	6	M	P		1		1	1	1	1		1						1											
125	43.8873466	-89.4017155	6	M	P		1		1	1	1	1		1			1														
126	43.8869775	-89.4017192	6	M	P		2		1	1	1	1		1	1	1		2		1											
127	43.8866084	-89.4017229	6	M	P		3		1	1	1	1		1		1	1	1		2											
128	43.8862393	-89.4017266	6	M	P		1		1	1	1	1			1					1											
129	43.8858701	-89.4017303				Fisherman																									
130	43.8855010	-89.4017340	6	M	P		2		1	1	1	1	1			1	1	1													
131	43.8851319	-89.4017377	6	M	P		1		1	1	1	1																			
132	43.8847627	-89.4017413	6	M	P		2		1	1	1	1	1	1		1		2													
133	43.8843936	-89.4017450	8	M	P		1						1		1	1															
134	43.8840245	-89.4017487	8	M	P		2						1	2	1	1	1														
135	43.8836553	-89.4017524	6	M	P		1		1	1	1	1		1	1	1															
136	43.8832862	-89.4017561	3	M	P		2		1	1	1	1	1		1	1		2	1												
137	43.8829171	-89.4017598	2	M	P		3		1	1	1	1	3											1							
145	43.8825479	-89.4017635				Unreachable																									
146	43.8821788	-89.4017672				Unreachable																									
147	43.8818097	-89.4017709				Unreachable																									
148	43.8814405	-89.4017746				Unreachable																									
149	43.8810714	-89.4017783				Unreachable																									
150	43.8807023	-89.4017820				Unreachable																									
151	43.8803332	-89.4017857				Unreachable																									
152	43.8799640	-89.4017894	3	M	P		2		1	1	1	1	1	1	2				1												
153	43.8795949	-89.4017931	3	M	P		1		1	1	1	1	1		1			1													
154	43.8792258	-89.4017968	3	M	P		2		1	1	1	1	1	2	1			1			1										
155	43.8788566	-89.4018004	4	M	P		1		1	1	1	1	1	1																	
156	43.8784875	-89.4018041	4	M	P		1		1	1	1	1	1	1																	

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157	43.8781184	-89.4018078	4	M	P		2		1	1	1	1		1		2															
158	43.8777492	-89.4018115	5	M	P		2		1	1	1	1	2	1	1		1														
159	43.8773801	-89.4018152	5	M	P		1		1	1	1	1	1		1		1														
160	43.8770110	-89.4018189	5	M	P		1		1	1	1	1	1	1	1																
161	43.8766418	-89.4018226	5	M	P		3		1	1	1	1	3	1	1																
162	43.8762727	-89.4018263	5	M	P		2		1	1	1	1	2	1		1	1														
163	43.8759036	-89.4018300	5	M	P		1	1	1	1	1	1	1		1	1		1													
164	43.8925118	-89.4011533	5	M	P		1		1	1	1	1	1	1	1																
165	43.8921427	-89.4011570	5	M	P		1		1	1	1	1				1															
166	43.8917735	-89.4011607	6	M	P		1		1	1	1	1		1	1	1															
167	43.8914044	-89.4011644	6	M	P		1		1	1	1	1	1		1		1														
168	43.8910353	-89.4011681	6	M	P		2		1	1	1	1	2	1	1		1														
169	43.8906661	-89.4011718	6	M	P		3		1	1	1	1	1	3	1		1	1													
170	43.8902970	-89.4011755	7	M	P		2		1	1	1	1	1	1	1	1	2	1													
171	43.8891896	-89.4011866	6	M	P		2		1	1	1	1	2	1	1	1	1	1													
172	43.8888205	-89.4011903	7	M	P		1		1	1	1	1	1			1	1														
173	43.8884514	-89.4011940	6	M	P		1		1	1	1	1																			
174	43.8880822	-89.4011977	6	M	P		2		1	1	1	1	2	1		1	1	1													
175	43.8877131	-89.4012014	6	M	P		2						1	1		1		2													
176	43.8873440	-89.4012051	7	M	P		3							1			1	3													
177	43.8869748	-89.4012088	9	M	P		1						1																		
178	43.8866057	-89.4012125	7	M	P		1						1	1		1															
179	43.8862366	-89.4012162	6	M	P		1		1	1	1	1		1		1															
180	43.8858674	-89.4012199	1	M	P		1		1	1	1	1	1									1									
181	43.8854983	-89.4012236	2	M	P		2		1	1	1	1	2						1			1									
188	43.8851292	-89.4012273				Unreachable																									
189	43.8847601	-89.4012310	3	M	P		1		1	1	1		1	1	1				1												
190	43.8843909	-89.4012347	2	M	P		1		1	1	1	1	1		1				1												
191	43.8840218	-89.4012384	3	M	P		2		1	1	1	1	2		1																
192	43.8836527	-89.4012421	3	M	P		3		1	1	1	1	3		1																
193	43.8832835	-89.4012458	2	M	P		2		1	1	1	1	1	1	2									1							
194	43.8829144	-89.4012495	3	M	P		1		1	1	1	1	1		1									1							
195	43.8825453	-89.4012532	3	M	P		2		1	1	1	1	2	1									1								
196	43.8821761	-89.4012569	2	M	P		1		1	1	1	1	1		1																
197	43.8818070	-89.4012606	3	M	P		3		1	1	1	1	3	1	1																
198	43.8814379	-89.4012642	3	M	P		2		1	1	1	1	1	2																	
199	43.8810687	-89.4012679	3	M	P		2		1	1	1	1	1	2																	
200	43.8806996	-89.4012716	3	M	P		2		1	1	1	1	2																		
201	43.8803305	-89.4012753	4	M	P		1		1	1	1	1	1	1		1	1														
202	43.8799613	-89.4012790	4	M	P		1		1	1	1	1	1		1	1	1	1													
203	43.8795922	-89.4012827	5	M	P		2		1	1	1	1	2	1	1		1														
204	43.8792231	-89.4012864	5	M	P		1		1	1	1	1	1	1	1	1															
205	43.8788540	-89.4012901	5	M	P		2		1	1	1	1	1	1		2	1														

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206	43.8784848	-89.4012938	6	M	P		1		1	1	1	1	1	1			1														
207	43.8781157	-89.4012975	6	M	P		1		1	1	1	1	1																		
208	43.8777466	-89.4013012	6	M	P		2		1	1	1	1	1	2	1	1	1														
209	43.8773774	-89.4013049	6	M	P		1		1	1	1	1	1	1	1			1													
210	43.8770083	-89.4013086	6	M	P		2		1	1	1	1	1	2	1																
211	43.8766392	-89.4013123	6	M	P		1							1			1														
212	43.8762700	-89.4013160	6	M	P		1						1	1		1															
213	43.8921400	-89.4006466	6	M	P		1		1	1	1	1	1		1																
214	43.8917709	-89.4006503	6	M	P		2		1	1	1	1	1	2	1	1	1														
215	43.8914017	-89.4006540	7	M	P		1		1	1	1	1	1		1	1															
216	43.8910326	-89.4006577	7	M	P		1						1		1		1														
217	43.8906635	-89.4006614	7	M	P		2						1	1		2	1														
218	43.8902943	-89.4006651	7	M	P		1		1	1	1	1	1	1	1	1	1														
219	43.8899252	-89.4006688	7	M	P		2						1	2	1	1															
220	43.8895561	-89.4006725	7	M	P		2						1	1			2										1				
221	43.8891869	-89.4006762	7	M	P		1						1																		
222	43.8888178	-89.4006799	7	M	P		1						1																		
223	43.8884487	-89.4006836	6	M	P		3		1	1	1	1	2	2	1																
224	43.8880796	-89.4006873	2	M	P		1		1	1	1	1							1					1							
225	43.8877104	-89.4006910	3	M	P		2		1	1	1	1	1	2																	
226	43.8873413	-89.4006947	2	M	P		1		1	1	1	1	1	1																	
227	43.8869722	-89.4006984	3	M	P		2	1	1	1	1	1	2								1										
228	43.8866030	-89.4007021	3	M	P		2		1	1	1	1	2	1							1										
229	43.8862339	-89.4007058	3	M	P		1		1	1	1	1	1	1	1																
230	43.8858648	-89.4007095	3	M	P		1		1	1	1	1	1		1																
231	43.8854956	-89.4007132	3	M	P		2		1	1	1	1	2						1												
232	43.8851265	-89.4007169	3	M	P		3		1	1	1	1	3		1				1												
233	43.8847574	-89.4007206	3	M	P		1		1	1	1	1	1	1																	
234	43.8843882	-89.4007243	3	M	P		2		1	1	1	1	2		1																
235	43.8840191	-89.4007280	3	M	P		2		1	1	1	1	2		1																
236	43.8836500	-89.4007317	3	M	P		1		1	1	1	1	1	1	1																
237	43.8832809	-89.4007354	3	M	P		1		1	1	1	1			1				1												
238	43.8829117	-89.4007391	3	M	P	No Vegatation																									
239	43.8825426	-89.4007428	3	M	P		2		1	1	1	1	2	1	1																
240	43.8821735	-89.4007465	3	M	P		1		1	1	1	1	1																		
241	43.8818043	-89.4007502	4	M	P		1		1	1	1	1		1																	
242	43.8814352	-89.4007539	4	M	P		1		1	1	1	1		1	1																
243	43.8810661	-89.4007576	4	M	P		1		1	1	1	1				1															
244	43.8806969	-89.4007613	4	M	P		1		1	1	1	1	1	1			1														
245	43.8803278	-89.4007650	5	M	P		1		1	1	1	1	1	1		1															
246	43.8799587	-89.4007687	5	M	P		1		1	1	1	1	1				1														
247	43.8795895	-89.4007724	5	M	P		1		1	1	1	1				1															
248	43.8792204	-89.4007761	5	M	P		1		1	1	1	1		1	1	1	1														

Point Number	Latitude	Longitude	Depth (ft)	Sediment type (M=muck, S=Sand, R=Rock)	Rope (R); Pole (P); Visual (V)	Notes	Total Rake Fullness	Potamogeton crispus	Lemna turionifera	Wolffia columbiana	Wolffia borealis	Spirodela polyrhiza	Ceratophyllum demersum	Elodea canadensis	Potamogeton zosteriformis	Heteranthera dubia	Potamogeton amplifolius	Vallisneria americana	Zizania palustris	Chara spp.	Ranunculus aquatilis	Potamogeton nodosus	Myriophyllum sibiricum	Sagittaria rigida	Potamogeton friesii	Stuckenia pectinata	Lemna trisulca	Myriophyllum verticillatum	Nuphar variegata	Schoenoplectus tabernaemontani	Carex comosa
249	43.8788513	-89.4007798	6	M	P		2		1	1	1	1	1	1		1	1														
250	43.8784821	-89.4007835	6	M	P		2		1	1	1	1	1	2	1																
251	43.8781130	-89.4007872	6	M	P		1		1	1	1	1	1	1			1														
252	43.8777439	-89.4007909	6	M	P		1		1	1	1	1	1	1	1	1	1														
253	43.8773748	-89.4007946	6	M	P		2		1	1	1	1	2	1	1	1	1														
254	43.8770056	-89.4007983	6	M	P		1		1	1	1	1	1	1	1																
255	43.8766365	-89.4008020	6	M	P		1		1	1	1	1	1	1																	
256	43.8762674	-89.4008057	6	M	P		1		1	1	1	1	1		1																
257	43.8913991	-89.4001436	6	M	P		1		1	1	1	1	1			1															
258	43.8910299	-89.4001473	6	M	P		2						1					2													
259	43.8906608	-89.4001510	6	M	P		1						1	1	1	1															
260	43.8902917	-89.4001547	6	M	P		1		1	1	1	1	1			1															
261	43.8899225	-89.4001584	6	M	P		1						1		1		1														
262	43.8895534	-89.4001621	6	M	P		1								1																
263	43.8891843	-89.4001658	7	M	P	No Vegatation																									
264	43.8888151	-89.4001695	6	M	P		1						1																		
265	43.8884460	-89.4001732	4	M	P		1		1	1	1	1	1																		
266	43.8880769	-89.4001769	2	M	P		2		1	1	1	1	1	2																	
267	43.8877077	-89.4001806	2	M	P		2		1	1	1	1			2				1												
268	43.8873386	-89.4001843	2	M	P		1		1	1	1	1	1													1					
269	43.8869695	-89.4001880	2	M	P		2		1	1	1	1	2																		
270	43.8866004	-89.4001917	3	M	P		1		1	1	1	1	1	1																	
271	43.8862312	-89.4001954	3	M	P		1		1	1	1	1	1	1	1																
272	43.8858621	-89.4001991	4	M	P		1		1	1	1	1	1	1	1						1										
273	43.8854930	-89.4002028	3	M	P		1		1	1	1	1																			
274	43.8851238	-89.4002065	3	M	P		2		1	1	1	1	2	1																	
275	43.8847547	-89.4002102	4	M	P		1		1	1	1	1	1	1																	
276	43.8843856	-89.4002139	4	M	P		1		1	1	1	1	1	1	1																
277	43.8840164	-89.4002176	4	M	P		1								1																
278	43.8836473	-89.4002213	4	M	P		1		1	1	1	1	1																		
279	43.8832782	-89.4002250	4	M	P		2		1	1	1	1	2	1	1																
280	43.8829090	-89.4002287	3	M	P		1		1	1	1	1		1	1																
281	43.8825399	-89.4002325	4	M	P		1		1	1	1	1			1																
282	43.8821708	-89.4002362	5	M	P		1		1	1	1	1																			
283	43.8818017	-89.4002399	4	M	P		1		1	1	1	1			1	1															
284	43.8814325	-89.4002436	4	M	P		1		1	1	1	1																			
285	43.8810634	-89.4002473	4	M	P		2		1	1	1	1	1	1		1		2													
286	43.8806943	-89.4002510	4	M	P	No Vegatation																									
287	43.8803251	-89.4002547	5	M	P		1		1	1	1	1	1	1																	
288	43.8799560	-89.4002584	4	M	P		1	1	1	1	1	1																			
289	43.8795869	-89.4002621	4	M	P		1	1	1	1	1	1		1	1																
290	43.8792177	-89.4002658	5	M	P		1	1	1	1	1	1	1	1																	
291	43.8788486	-89.4002695	4	M	P		2	1	1	1	1	1	2	1	1																

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292	43.8784795	-89.4002732	6	M	P		2		1	1	1	1	2	1		1															
293	43.8781103	-89.4002769	5	M	P		2		1	1	1	1	2	1	1	1															
294	43.8777412	-89.4002806	5	M	P		1		1	1	1	1	1		1																
295	43.8773721	-89.4002843	5	M	P		1		1	1	1	1																			
296	43.8770029	-89.4002880	4	M	P		1		1	1	1	1																			
297	43.8766338	-89.4002917	5	M	P		2		1	1	1	1	1	1	1	2					1										
298	43.8762647	-89.4002954	5	M	P		1		1	1	1	1			1																
299	43.8913964	-89.3996331	5	M	P		1								1																
300	43.8910272	-89.3996368	6	M	P		1						1																		
301	43.8906581	-89.3996405	5	M	P	No Vegatation																									
302	43.8902890	-89.3996442	6	M	P		1						1																		
303	43.8899199	-89.3996480	5	M	P		1		1	1	1	1	1																		
304	43.8895507	-89.3996517	5	M	P		1						1	1	1	1	1														
305	43.8891816	-89.3996554	5	M	P		1								1																
306	43.8888125	-89.3996591	5	M	P	No Vegatation																									
307	43.8884433	-89.3996628	3	M	P		1		1	1	1	1	1									1									
308	43.8880742	-89.3996665	3	M	P		2		1	1	1	1	2	1																	
309	43.8877051	-89.3996702	3	M	P		2		1	1	1	1	2	1	1							1									
310	43.8873359	-89.3996739	3	M	P		2		1	1	1	1	2	1	1																
311	43.8869668	-89.3996776	3	M	P		2		1	1	1	1	2	1	1																
312	43.8865977	-89.3996813	3	M	P		1		1	1	1	1	1	1																	
313	43.8862285	-89.3996850	4	M	P		2		1	1	1	1	2	1	1																
314	43.8858594	-89.3996887	4	M	P		2	1	1	1	1	1	2	1																	
315	43.8854903	-89.3996924	4	M	P		1		1	1	1	1	1	1	1																
316	43.8851212	-89.3996962	4	M	P		2		1	1	1	1	1	2																	
317	43.8847520	-89.3996999	4	M	P		2		1	1	1	1	1	1				2					1								
318	43.8843829	-89.3997036	4	M	P		1		1	1	1	1						1													
319	43.8840138	-89.3997073	4	M	P		1		1	1	1	1		1							1										
320	43.8836446	-89.3997110	4	M	P		1		1	1	1	1		1																	
321	43.8832755	-89.3997147	4	M	P		2		1	1	1	1	1		1	2															
322	43.8829064	-89.3997184	4	M	P		2		1	1	1	1	1	1				2			1										
323	43.8825372	-89.3997221	4	M	P		1		1	1	1	1																			
324	43.8821681	-89.3997258	4	M	P		1	1	1	1	1	1	1	1	1	1															
325	43.8817990	-89.3997295	3	M	P		1		1	1	1	1	1		1								1								
326	43.8814298	-89.3997332	3	M	P		1		1	1	1	1			1																
327	43.8810607	-89.3997369	3	M	P		1		1	1	1	1			1																
328	43.8806916	-89.3997406	4	M	P		1		1	1	1	1	1	1																	
329	43.8803224	-89.3997443	4	M	P		1		1	1	1	1																			
330	43.8799533	-89.3997480	5	M	P		1		1	1	1	1		1																	
331	43.8795842	-89.3997517	5	M	P		1		1	1	1	1	1	1	1	1					1										
332	43.8792151	-89.3997555	4	M	P		1		1	1	1	1	1	1	1																
333	43.8788459	-89.3997592	4	M	P		1		1	1	1	1	1																		
334	43.8784768	-89.3997629	4	M	P		1		1	1	1	1																			

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335	43.8781077	-89.3997666				Unreachable																									
336	43.8777385	-89.3997703	2	M	P		1		1	1	1	1			1			1	1												
337	43.8773694	-89.3997740	4	M	P		1		1	1	1	1																			
338	43.8770003	-89.3997777	4	M	P		1						1			1															
339	43.8766311	-89.3997814	5	M	P		1						1																		
340	43.8899172	-89.3991375	5	M	P		1		1	1	1	1	1																		
341	43.8895480	-89.3991412	4	M	P		1		1	1	1	1	1		1																
342	43.8891789	-89.3991450	4	M	P	No Vegatation																									
343	43.8888098	-89.3991487	1	S	P		1		1	1	1	1	1		1																
344	43.8884406	-89.3991524	2	M	P		1		1	1	1	1	1	1								1									
345	43.8880715	-89.3991561	2	M	P		2		1	1	1	1	2	1	1							1			1						
346	43.8877024	-89.3991598	3	M	P		2		1	1	1	1	2		1							1									
347	43.8873333	-89.3991635	3	M	P		1		1	1	1	1	1	1																	
348	43.8869641	-89.3991672	3	M	P		1		1	1	1	1	1	1							1										
349	43.8865950	-89.3991709	3	M	P		2		1	1	1	1	2	1	1	1							1					1			
350	43.8862259	-89.3991746	3	M	P		3		1	1	1	1	3		1	1		1			1										
351	43.8858567	-89.3991784	3	M	P		1		1	1	1	1	1																		
352	43.8854876	-89.3991821	3	M	P		2		1	1	1	1	1			1		2													
353	43.8851185	-89.3991858	3	M	P		1		1	1	1	1																			
354	43.8847493	-89.3991895	2	M	P		3		1	1	1	1	3		1			1													
355	43.8843802	-89.3991932	3	M	P		1		1	1	1	1	1																		
356	43.8840111	-89.3991969	3	M	P		1		1	1	1	1	1	1	1								1								
357	43.8836419	-89.3992006	3	M	P		2		1	1	1	1	2	1				1			1										
358	43.8832728	-89.3992043	3	M	P		2		1	1	1	1	1	1	1			2													
359	43.8829037	-89.3992080	4	M	P		1		1	1	1	1		1																	
360	43.8825346	-89.3992117	4	M	P		1		1	1	1	1																			
361	43.8821654	-89.3992155	4	M	P		1		1	1	1	1																			
362	43.8817963	-89.3992192	4	M	P		1		1	1	1	1																			
363	43.8814272	-89.3992229	4	M	P		1		1	1	1	1		1	1					1											
364	43.8810580	-89.3992266	4	M	P		1		1	1	1	1			1																
365	43.8806889	-89.3992303	4	M	P		2		1	1	1	1		1	2																
366	43.8803198	-89.3992340	4	M	P		1		1	1	1	1																			
367	43.8799506	-89.3992377	3	M	P		1		1	1	1	1								1											
368	43.8795815	-89.3992414	4	M	P		1		1	1	1	1	1		1																
369	43.8792124	-89.3992451	4	M	P		1		1	1	1	1																			
370	43.8788432	-89.3992488	4	M	P		1		1	1	1	1																			
371	43.8784741	-89.3992525	1	S	P		1		1	1	1	1																			
372	43.8781050	-89.3992563				Unreachable																									
373	43.8777358	-89.3992600	2	M	P		1		1	1	1	1	1																		
374	43.8773667	-89.3992637	3	M	P		1		1	1	1	1				1					1										
375	43.8769976	-89.3992674	3	M	P		1		1	1	1	1								1											
376	43.8766284	-89.3992711	4	M	P		1		1	1	1	1			1								1								
377	43.8888071	-89.3986383	3	M	P		1		1	1	1	1		1	1					1											

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378	43.8884380	-89.3986420	4	M	P		1		1	1	1	1																			
379	43.8880688	-89.3986457	4	M	P		2		1	1	1	1		1	2	1				1											
380	43.8876997	-89.3986494	4	M	P		2		1	1	1	1			1	2		1					1								
381	43.8873306	-89.3986531	4	M	P		1		1	1	1	1			1																
382	43.8869614	-89.3986568	1	M	P		1		1	1	1	1																		1	
383	43.8865923	-89.3986605	2	M	P		1		1	1	1	1	1					1								1					
384	43.8862232	-89.3986643	3	M	P		1		1	1	1	1	1		1						1										
385	43.8858540	-89.3986680	4	M	P		1		1	1	1	1			1																
386	43.8854849	-89.3986717	4	M	P		1		1	1	1	1			1																
387	43.8851158	-89.3986754	4	M	P		1		1	1	1	1		1																	
388	43.8847467	-89.3986791	4	M	P		1		1	1	1	1			1																
389	43.8843775	-89.3986828	4	M	P		2		1	1	1	1			2														1		
390	43.8840084	-89.3986865	3	M	P		1		1	1	1	1	1		1																
391	43.8836393	-89.3986903	4	M	P		1		1	1	1	1	1																		
392	43.8832701	-89.3986940	2	M	P		1		1	1	1	1	1		1				1												
393	43.8829010	-89.3986977	3	M	P		3		1	1	1	1	2	1	1	1		1			1										
394	43.8825319	-89.3987014	4	M	P		1		1	1	1	1																			
395	43.8821627	-89.3987051				Unreachable																									
396	43.8817936	-89.3987088	3	M	P		1		1	1	1	1	1																		
397	43.8814245	-89.3987125	4	M	P		1		1	1	1	1																			
398	43.8810553	-89.3987162				Unreachable																									
399	43.8806862	-89.3987200	4	M	P		1		1	1	1	1																			
400	43.8803171	-89.3987237	3	M	P		1						1			1			1												
401	43.8784714	-89.3987422	1	M	P		1		1	1	1	1	1						1												
402	43.8773640	-89.3987534	5	M	P		1		1	1	1	1																			
403	43.8769949	-89.3987571	4	M	P		1		1	1	1	1																			
404	43.8766258	-89.3987608	4	M	P		1		1	1	1	1	1																		
405	43.8862205	-89.3981539	4	M	P		1		1	1	1	1																			
406	43.8840057	-89.3981762	4	M	P		1		1	1	1	1																			
407	43.8836366	-89.3981799	4	M	P		1		1	1	1	1																			
408	43.8832674	-89.3981836				Unreachable																									
409	43.8828983	-89.3981873	5	M	P		1		1	1	1	1																			
410	43.8825292	-89.3981910	5	M	P		1		1	1	1	1	1																		
411	43.8821600	-89.3981948	5	M	P		1		1	1	1	1																			
412	43.8817909	-89.3981985	4	M	P		1		1	1	1	1	1																		
413	43.8814218	-89.3982022				Unreachable																									
414	43.8810527	-89.3982059				Unreachable																									
415	43.8769922	-89.3982468	4	M	P		1		1	1	1	1	1						1												1